Volume 46 Issue 3 October 2024

Journal of Indian Academy of Forensic Medicine

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Volume 46 Issue 3 October 2024

Journal of Indian Academy of Forensic Medicine

Contents

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Original Article

A Demographic Study of Fall-related Mortality in a Tertiary Care Hospital of North India

Journal of Indian Academy
of Forensic Medicine
46(3) 315–318, 2024

DOI: 10.1177/09710973251316383
journals.sagepub.com/home/iaf
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Abstract

An accident is an unintentional and unplanned event which may lead to physical damage. Falls constitute the second leading cause of unintentional deaths due to injuries; after road traffic accidents. Injuries sustained due to a fall lead to significant morbidity and mortality, and put undue strain on healthcare infrastructure and the national economy at large. This study was conducted to analyse and prepare a demographic profile of victims and types of injuries sustained by the victims of fatal falls from heights in cases brought for autopsy in a tertiary care hospital in the Haryana region. Findings from the autopsy of 70 cases of fatal falls were incorporated and analysed in the present study. Important findings of the study showed that males were invariably more involved, especially in the working age group of 31–40 years with the brain being the most common organ injured in fatal fall cases. The study also emphasizes the need for workplace safety and the role of alcohol in cases of unintentional falls.

Keywords

Accident, morbidity, falls, alcohol

Received 30 June 2023; **accepte**d 05 October 2023

Introduction

A fall is defined as an event that results in a person coming to rest inadvertently on the ground floor or other lower level. An estimated 684,000 fatal falls occur each year, making it the second leading cause of unintentional injury death, after road traffic injuries.[1] International Classification of Disease (ICD-10) has codified Y30 as the code for morbidity and mortality associated with falls as an external factor which includes falling, jumping, or being pushed from a high place.[2]

Deaths due to falls from height are more common in urban settings due to multi-story buildings, hard concretized ground surface and other factors. Among occupational hazards, it is the most common type of accident. Builders, electricians, miners and painters are particularly at risk. It is also a major cause of unintentional harm; especially for the children and the elderly, which leads to partially avoidable morbidity and mortality. Other risk factors include alcohol or substance use, socioeconomic factors including poverty, overcrowded housing, underlying medical conditions causing loss of balance and unsafe working environments. Fall from height can be classified into (a) high fall and (b) low fall depending on the height of fall. This may also be classified as intrinsic and extrinsic based on the causative factors involved. Intrinsic factors involve some event or condition which may affect the postural control while in extrinsic factors; the environment is the main contributing reason for the fall.[3]

Fall from height is a major public health concern and a significant cause of morbidity and mortality. It is the second leading cause of accidental or unintentional injury deaths worldwide after road traffic accidents. Each year an estimated 646,000 individuals die from falls, globally, out of which over 80% are in low and middle-income countries. Adults, older than 65 years of age suffer the greatest number of fatal falls.[4] Elderly also face the highest risk of fall-related mortality.

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From the above discussion, we can see that there are multiple factors which are involved in fall from height and varied outcomes once the incident has occurred. A demographical analysis of the factors will help us better understand the mechanisms involved and prepare targeted policies to reduce the incidence of mortality and morbidity associated with falls from height. Hence, we conducted the present study with the aim of preparing a demographic profile of factors involved and injuries sustained in cases of fatal fall from height in the Haryana region.

Materials and Methods

We conducted the present prospective cohort study in the Department of Forensic Medicine at an apex institute of Northern Haryana, on cases brought to the mortuary of the department for autopsy with death due to a history of fall. Findings from a total of 70 cases were analysed which were brought to the mortuary from December 2019 to March 2021 (15 months).

The information regarding the circumstances and demographic profile of the fall was gathered from relatives/friends, police officials/police inquest papers and persons accompanying the deceased to the mortuary of the Forensic Department at an apex institute of Northern Haryana. After recording the information, relevant details were noted on a proforma especially designed for the study and subsequently, the demographic profile of the victims and injuries was prepared in a scientific and systemic manner with regards to general population traits, type and nature of injury, etc., to reach a conclusion.

Results

During the study, 70 fatal cases of known history of fall from height were studied which were brought for autopsy to the department. Our study showed that, out of the total 70 cases studied; 59 victims or 86% cases belonged to male gender and rest 11 cases were female. A maximum number of cases were reported during the summer season, that is, 26 (37.14%) cases, 21 (30%) cases were reported in winter season, followed by 11 cases in monsoon season and 12 cases in autumn. Another important finding was that in most of the incidents, 49 out of the total falls (70%) of the falls occurred during daylight hours, that is, 6:00 am to 6:00 pm. With regards to social background of the victims; 44 cases were from urban backgrounds while 26 cases were from rural settings. Thirty-two victims or 45% of the victims were laborer or construction workers by profession. Among the contributory factors leading to falls from height alcohol was found in a chemical analysis of 21 cases, that is, 30% of the total victims consumed alcohol prior to their death.

Discussion

Injuries due to falls from height remain a significant cause of morbidity and mortality in our day-to-day lives. Fall from heights is one of the most common causes of traumatic death all over the world. The pattern and distribution of injuries sustained during a fall are dependent on a number of variables such as age and sex of victims, height of fall, type of surface, site of primary impact, etc. All people who fall, are at risk of injury, however, the age, gender and health of the individual can affect the type and severity of injury. In the present study, male victims were more as compared to female victims, that is, 59 (86%) males and 11 (14%) females. The preponderance of male victims is probably due to males being outside the house for work, while the females stay back in their homes for household work. The higher rate of fatality in men has been ascribed to men taking more risks than women, consumption of alcohol (30% cases) and working in dangerous employment sectors like construction. However, in the majority of the cases (47.14%) no associated risk factors were observed. After the consumption of alcohol a person's ability to judge and react to a situation accordingly is reduced and hence leading to fatal falls. The involvement of alcohol as a contributory factor was also observed by Ola G. Haggag et al.[5]

Age is another risk factor as observed in the study that the maximum number of cases of falls from height was seen in the age group 31–40 years, comprising 22.8% of all cases of fall from height, which is similar to the results of a study conducted by Manoj K and Munawwar H.[6] The youngest victim was a two years old child and the eldest was 80 years old. These results are in contrast with the study conducted by Roopak SN and Jagannatha SR in 2015 who observed that the most common age group involved was 21–30 years followed by 31–40 years (Table 1).[7] The difference observed in both the studies with regards to the most common age could be due to differences in society wherein average age of engaging in manual labor could be older or better awareness levels due to increased social media exposure. The maximum number of cases of fatal falls from height was quite understandably laborers or who were construction workers by occupation comprising 32 cases of fatal fall from height constituting 45.72% of total cases followed by unemployed amounting 17.14%, that is, 12 (Table 2). The construction workers and laborers belong to the lower economic strata and are forced to work in unsafe environments putting their lives in danger. Workplace safety guidelines to be followed at construction sites are in place but are seldom followed due to widespread neglect and lack of awareness among those involved. Maximum cases occurred during daylight hours since economically it is the most productive time when people are engaged in their vocations.

With regard to height of fall, most of the cases fell from a height ranging from 10 to 14 feet (41%) followed by 28% of cases between heights of five to nine feet. Fatality in such cases is strongly dependent on the height of the fall (Table 3) and due to the semi-urban setting of patient base and lack of multi-story buildings in our setting, similar studies in metro cities will lead to different results and could be a source of a

Table 1. Distribution of Cases According to Age.

Sr. No.	Age Groups (Years)	Number of Cases	Percentage
1.	0–10	9	12.85
2.	11–20	5	7.14
3.	21–30	7	10
4.	31–40	16	22.85
5.	41–50	9	12.85
6.	51–60	10	14.28
7.	61–70	7	10
8.	71–80	7	10
9.	>80	0	0
	Total	70	100

Note: Table 1 shows that out of 70 cases majority of the 16 cases belonged to the age group of 31–40 years. In our study, no cases were reported in the age group of more than 80 years.

Table 2. Distribution of Cases According to the Occupation.

Sr. No.	Occupation	Number of Cases	Percentage
1.	Laborer/construction worker	32	45.71
2.	Unemployed	12	17.14
3.	Housewife	9	12.85
4.	Student	7	10
5.	Private job	6	8.5
6.	Others	4	5.7
	Total	70	100

Note: The table shows that most of the cases of fatal falls from height belonged to construction workers or laborer by profession followed by unemployed, housewives, students, private job and others, that is, 12 (17.14%), 9 (12.85%), 7 (10%), 6 (8.5%), and 4 (5.7%), respectively.

Table 3. Distribution of Cases According to the Height of Fall.

Sr. No.	Height of Fall (in Feet)	Number of Cases	Percentage
1.	0–4	18	25.71
2.	5–9	20	28
3.	10–14	29	41.42
4.	>15	3	4.28

Note: Table 3 shows that the maximum no. of cases of fall from height belong to height of 10–14 feet accounting for 29 (41.42%) of cases followed by height of 5–9 feet, 0–4 feet and more than 15 feet accounting for 20 (28%), 18 (25.71%), and 3 (4.28%) cases respectively.

future similar study. Urban settings were more prone to fatal fall incidents as compared to rural households (44 and 26 cases, respectively) due to the lack of high-rise buildings in rural settings. Summer seasons were more prone to fatal incidents (37%) as compared to other seasons; probably due to longer days, exhaustion and people sleeping on the roof to escape the heat at lower levels.

Table 4. Distribution of Cases According to the Cause of Death.

Sr. No.	Cause of Death	Number of Cases	Percentage
1.	Head injury alone	39	55.71
2.	Head injury plus thoracic injury	15	21.42
3.	Head injury plus thoracic plus abdominal injury	4	5.71
4.	Head injury plus abdominal injury	4	5.71
5.	Head and spinal injuries	3	4.28
6.	Thoracic injury plus pelvic injury	2	2.85
7.	Spinal injury	2	2.85
8.	Thoracic injury alone	1	1.42

Note: Our study showed that head injury was the most common as well as most commonly associated injury when other body parts were involved. Head injury alone accounted for death in more than half (39 cases or 55.71%) of the cases.

Table 5. Distribution of Cases According to Involvement of Internal Organs.

Sr. No.	Organs Involved	Number of Cases	Percentage
1.	Brain	57	81.42
2.	Spinal cord	13	14.28
3.	Liver	9	12.85
4.	Lung	6	8.57
5.	Mesentery and intestines	4	5.71
6.	Spleen	3	4.28
7.	Kidney	3	4.28
8.	Heart	0	0

Note: Brain was the most commonly involved organ followed by spinal cord and liver.

In the present study, the most common cause of death was head injury alone accounting for 39 (55.71%) cases followed by head injuries coupled with thoracic injuries accounting for 15 cases (21.42%), head injury combined with thoracic and abdominal injuries accounting for 4 (5.71%) cases and head injury combined with abdominal injury accounting for 4 (5.71%) cases and head injuries combined with spinal injuries seen in 3 (2.85%) cases. Overall, it was observed that the fatal head injury was present in 65 (92.85%) cases. Isolated spinal and thoracic injuries were the cause of death in 2 and 1 case, respectively (Table 4). The head is the most susceptible part of our body in cases of free fall from height and any injury involving the head may lead to injury to the brain and any trivial injury over the brain may prove to be fatal. Similar

findings were observed in a study performed by Ismael Aunnon Martin et al.[8] Since the head is the most common body part involved in such cases, the most common injured organ was observed to be the brain, that is, in 57 (81.42%) cases, followed by a spinal cord in 13 cases (18.57%) cases. Similar findings were observed by V. Prathapan et al., Ramesh C et al., and Saritha SR and Sreedevi CS (Table 5).[9,10,11]

During the course of our study, we observed a few limitations in the form of lack of population variability and lack of environmental factors such as high-rise multi-story buildings and hills and mountains. The results and observations in different settings could offer new insights into the issue and an opportunity for fellow researchers to study the topic in different settings.

Conclusion

Our study shows that individuals of age 31–40 years age, male gender, laborer by occupation and residents of urban areas are more prone to fatal falls. The head is the most common part to be involved with the brain being the most common internal organ injured. In view of our findings and other similar studies, safety guidelines should be framed to decrease mortality associated with fall-related deaths. Multipronged prevention strategies should emphasize creating awareness through social media and otherwise, safer workplace and home environments among other interventions to bring down the number of cases.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The study was commenced after obtaining clearance from Institutional Ethical Committee (vide letter No IEC/TH/18/Forensic/04 dated 8/11/2019).

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

The informed Consent has been obtained for the study.

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Original Article

A Digital Retrospective Study: Evaluating the Reliability of Mandibular Parameters as Sex Predictors in the Maharashtra Population

Journal of Indian Academy of Forensic Medicine
46(3) 319–324, 2024

DOI: 10.1177/09710973251316345
journals.sagepub.com/home/iaf
Sage

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Abstract

Sex identification is a crucial factor in both forensic investigations and medico-legal cases, with age determination following closely. When soft tissues are missing, skeletal features are analysed. If the skull is incomplete, the mandible helps determine sex. Numerous studies have demonstrated the accuracy of panoramic radiographs in assessing anatomical measurements for sex determination. This current study investigates the use of digital orthopantomographs to analyse mandibular parameters for sex prediction specifically within the Maharashtra population. The objective is to assess the importance of the mandible in sex determination which will be achieved by analysing different morphometric parameters observed on panoramic radiographs, with the aim of identifying the most reliable predictor for sex determination. In this retrospective study, a total of 200 digital orthopantomographs (100 male and 100 female) were analysed. The collected data were then analysed using the SPSS version 20.0 statistical package. With the exception of the gonial angle, all measurements demonstrated higher values in males compared to females. Out of the eight parameters assessed, four parameters, namely condylar height, coronoid height, projective height of the ramus, and gonial angle exhibited significant differences. The overall accuracy of sex prediction based on these parameters was determined to be 72.5%. Within the sample of this study, a notable level of sexual dimorphism was observed in the gonial angle and mandibular ramus. As a result, the mandible can be considered a valuable tool for determining the sex of an individual. The utilization of digital orthopantomographs proved to be a reliable method for conducting morphometric analysis.

Keywords

Digital orthopantomographs; mandible, gender determination, forensic identification

Received 16 July 2023; **accepted** 12 December 2023

Introduction

In a world, where crime scenes are at an increasing rate, investigative techniques should be potent enough to solve the various criminal cases. The determination of sex is a vital aspect in forensic investigations and medico-legal cases, with age identification being subsequently prioritized. In cases of explosions, mass disasters, and air hurricanes where usually only the fragmented parts of the skeleton are found, complete accuracy of sex determination is not possible. In such situations, the pelvis and the skull bones are mainly used for the sex determination of an individual.[1] The skull, second only to the pelvis, is the most dimorphic and easily identifiable part of the skeleton in terms of sex, offering a level of accuracy of up to 92%.[1,2]

In situations, where an intact skull is not found the mandibular bone is proven to play an important role in determining the sex of an individual.[3] Based on studies conducted on the mandible, it has been found that the mandibular condyle and ramus exhibit the highest degree of sexual dimorphism. These specific sites undergo substantial morphological changes in terms of size and remodeling during growth.[2,4]

In dental practices, panoramic radiographs are commonly employed to evaluate the structures of both the mandible and maxilla.[5] The utilization of orthopantomography for identification purposes, as it allows for the comprehensive visualization of the jaws and associated areas in a single radiograph.[6]

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Multiple researchers have asserted that utilizing radiographic examination of the skull for sex prediction is a dependable method that can achieve accuracy rates ranging from 80% to 100%.[7]

The present study was conducted to evaluate the accuracy of mandibular parameters in the sex determination of an individual using digital panoramic radiographs among the Maharashtra population.

Material and Methods

A retrospective study was conducted using 200 digital orthopantomographs (100 male & 100 female) taken by using SIRONA ORTHOPHOS XG Digital Panoramic Machine (69 kVp, 15 mA, 14.1 sec) in the Maharashtra population in the age range of 18–60 years.

Inclusion Criteria

1. Age group between 18 and 60 years
2. Permanent dentition
3. High-quality OPGs

Exclusion Criteria

1. Primary and mixed dentition stages
2. Edentulous arches
3. Pathological, fractured, deformed, and developmental disturbances of the mandible

OPGs were collected in JPEG format and were stored digitally and then it was exported to Adobe Photoshop 7.0 software. For the analysis part, OPGs were first life-sized in the software with the help of scale of reference, and then all the eight mandibular measurements were carried out in the software using the "Measure tool" (Figure 1).

1. Point A-Maximum ramus breadth: It is the distance between most anterior and posterior points on the mandibular ramus.[7]
2. Point B-Minimum ramus breadth: It is the smallest anteroposterior diameter of the mandibular ramus.[7]
3. Point C-Condylar height: It is the distance between the most superior points on the condyle to the most protruded point on the inferior border of the ramus.[7]
4. Point D-Projective Height of the Ramus: It is the distance between the most superior points on the condyle to the lower margin of the alveolar bone on the inferior border of the ramus.[7]
5. Point E-Coronoid Height: It is the distance between the most superior points on the coronoid to the most protruded point on the inferior border of the ramus.[7]
6. Point F-Height of the mandible at symphysis region: It is the distance between the midline of the central incisors to the lower border of the mandible. The mandibular symphysis region shows a significant difference between both males and females.[8]
7. Point G-Bigonial Width: It is the distance between both gonion (Go). Go is the most inferior, posterior, and lateral point on the external angle of the mandible. It was measured horizontally from the right to the left Go.[9]

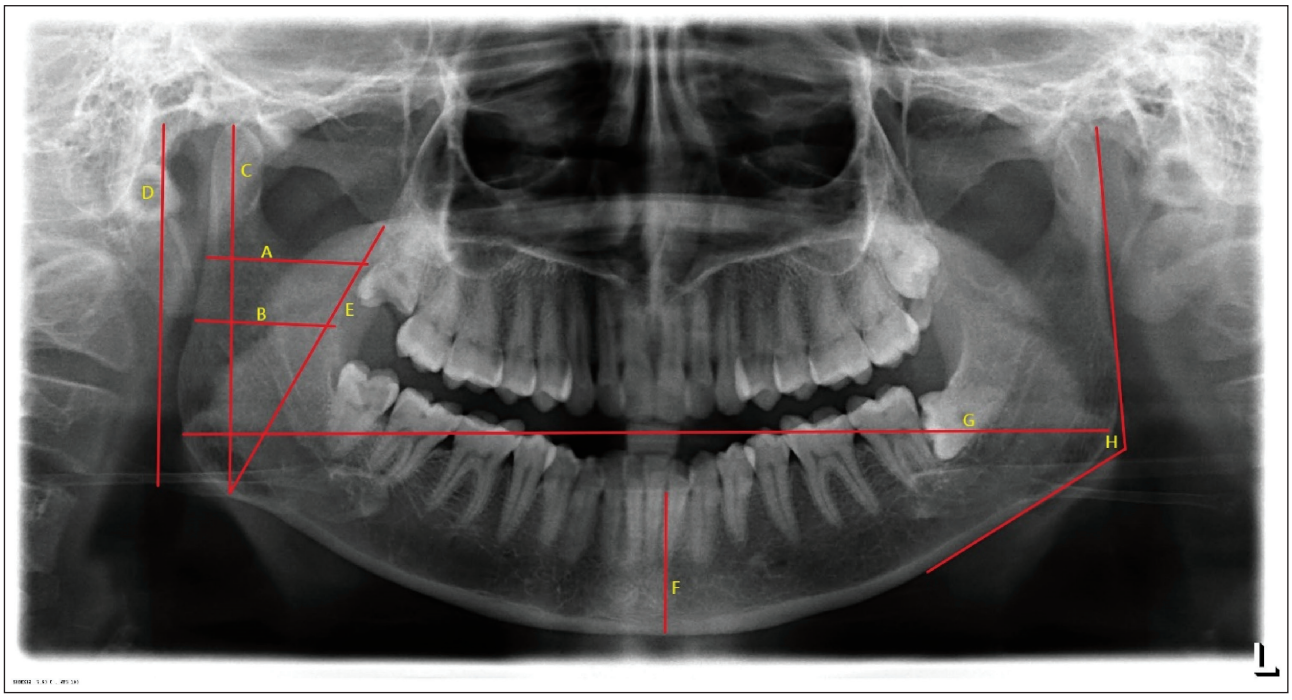

Figure 1. Orthopantomograph Showing all Eight Mandibular Measurements.

8. Point H-Gonial Angle: A line was digitally traced on the OPGs tangential to the posterior border of the ramus and the condyle and another line was drawn tangential to the lower border of the mandible up to the distal root of the first molar. The intersection of these two lines forms the gonial angle which was measured by the software.[9]

Statistical Analysis

IBM SPSS (Statistical Package for Social Sciences) version 20.0 statistical software was utilized for conducting the statistical analysis. Discriminant function analysis was employed to identify variables that differentiate between males and females, as well as to identify the most accurate predictors for determining an individual's sex.

Results

The descriptive statistics for both sexes are represented in Table 1. It shows that all the measurements recorded are higher in males as compared to females except for the gonial angle (Table 2). The f-statistic value indicates that the highest sexual dimorphism is seen with the gonial angle and the least with the bigonial width (Table 3). In this study, out of eight parameters, four parameters which are gonial angle, coronoid height, condylar height, and projective height of ramus are found to be the best parameters for the determination of the sex of an individual with the *P* value being <.05 (Table 3).

From the values obtained by linear discriminant function analysis, the equation has been derived with the help of which we can determine the sex in an unknown sample (Table 4).

For Female = − 323.884 − 4.832 (MxRB) + 4.851 (MnRB) − 1.856 (Condylar Height) + 2.239 (PHR) + 1.115 (Coronoid Height) − 1.602 (Symphysis Region Height) + 0.358 (BW) + 4.431 (GA)

For Male = − 301.634 − 4.741 (MxRB) + 4.717 (MnRB) − 1.601 (Condylar Height) + 2.046 (PHR) + 1.123 (Coronoid Height) − 1.542 (Symphysis Region Height) + 0.323 (BW) + 4.251 (GA)

In order to classify a given sample as either male or female, a maximum of two equations were utilized. This study determined the threshold to be 0, where values exceeding this threshold are classified as male, while values below it are classified as female.

The prediction accuracy was calculated for all the variables. Out of 100 male samples 73 samples were correctly classified and out of 100 female samples 72 samples were correctly classified. The overall prediction accuracy was 72.5% (Table 5).

The intra and inter-observer variability of all the variables was examined by using the chi-square test with a Pearson

Table 1. Descriptive Statistics.

	Male		Female	
Variables	**Mean**	**SD**	**Mean**	**SD**
Point A	40.5418	6.30709	39.5069	7.18806
Point B	35.1653	5.73728	34.0375	6.03152
Point C	88.7877	11.85037	83.0756	13.15565
Point D	86.2773	11.42335	80.8602	13.25603
Point E	75.7285	11.80667	69.9390	12.59840
Point F	39.8345	5.76040	38.9936	6.53661
Point G	237.2072	28.00726	234.7054	31.89758
Point H	116.1440	7.03234	123.1540	6.54588

Table 2. Table Showing a Comparison of the Measurements Recorded for one of the Male and Female Samples.

Serial no.	Parameters	Male	Female
1	Maximum ramus breadth	49.79 mm	35.46 mm
2	Minimum ramus breadth	45.83 mm	27.69 mm
3	Condylar height	97.71 mm	78.16 mm
4	Projective height of ramus	92.22 mm	76.87 mm
5	Coronoid height	77.18 mm	62.19 mm
6	Height at symphysis region	46.11 mm	31.57 mm
7	Bigonial width	269.03 mm	208.34 mm
8	Gonial angle	127°	130.6°

Table 3. Tests of Equality.

Variables	Wilks' Lambda	F-value	Significance
Point A	0.994	1.171	0.280
Point B	0.991	1.836	0.177
Point C	0.950	10.408	**0.001**
Point D	0.954	9.583	**0.002**
Point E	0.946	11.243	**0.001**
Point F	0.995	0.932	0.336
Point G	0.998	0.347	0.556
Point H	0.788	53.238	**0.000**

Note: Bold values indicate the best parameters for the determination of the sex of an individual with the *P* value being <0.05.

Table 4. Linear Discriminant Function.

	Gender	
Variables	**Male**	**Female**
Point A	−4.741	−4.832
Point B	4.717	4.851
Point C	−1.601	−1.856
Point D	2.046	2.239
Point E	1.123	1.115
Point F	−1.542	−1.602
Point G	0.323	0.358
Point H	4.251	4.431
(Constant)	−301.634	−323.884

Table 5. Prediction Accuracy.

Classification Result for all Eight Variables					
			Predicted Group Membership		
		Gender	Female	Male	Total
Original	Count	Female	72	28	100
		Male	27	73	100
	%	Female	72.0	28.0	100.0
		Male	27.0	73.0	100.0

Note: [a]72.5% of originally grouped cases are correctly classified.

Correlation Coefficient (R-Value) of 0.98 and 1, respectively. The asymptomatic error was found to be very low. There were no significant differences found between intra and inter-observer analysis.

Discussion

Forensic odontology is a major branch of forensic science that deals with crime and law. Worldwide crime scenes are at an increasing rate; hence we need some strong investigative techniques to deal with criminality. The investigation starts with identification. Age estimation and sex determination are the key phases in identification. In the case of fresh bodies, it is possible to give a positive identification of gender by visual comparison. But in cases of badly decomposed or decayed bodies, it becomes difficult to identify the sex of a person.

When soft tissue parts are not available then the only source of identification is the skeleton. Skull and pelvis bones are sexually dimorphic bones of a body. The skull, second only to the pelvis, is the most dimorphic and easily identifiable part of the skeleton in terms of sex, offering a level of accuracy of up to 92%.[1] In the absence of an entire skull, the mandible can serve as a source of identification.

Based on studies conducted on the mandible, it has been found that the mandibular condyle and ramus exhibit the highest degree of sexual dimorphism. These specific sites undergo substantial morphological changes in terms of size and remodeling during growth.[2,4] However, individuals of the same or similar height do not necessarily share identical mandibular morphology. Biological differences exist in the mandibular dimensions of males and females, leading to variations in morphology, which are significant in morphometric studies.[10,11]

Radiography is a non-invasive technique.[1] Panoramic radiographs are routinely used for the examination of patients. Hence, it is easily available and does not involve a patient in any extra exposure dose and cost. These are good sources for retrospective studies. Panoramic radiographs examine the maxillofacial complex effectively.

In this study total of eight parameters were evaluated. Five mandibular rami parameters (maximum ramus breadth, minimum ramus breadth, condylar height, projective height of ramus and coronoid height), the height of mandible at symphysis region, bigonial width, and the gonial angle. The parameters represent the vertical and horizontal dimensions of the mandible. In this study, the mean values of all the variables were higher in males as compared to their female counterparts except in the gonial angle.

Among all eight variables, there were four variables that were statistically highly significant. Gonial angle, condylar height, the projective height of ramus, and coronoid height were highly significant in the present study with a P value <.05. In the present study, the prediction accuracy for a total of eight variables was 72% for females and 73% for males and overall it was 72.5%.

When comparing with other studies it was found that the results were almost similar to some of the studies.[12] conducted a study on the Bangalore population using mandibular rami parameters. They found all variables were significant predictors. Overall 76% of cases were correctly identified.[13] conducted a study on the Egyptian population using mandibular rami measurements and gonial angle as a parameter. They have found mandibular rami and gonial angle statistically highly significant and proved to be beneficial in gender estimation.

Nayyar et al. (2017) conducted a study on the South Indian population. They have found almost similar results to our study. Among five mandibular rami parameters, they found only three parameters, that is, condylar height, coronoid height, and projective height of ramus statistically highly significant.[7]

Few studies, however, have been undertaken on the Maharashtra community[14,15]; thus, the current study attempted to evaluate the efficacy of mandibular factors in predicting an individual's gender in the Maharashtra population, with the goal of using the same in forensic analysis and anthropology.

Conclusion

From the present study, it can be concluded that mandibular ramus parameters (condylar height, coronoid height, projective height of ramus) and gonial angle can be used as aids for the gender determination of an individual. The mandibular ramus and gonial angle a valuable aids for the gender determination of a person as it is readily available, accessible, and resistant to any disintegration process.

Digital orthopantomographs were found to be reliable when all mandibular measurements were carried out for the determination of sex using image analysis software.

We recommend the use of this method in adjunct to other sex estimation techniques. However, there is a need for some research with a larger sample size and population-specific studies which will provide a uniform formula for the various populations. These will improve the usefulness of this study and help in a better understanding of the topic.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The data were collected from the archives following the approval of the Institutional Ethical Committee.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

This study utilizes anonymized Orthopantomograms (OPGs) obtained from a secondary database of hospital records. All images were stripped of personally identifiable information before inclusion in this research, ensuring compliance with ethical and legal standards. Since the data used in this study were collected retrospectively from an existing pool of radiographic images with no direct patient interaction, individual informed consent was not obtained. The use of these anonymized OPGs has been approved by Institutional Ethical Committee, confirming that the research adheres to ethical guidelines and poses no risk to patient confidentiality.

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An Autopsy-based Study on Pattern of Fatal Injuries in Fall from Height

Journal of Indian Academy of Forensic Medicine
46(3) 325–329, 2024

DOI: 10.1177/09710973251321990
journals.sagepub.com/home/iaf
Sage

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Abstract

Falls are the second most common cause of injury-associated mortality after traffic accidents. The present study aims to find out the pattern of injuries among the victims of falls from height. This prospective observational study was conducted among victims of falls from height at SRTR Government Medical College morgue during the period of July 2020 to July 2022. All medico-legal cases involving head injuries brought for autopsy during the study period were included. Exclusion criteria include all medico-legal cases not involving head injury, advanced decomposed bodies, intracranial haemorrhage, infarctions, lesions as a result of natural disease. Various data were collected. A total of 996 autopsies were performed during the study period out of which 48 (4.82%) were cases of fall from height. Among them 30 (62.5%) were male and 18 (37.5%) victims were female. Most of the victims were day labourers or construction workers 16 (33.33%). Most deaths occurred during day time 35 (72.92%) with the highest mortality being due to accidental falls 31 (64.58%). The age of maximum victims was between 31 and 40 years (37.5%). All the victims had multiple abrasions and bruises on their bodies, followed by intracranial haemorrhage 42 (87.5%), laceration 34 (70.84%) among others. In the skull, linear fracture was the most common 26 (54.17%). Temporal bone was the commonest bone to fracture 25 (52.08%) and most of the victims 17 (35.42%) had a subdural haemorrhage. Most common cause of death is due to major injuries overhead 36 (75%). Strategies designed to prevent these falls should have a substantial effect.

Keywords

Fall from height, minor injuries, major injuries

Received 12 September 2023; **accepted** 01 January 2024

Introduction

Falls are the second most common cause of injury-associated mortality after traffic accidents.[1] A fall is defined as an injury to a person that occurs after landing on the ground after falling from a higher place, such as a ladder, scaffold, building, roof or other elevated place or work area.[2] Factors determining serious and fatal injuries in a fall depend on the distance of the fall, the characteristics of the landing surface, the orientation of falling, and whether the fall was direct or broken.[3] The skull, brain, spinal cord and extremities are the most commonly injured systems. Falls from first/second stories are more frequently nonfatal, but falls from more than twenty feet have historically been triaged to trauma centres. But even low-level falls can cause serious head injuries and death.[4,5]

Objectives

The objective of this study was to find out the pattern of injuries among the victims of falls from height.

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Table 1. Type of Victims by Profession (n = 48).

Type of Victims by Profession	Total Number of Victims			Total Percentage (%)
	Male	Female	Total	
Day wagers/construction workers	13	3	16	33.33
Students	4	3	7	14.58
Housewife	0	8	8	16.67
Farmers	9	2	11	22.92
Children (<10 years)	2	1	3	6.25
Others	2	1	3	6.25
Total	30	18	48	100

Table 2. Variation of Types of Injuries Among Victims (n = 48).

Types of Injuries	Number of Victims	Percentage %
Multiple abrasions	48	100
Contusions	48	100
Intracranial injuries	42	87.5
Laceration	34	70.84
Skull fractures	30	62.5
Fracture of upper limb	20	41.67
Fracture of lower limb	28	58.33
Fracture of vertebra	6	12.5
Fracture of ribs	8	16.67
Injury to abdominal organs	21	43.75
Pelvic fracture	17	35.42

Note: The same victims had multiple types of injuries.

Table 3. Types of Skull Fracture (n = 48).

Types of Skull Fracture	Number of Victims	Percentage %
Linear/Fissured fracture	26	54.17
Comminuted fracture	23	47.92
Diastatic fracture	9	18.75
Depressed fracture	10	20.83
Ring fracture	12	25
No fracture skull	18	37.5

Note: The same victims had multiple types of injuries.

Materials and Methods

This prospective observational study was conducted among the victims of falls from height at SRTR Government Medical College and Hospital morgue during the period of July 2020 to July 2022.

Various data of the victim were collected from inquest reports submitted by the investigating officers. Specific points regarding injuries were noted during autopsy examinations. Later on, the data were analysed.

Results

A total of 996 autopsies were performed during the study period out of which 48 (4.82%) were cases of fall from height. Among them 30 (62.5%) were male and 18 (37.5%) victims were female. Most of the victims were day labourers or construction workers 16 (33.33%) (Table 1). Considering timing, the highest incidents occurred during the daytime 35 (72.92%) and 13 (27.08%) at night. The highest mortality is due to accidental falls 31 (64.58%). The ages of maximum victims were between 31 and 40 years (37.5%). All the victims had multiple abrasions and bruises all over the body, followed by intracranial haemorrhage 42 (87.5%), laceration 34 (70.84%), fracture of skull bone 30 (62.5%), injury to long bones of upper limbs 20 (41.67%), injury to long bones of lower limbs 28 (58.33%), injury to abdominal organs like liver, spleen, kidney 21 (43.75%), fracture of pelvis 17 (35.42%) (Table 2). In skull bones linear fracture was the commonest one 26 (54.17%) (Table 3), Temporal bone was the commonest bone to fracture 25 (52.08%) (Table 4) and most of the victims 17 (35.42%) had subdural haemorrhage (Table 5). The most common injuries responsible for death were injuries over the head 36 (75%) followed by injuries over the thoracic region 21 (22.92%), abdominal region 21 (43.75%) and due to fracture of long bones 33 (68.75%) (Table 6).

Discussion

Injury due to falls from height remains a significant cause of morbidity and mortality in our day-to-day lives. Fatalities occur primarily when a person falls from greater than two

Table 4. Location of Skull Fracture in Different Cranial Bone (n = 48).

Skull Bones	Number of Victims	Percentage %
Frontal bone	16	33.33
Parietal bone	20	41.67
Occipital bone	6	12.5
Temporal bone	25	52.08
Anterior cranial fossa	7	14.58
Middle cranial fossa	9	18.75
Posterior cranial fossa	13	27.08
No fracture skull	18	37.5

Note: The same victims had multiple types of injuries.

Table 5. Different Types of Intracranial Haemorrhage (n = 48).

Intracranial Haemorrhages	Number of Victims	Percentage %
Extradural haemorrhage (EDH)	6	12.5
Subdural haemorrhage (SDH)	17	35.42
Subarachnoid haemorrhage (SAH)	12	25
Intracerebral haemorrhages	7	14.58

Note: The same victims had multiple types of injuries.

Table 6. Major Body Region Injured Leading to Death (n = 48).

Major Body Part Involved (Major Injuries)		Number of Victims	Percentage (%)	Percentage in Total %
Head (total = 36)	Skull fracture	30	62.5	75
	Intracranial injuries	42	87.5	
Thorax (total = 11)	Rib fracture	8	16.6	22.92
	Lung injury	6	12.5	
	Pneumothorax	3	6.25	
	Hemo-thorax	6	12.5	
	Heart injury	2	4.17	
Abdomen (total = 21)	Injury to liver	10	20.83	43.75
	Injury to spleen	16	33.33	
	Injury to kidneys	8	16.6	
	Hemoperitoneum	20	41.66	
Fracture of long bones (total = 33)	Fracture of upper limb	20	41.66	68.75
	Fracture of lower limb	28	58.33	

Note: The same victims had multiple types of injuries.

stories or when the head of the victim hits a hard surface. This includes falls from rooftops, windows and balconies.[3–5] In an Indian study, falls from height comprised the highest number of deaths among workplace accidents and the majority of these falls were from construction sites.[6] In this study, most of the victims were day labourers or construction workers 16 (33.33%) followed by housewives 8 (16.67%), farmers 11 (22.92%), students 7 (14.58%), children and others 3 (6.25%). Considering timing highest incidents occurred during daytime 35 (72.92%) and 13 (27.08%) at night.

Males are predominantly the earning members in our society context. Generally, men are exposed to trauma and falls more often than women because boys are more active than girls at early ages and more men are physical labourers than women.[7,8] In this study 30 (62.5%) were male and 18 (37.5%) victims were female. Nowadays a number of high-rise buildings are being constructed in Ambajogai City and nearby places and being a rural area building safety codes are not always properly followed. This indicates the significance of the highest number of victims as construction workers. Falling from rooftops and buildings is usually considered accidental in nature. But sometimes due to familial disharmony, financial issues, failure in examination, emotional blackout after refusal by lovers, drug addiction also leads to suicidal cases as these sites are commonly used to commit suicide. Homicidal cases are also not rare. Circumstantial evidence of some cases which occurred during the night points towards homicidal activities. In this study, most of the victims died due to accidental falls 31 (64.58%) followed by suicidal falls 10 (20.84%), homicide 5 (10.42%) and 2 (4.16%) were undetermined.

The Indian construction industry is the second largest contributor to the nation's economy. While the industry is set to pick pace in the coming years, the government has also established regulations on how construction workers are supported. They include:

1. The Fatal Accidents Act, 1885
2. The Workmen's Compensation Act, 1923
3. The Factories Act, 1948
4. The Employees State Insurance Act, 1948
5. The Central Labour (Regulation & Abolition) Act, 1970
6. Building & Other Construction Workers (Regulation of Employment and Conditions of Services) Act, 1996
7. Building & Other Construction Workers Welfare Cess Act, 1996
8. Building & Other Construction Workers (Regulation of Employment and Conditions of Services) Central Rules, 1998
9. The National Building Code of India, 2005

The falls from greater heights tend to cluster in the summer months, presumably because windows are more likely to be open and children are more likely to be playing on fire escapes, roofs and balconies.[4,9,10] Falls in the elderly tend to occur with activities of daily living. In England falls account for 29% of injury deaths among adults aged 65 and older. Older adults are five times more likely to be hospitalised due to falls than to injuries from other causes.[11]

Overall, in this study, 28 (58.34%) of the patients were between 20 and 40 years old, indicating that people of active ages are more frequently involved in trauma. Older individuals, especially those over 60 years old, lose their ability to balance, which causes more falls.[12] Host factors such as poor muscle tone, vision problems, medication use and sedentary lifestyle are the biggest contributors to ground-level and stair falls, but environmental components such as poor lighting and no handrails may increase the frequency. Factors contributing to falls from heights include faulty equipment, such as ladders and scaffold structures, and human factors, such as intoxication and inattention.

In this study, all the victims had multiple abrasions and bruises on their bodies which were minor in nature and not a definitive cause of death. Head trauma and severe loss of blood that leads to shock were the most common causes responsible for death due to blunt traumatic injury. In this study, the major cause responsible for death was head injury 36 (75%) in the form of skull bone fracture 30 (62.5%) and intracranial haemorrhages 42 (87.5%), followed by thoracic injury 11 (29.92%) in the form of fracture ribs 8 (16.67%), lung 6 (12.5%) and heart 2 (4.17%) injuries, pneumo-thorax 3 (6.25%) and haemothorax 6 (12.5%), abdominal injuries 21 (43.75%) in the form of injuries to liver 10 (20.83%), spleen 16 (33.33%), kidneys 8 (16.6%) and hemoperitoneum 20 (41.66%), long bone fractures 33 (68.75%) including upper 20 (41.66%) and lower 28 (58.33%) limbs.

Musemeche et al. and Meller et al. noted that fractures of the radius, ulna and femur were the most common injuries.[13,14] Velcek et al. and Lehman et al. in their study pointed out that, rib, spine, pelvis and calcaneus fractures were much less common among children than among adults because children tend to use their arms to protect their heads and they have relatively flexible bones.[15,16] Meller et al. and Lehman et al. noted that multiple fractures and cranio-cerebral trauma were common, especially in those cases that resulted from falls from greater heights. Abdominal and chest injuries were relatively uncommon in low-height falls but they are more frequent in fatal falls from greater heights.[14,16] In this study, the occurrence of major injuries was less in children as compared to the adult population.

The nature of the surface onto which the victim falls and the degree to which the fall is broken on the way down modify the pattern and severity of injuries. Children younger than three years are much less likely to have serious injuries than older children who fall the same distance because younger children have more fat and cartilage and less muscle mass than older children, they better dissipate the energy transferred by the fall.[17]

The same victims had multiple types of skull fractures like linear, comminuted, depressed, diastatic and others. The force required to cause fracture depends on area of the skull struck, the thickness of the skull, scalp and hair and direction of impact. In this study, among skull bones linear fracture was the commonest one 26 (54.17%) and Temporal bone was the commonest bone to fracture 25 (52.08%). A skull fracture can occur if the moving head directly strikes an object in case of fall from height, it can be the hard ground. The linear fracture can also occur on the opposite side by contrecoup if the head moves and its movement is suddenly arrested by coming in contact with a hard surface. In most cases of fall from height head strikes by forcible contact with broad resisting surfaces like the concrete or tarred ground resulting in the liner fracture. The thinnest area in our skull is temporal bone (4 mm), followed by frontal bone (6 mm), parietal bone (10 mm) and occipital bone (15 mm). A force of 400–600 pounds per square inch is required to fracture a skull covered by a cushion of hair and scalp. However, a fall from three feet height will produce an impact energy of 35 feet pounds, causing two linear fractures or mosaic fractures. This indicates the predominance of different fractures, where the victims of fall from height are thrown with great impact.[18,19]

This study has shown that most of the victims 17 (35.42%) had a subdural haemorrhage. Subdural haemorrhage is due to vascular injury, especially the bridging veins, where the head rapidly decelerates because of impact to a firm, underlying surface.

Subdural haemorrhages most commonly occur in old ages and children due to falls on ground by accidents, whereas subarachnoid haemorrhages were the most common pattern in intra cranial haemorrhage in RTA. Extradural haemorrhages were more common in 20–40 years of age and occurred mostly due to road traffic accidents (RTA) or hit by any other object.[20] Acute extradural haemorrhage is generally due to rupture of the middle meningeal artery as a result of fracture at 'pterion', an H-shaped formation of sutures on the side of the skull representing the junction of four skull bones, that is, Frontal, parietal, temporal and greater wing of the sphenoid.

The majority of traumatic deaths occurred in pre-hospital settings; on-scene or during transport and the leading cause of

death is poly-trauma. The incidence of pre-hospital mortality is great among overall trauma-related deaths. So, pre-hospital medicine and trauma prevention programmes are significant factors in reducing traumatic deaths.[21]

Conclusion

From the above study, we can arrive at a conclusion that most of the victims who died due to falls from height were construction site workers and death was accidental in nature and was preventable. Employers need to provide better access to job sites and invest in safety equipment that secures a worker. This includes both securing the worker to a safety line and providing a safety helmet. It is important that all scaffolding jobs should be carried out by trained professionals who are knowledgeable about the specialised safety equipment. This also includes the maximum amount of load they carry while working on scaffolds. Scaffolding should be designed so as to offer a solid footing for workers, be completely planked and away from any dangerous power lines. It is necessary that employers choose to work with the most suited ladder systems associated with the site of work. Workers should also be regularly trained about new ladder systems. Most construction workers in India come from rural areas looking for jobs. They are inexperienced and lack training in using safety gear. It is necessary that workers are chosen properly and that all are given the necessary training before being put on the job. Most of the time, workers are not informed or knowledgeable about the health and safety risks they are exposed to on construction sites. It is necessary that they are able to read and understand Material Safety Data Sheets and are prepared for the same. Implement safety programmes to ensure that workers understand the risk and are well prepared to face the challenges without risking their lives or health. Discouraging or prohibiting children from playing on fire escapes, roofs and balconies, especially those that are not adequately fenced with vertical bars and encouraging the use of ground-level safe play areas, such as public parks and playgrounds can reduce the number of incidents. At the same time, modernisation of physical environment and strict maintenance of safety procedures can protect vulnerable personnel and reduce economic burden. Triage must be done accurately at the accident location and critical patients should be referred to trauma centres quickly. This can reduce the mortality and morbidity due to falls from height.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of the college before commencing the study.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

Not applicable.

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Comparison of Skeletal Age with Chronological Age by Tanner–Whitehouse (TW3) Method: A Cross-sectional Study in Ethnic Meitei Subjects

Journal of Indian Academy of Forensic Medicine
46(3) 330–335, 2024

DOI: 10.1177/09710973251321988
journals.sagepub.com/home/iaf
Sage

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Abstract

Age estimation of an individual is often required in civil and criminal cases, as well as in sports competitions. The study of the epiphyseal union of bones is considered a reasonable and accepted scientific method for estimating age by courts of law all over the world. The present work is a prospective cross-sectional study in which a calculated sample size of 86 subjects is studied. A comparative study is conducted between the chronological age (CA) of the subjects and the estimated age derived using the Tanner–Whitehouse (TW3) method. Based on the results, the following conclusions are drawn about the TW3 method in our set-up: (a) It is reliable for bone age assessment (BAA) with a root mean square (RMS) deviation of ±0.7Y = ±8 months. (b) It has a lower rate of correct classification in boys (40%) compared to girls and is a better match for girls. (c) It tends to underestimate age in both genders, so readings should be interpreted as far as possible toward the higher side. (d) CA predictions within six months (CA ± 6 months) are above 46.51%. in both genders. This study demonstrates the reliability of the results obtained through BAA using the TW3 method.

Keywords

Chronological age, bone age, correlation, age estimation, TW3 method, underestimation, overestimation

Received 27 September 2023; **accepted** 08 January 2024

Introduction

Age estimation of an individual is often required in civil and criminal cases, as well as in sports competitions. The study of the epiphyseal union of bones for bone age (BA) is considered a reasonable and accepted scientific method for the estimation of age by courts of law all over the world.[1] Chronological age (CA) is defined as the age in years between birth and the evaluation of a subject; BA is defined as the age expressed in years that corresponds to the level of maturation of bones. This determination is based on the presence of particular centres of bone formation, as well as the dimension and structure of the bones.[2]

The Tanner–Whitehouse (TW) method was developed in 1930 using data obtained from European children.[3,4] It is based on the determination of a score obtained from hand and wrist skeletal maturation. A score is assigned to each bone based on the maturation and sex of the participant. In this way, a maturity score is obtained for each area of clinical interest, generally categorised as A, B, C, D, E, F, G, H and I. A numerical value is then assigned to each stage with specific differences between genders. Over the years, this system has been refined by moving from an initial system known as the TW1 method to two subsequent methods known as TW2 and TW3.[3–5] The score based on 20 bone segments was abolished, and a new one based on 13 bones has been established, and the reference values and graphs were modified based on data obtained from native North American children. Thus, establishing specific parameters for other populations is valuable because the subjects used to develop the standard methods were from the United States and Europe. Conventional age estimation techniques can only give an age estimate in terms of plus-minus one to two years. The present study aims to bring out the feasibility of TW3 skeletal age estimation in the

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ethnic Meitei population with a close approximation in terms of months and to help in formulating a standardised system specifically for the ethnic Meitei population by comparing the TW3 RUS SA (TW3 Radius-Ulna-Short Bones Skeletal Age) of ethnic Meitei youths with their CA.

Materials and Methods

The present study is a prospective cross-sectional study. Athletes who came for age determination in the Forensic Medicine & Toxicology department of a tertiary care teaching hospital in Imphal, as well as healthy ethnic Meitei subjects in various schools in Imphal, were included.

The sample size was calculated using PASS software, with alpha = 0.05, beta = 0.02 (80% power), and correlation to detect = 0.03. After obtaining approval from the institutional ethics committee and informed written consent from the participants, left-hand wrist radiographs of 86 healthy Meitei subjects (45 boys and 41 girls) aged 12–18 years were analysed. Individuals with bony abnormalities, including fractures, and those diagnosed with growth or endocrine disorders were excluded. The BA was estimated using the TW3 method, which calculated the average of the RUS bone score. Participant-identifying information, except for sex, was masked during interpretation, including the subject's CA. The correlation between the BA and CA of each person was analysed using Pearson's correlation coefficient and scatter plot.

The data were analysed using the SPSS statistical software (version 25.0, SPSS, Inc., Chicago, IL, United States). A paired student's t-test was used to compare CA with BA by the TW3 method for the cohort stratified by gender. Frequency tests were carried out to analyse the correlation between CA and the discrepancy between CA and BA for at least six months. A $P < .05$ was considered significant. The differences between CA and measured BA were calculated for each participant, and the root mean square (RMS) of the differences between the two was calculated.

Results

A total of 86 cases were studied. There were 45 male subjects and 41 female subjects (Table 1). The CA of the study participants ranged from 12 to 18 years (Table 2). The estimated age of the study participants using the TW3 method ranges from 11 to 18 years (Table 3).

Table 1. Showing Sex Wise Distribution of Study Participants.

	Frequency	Percent
Male	45	52.3
Female	41	47.7
Total	86	100.00

It was observed that underestimation was more common in boys than in girls. Girls have a higher chance of correct age classification (Table 4). Thus, the TW3 score seems to be a better match for girls' ages than for boys'. The Pearson's correlation coefficient between the CA and estimated age for both boys and girls was 0.94. The paired t-test between the CA and estimated age was statistically significant, with a two-tailed *P* value of .0001 for both boys and girls (Table 5). Figure 1 shows the scatter plot for both boys and girls in CA and the estimated age. Figure 2 shows the line chart showing a correlation between boys' and girls' chronological and estimated ages.

For boys, the correlation between CA and estimated age was 0.95, and for girls, the correlation between CA and estimated age was 0.92. Figure 3 shows the line chart showing a correlation between boys' chronological and estimated ages. Figure 4 shows the line chart showing a correlation between girls' chronological and estimated ages.

The RMS of differences for males and females combined was ±0.7Y or ±8 months (Table 5). For boys, the RMS of differences was ±0.7Y, and for girls, the RMS of differences was ±0.7Y. In boys, the estimated age was within ±6 months of

Table 2. Showing Chronological Age of Study Participants.

	N	Range	Minimum	Maximum
Chr. age in years	86	6.00	12.00	18.00
Valid N (listwise)	86			

Table 3. Showing Estimated Age of Study Participants.

	N	Range	Minimum	Maximum
Est. age in years	86	7.00	11.00	18.00
Valid N (listwise)	86			

Table 4. Showing Percentages of Participants with Correctly Classified (CC), Underestimated (under) and Overestimated (over) Age with Respect to the Class of CA ± 6 Months (New).

%	Boys	Girls	Both Boys and Girls
Underestimated (outside the ± 6 months range)	46.66	31.7	39.53
Correctly classified within± 6 months	40	53.65	46.51
overestimated (outside the ± 6 months range)	13.33	14.63	13.95

Table 5. Showing Pearson's Correlation, *P* Value and RMS (Root Mean Square).

	Boys + Girls	Boys	Girls
Pearson's correlation	0.94	0.95	0.92
P value	.0001	.0001	.0001
RMS	± 0.7Y	± 0.7Y	± 0.7Y

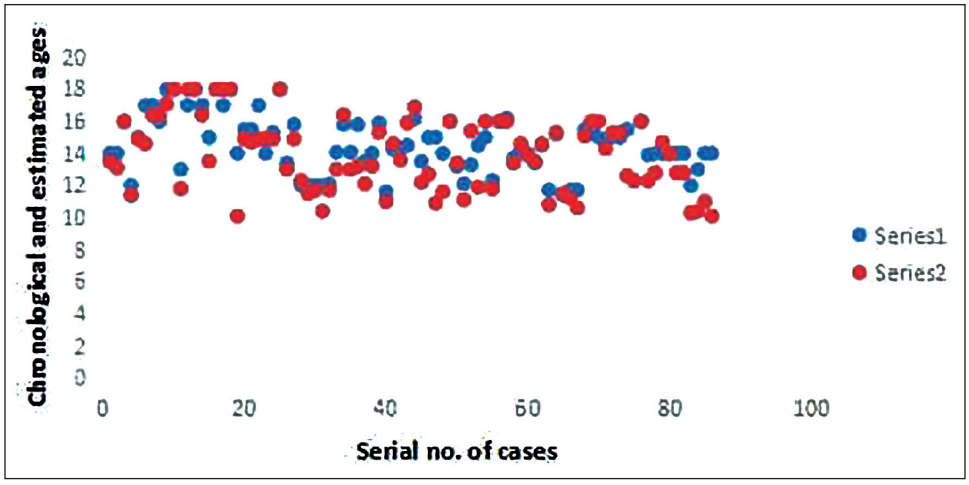

Figure 1. Scatter Plot for Both Boys and Girls Chronological Age and Estimated Age.

Note: Series 1: chronological age, Series 2: estimated age.

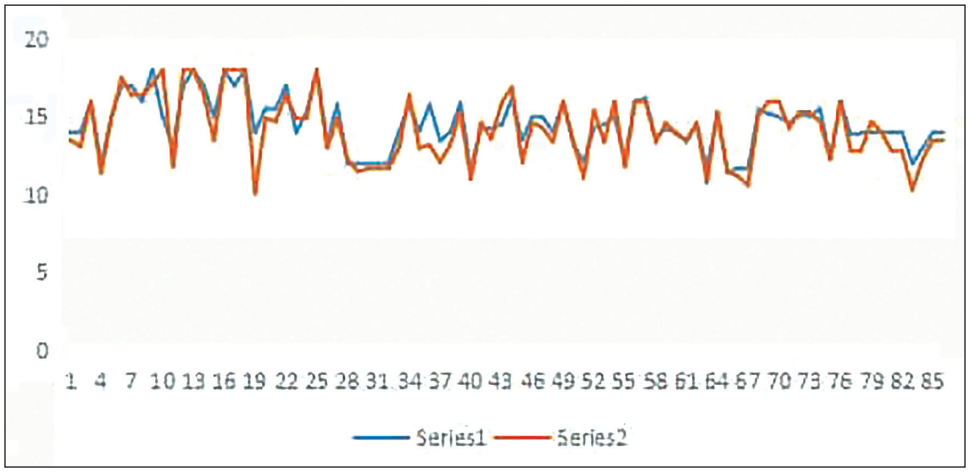

Figure 2. Line Chart Showing Correlation Between Boys' and Girls' Chronological and Estimated Ages.

Note: Blue line: chronological age, red line: estimated age, X-axis: Serial no. of cases, Y-axis: chronological and estimated ages.

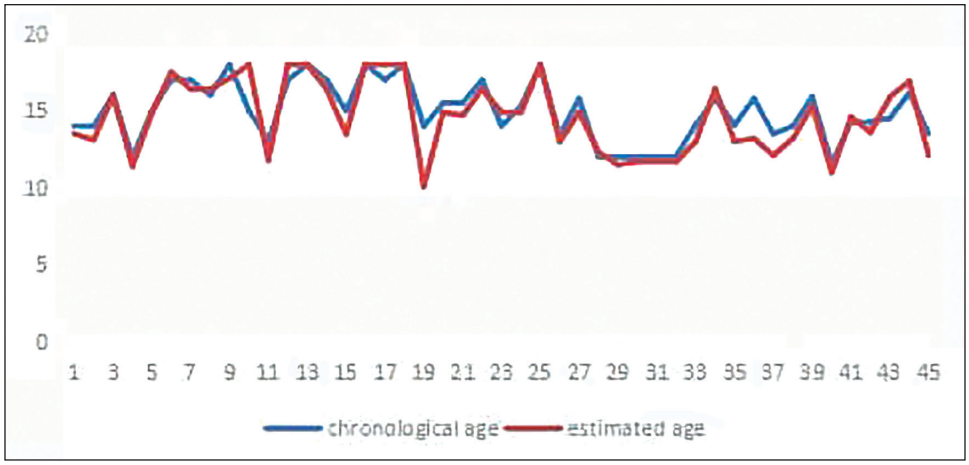

Figure 3. Line Chart Showing Correlation Between Boys' Chronological and Estimated Ages.

Note: Blue line: chronological age, red line: estimated age, X-axis: Serial no. of cases, Y-axis: chronological and estimated ages.

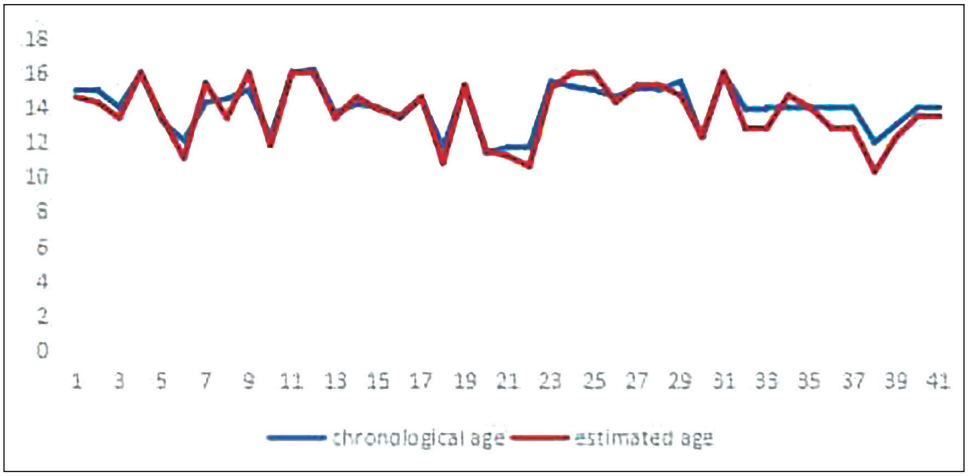

Figure 4. Line Chart Showing Correlation Between Girls' Chronological and Estimated Ages.

Note: Blue line: chronological age, red line: estimated age, X-axis: Serial no. of cases, Y-axis: chronological and estimated ages.

the CA for 18 out of 45 cases, or 40%. It was underestimated in 21 out of 45 cases, or 46.6%, and overestimated in 6 out of 45 cases, or 13.33%. In girls, the estimated age was within ±6 months of the CA for 22 out of 41 cases, or 53.65%. It was underestimated in 13 out of 41 cases, or 31.17%, and overestimated in 6 out of 41 cases, or 14.63%.

In both boys and girls, age estimation was within ±6 months of the CA in 40 out of 86 cases, or 46.51%. It was underestimated in 34 out of 86 cases, or 39.53%, and overestimated in 12 out of 86 cases, or 13.95%. It was also observed that fusion occurred earlier on the left side in both males and females. The phalanges fused earlier than the heads of the metacarpals, and the heads of metacarpals two to five were the last to fuse.

Discussion

Bone age assessment (BAA) is commonly and widely used to reflect skeletal maturity, evaluate growth status, and predict the future height of children. The TW3 method can evaluate and score the maturity of each hand and wrist bone.[6] The reference population of this study consisted of European and American families with average socio-economic status during the 1980s and 1990s, and the data were adjusted for the secular trend in 2001.

In a cross-sectional observational study on healthy Indian children in Pune,[7] the TW3 method was found to be the most suitable method overall ($P < .05$). The TW3 method was also the most applicable in prepubertal boys ($P < .05$), prepubertal girls (although not significant with $P > .1$), and pubertal girls ($P < .05$).

The differences between the chronological and estimated ages can be positive or negative, depending on whether the CA is greater or less than the estimated age. To eliminate the difference in signs, these differences are squared first and then the square root is taken to determine the deviation between the two ages. When comparing the RMS deviation between CA and BA for various methods of BA assessment, the TW3 method had the least RMS deviation, suggesting it to be the most suitable method for BA assessment of children.[7] In our study, the RMS was only ±0.7 months, which is lower. The *P* value (2-tailed, paired) was .0001 for both boys and girls, and the RMS of males and females was ±0.7 years or ±8 months. This indicates that the correlation is significant, as the *P* value is less than .05, and the age of the subject, whether a boy or a girl, can be determined within a range of plus or minus eight months.

In Thai children (8–16 years), BA was underestimated in boys until 12 years of age, after which it was overestimated. In girls, BA was overestimated at all ages.[8] In our study, there is also a tendency to underestimate BA.

In the present study, in boys, the estimated age was within ±6 months of CA in 40% of cases. It was underestimated in another 46.66% of cases and overestimated in 13.33% of cases. In girls, the estimated age was within ±6 months of CA in 53.65% of cases, underestimated in 31.7% of cases, and overestimated in 14.63% of cases. In both boys and girls, the estimated age was within ±6 months of CA in 46.51% of cases, underestimated in 60.43% of cases, and overestimated in 13.95% of cases. Therefore, the TW3 score seems to match more closely with girls' ages than boys'.

In our study, BA was underestimated more in boys, which is similar to a study on Indian boys.[7] In Indian girls, BA is underestimated until the pubertal growth spurt, after which there is a rapid advancement of BA.[7]

According to a study on Turkish children, the TW3 method underestimated the age of both male and female subjects,[9] which is somewhat similar to our results. In a Chinese study, there was a tendency to overestimate the age of both genders.

In a sample of normal Korean children, the skeletal age using the TW3 method was overestimated for male individuals (59.6%) and female individuals (72.2%).[8]

In a study in Turkey, Büken et al.[10] compared the TW3, GP, and GÖK12 methods in a sample of Turkish children aged between 11 and 16 years. They reported that TW3 underestimates the BA in both genders, resulting in mean differences in years between the CA and the estimated BA of −0.21 years for girls and −0.18 years for boys. They also reported that TW3 was the most accurate method, followed by GP in females, while for males, the GP method was the most accurate, followed by TW3. Our study also found underestimation to some extent (31.7% in girls and 46.66% in boys).

Schmidt et al.[11] found that in the legally relevant BA group between 14 and 16 years, the differences between the skeletal age and the mean value of the CA ranged from −0.4 to +0.2 years for TW3. TW3 (specificity 87.5 for males and 83.87 for females) was more reliable than GP, especially in criminal cases, given the remarkable trend of GP (specificity 87.2 for males and 82.8 for females) to overestimate the age.

Predictions with an age span of six months (EA ± 3 months) produced a very low occurrence of correct classifications (GP: 16% and 11.2%; TW3: 23.5% and 16.1%, respectively, for males and females). Therefore, some workers[12] suggested a greater span of age should be considered appropriate when providing a BA estimation, especially for forensic aims. Thus, we used a greater span of ±6 months, which resulted in a correct classification of 40% in boys, 53.65% in girls, and 46.51% in both boys and girls.

The combination of different methods for estimating skeletal age and an age assessment resulting from the evaluation of skeletal development, along with other biological features, may assure more reliable evidence for accomplishing the legal demands of age estimation.

In a previous study of Turkish children performed by Ersoy,[13] significant differences were found between CA and BA for boys only between 11 and 17 years of age using the TW3 method. The author determined that the differences were between 0.57 and 0.97 years for girls (0.57 years only at 11 years of age) and that the overestimation was between 0.32 and 1.13 years for boys of all ages. The differences were not significant for both genders, except for girls at 15 years of age. In our study, the underestimation between CA and BA for boys was between 0.3 and 1 year, and the overestimation was between 0.3 and 1.7 years. In girls, underestimation was between 0.1 and 1.7 years, and overestimation was between 0.1 and 1 year.

Unlike our findings, Haiter-Neto et al.[14] determined that there was no statistically significant difference between CA and BA using the TW3 method for both sexes in Brazil.

The studies of Birkberk and Herbert[15] and Wenzel and Melsen[16] stated that for boys up to about age nine, there were no discrepancies by the TW3 method. After that age, BA became delayed compared with the TW3 standards. In our study, an underestimation of BA was observed in the 12–18-year age group.

The present study, which is the first TW3 study done in this region, has some limitations. First, this is a cross-sectional study of only the Meiteis, and therefore the sample size is small. Second, it only covers a specific range of the population in the Imphal area. These results may only apply to the urban area of Imphal. Third, age groups under 12 years old were excluded for both sexes. Finally, we could not ascertain the full health of the participants, although no remarkable history of any genetic syndrome or trauma was noted. Hence, in-depth studies of all the tribes of this region are essential to substantiate these findings.

Conclusion

The present study aimed to compare the CA and BA of ethnic Meiteis using the TW3 method to determine the reliability. Based on the results, we could draw the following conclusions: the TW3 method (a) is reliable for BAA in clinical practice with an RMS deviation of ±0.7Y = ±8 months, (b) has a lower rate of correct classification in boys (40%) than girls and is more matching for girls, (c) has a tendency to underestimate in both genders and thus, reading should be done as far as possible towards the higher side. Furthermore, predictions within six months (CA ± 6 months) are above 53.65% in girls and 40% in boys. This study demonstrated that the results of BAA using the TW3 method are reliable.

Acknowledgement

We are grateful to the Department of Radiodiagnosis, Regional Institute of Medical Sciences, Imphal for allowing the utilization of resources for taking radiographs of the study subjects.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The ethical clearance has been granted by the Institutional Ethics Committee.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Regional Institute of Medical sciences (RIMS) Golden Jubilee Research Initiative (Intramural project).

Informed Consent

The informed consent has been obtained from the participant for this study.

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Original Article

Descriptive Study of Fatal Head Injuries and Its Associated Factors Sustained in Road Traffic Accident Cases in Prayagraj

Journal of Indian Academy of Forensic Medicine
46(3) 336–340, 2024

DOI: 10.1177/0971097325131610 9
journals.sagepub.com/home/iaf
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Abstract

Fatal road traffic accidents (RTA) have emerged as a major public health problem in the modern era. The present study conducted over a period of one year besides focusing on the demographic and medical aspects of head injuries due to fatal RTA is unique in sketching a pattern of head injuries. Males contributed to the majority (84.77%) of RTA while only 92 out of 604 (15.23%) victims were females. The majority of the victims were two-wheeler occupants with a total number of 317 cases (52.48%) who are followed by four-wheeler occupants with a total number of 152 cases (25.17%). The fatal head injury occurred on main road 320 (52.98%) which includes National and State highways, followed by the turning of main road 158 (26.16%). Sixty-three (10.43%) cases out of 604 cases alcohol was a contributory factor for the fatal head injury due to RTA. Extra-cranial injuries and scalp abrasion 594 (98.34%) were found in the majority of fatal head injury cases. Scalp laceration, 563 (93.21%) out of 604 cases, was the second most common extra-cranial injury observed in our study. Subdural haemorrhage 367 (60.76%) is the most common intra-cranial haemorrhage observed in the present study followed by sub-arachnoid haemorrhage 248 (41.06%) and intra-cerebral haemorrhage 195 (32.28%). The least number of intra-cranial haemorrhages observed was brain stem haemorrhage, that is, 54 cases (8.94%) out of 604 cases.

Keywords

Haemorrhage, injury, RTA, fatal head injury

Received 03 May 2023; **accepted** 02 July 2023

Introduction

A road traffic accident (RTA) is defined as any collision on the road involving two or more items, at least one of which must be a moving vehicle. RTAs are an unavoidable aspect of modernity. According to the National Advisory of Neurological Diseases and Stroke Council, 'Head Injury' is a morbid condition arising from large or subtle structural abnormalities in the scalp, skull, and/or the contents of the skull, caused by mechanical forces. The most common cause of death in trauma-related fatalities is head damage. Accidents are considered to occur when there is a state of disequilibrium between man and his environment involving several causal agents. The vast majority of traffic accidents occur on roads, and they are regarded as the most significant issue of our century. It is important to note that when an accident happens in air or rail travel, a thorough investigation is conducted, but this is uncommon in the case of road accidents, even if the number of fatalities and injuries is far higher. On the autopsy table, a minor injury with a seemingly normal appearance may reveal itself as a catastrophic injury. To paraphrase, 'No brain injury is too little or terrible to be hopeless about'. The current research was undertaken with the aforementioned objective using medico-legal autopsies performed at the mortuary of Swaroop Rani Nehru Hospital, Department of Forensic Medicine and Toxicology, M.L.N. Medical College, Prayagraj, U.P.

Materials and Methods

All known fatal RTA cases among dead bodies were brought to the mortuary of Swaroop Rani Nehru Hospital, Prayagraj

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from 1st April 2021 to 31st March 2022. Cases for this study were selected from the dead bodies brought into the mortuary of the S.R.N Hospital; Moti Lal Nehru Medical College; Prayagraj for medico-legal postmortem examination; from the various police stations of Prayagraj district. A prospective study. All the cases for the present study will be selected from dead bodies brought to the mortuary of Swaroop Rani Nehru Hospital, Prayagraj for medico-legal autopsy examination, were included for the purpose of the study. Dead bodies were brought to the mortuary of Swaroop Rani Nehru Hospital, Prayagraj. All of these subject's attendants will be interviewed using a structured pre-designed questionnaire, and information regarding preliminary information and data will be sought on that proforma.

Inclusion Criteria

All RTA sustained fatal head injuries cases brought to the mortuary of Swaroop Rani Nehru Hospital, Prayagraj.

Exclusion Criteria

Cases other than RTA and crushed injuries were brought to the mortuary of Swaroop Rani Nehru Hospital, Prayagraj.

Results

Table 1 shows that males contributed to the majority (84.77%) of RTA while only 92 out of 604 (15.23%) victims were females. It also depicts that the age group of 21–30 years has suffered the highest number of deaths due to fatal head injuries due to RTA 180 (29.80%) followed by the age group of 31–40 years 146 (24.17%) cases. Analysis of the data from Table 2 reveals that the majority of the victims were two-wheeler occupants with a total number of 317 cases (52.48%) who are followed by four-wheeler occupants with a total number of 152 cases (25.17%). Three-wheeler occupants were the least victims of fatal head injury due to RTA with only 15 (2.48%) cases. As per Table 3, the majority of the accidents responsible for the fatal head injury occurred on main road 320 (52.98%) which includes National and State Highways, followed by turning of main road 158 (26.16%). The least number of accidents that contributed to fatal head injury occurred in junctions of main roads 5 (0.83%) and in junctions of the main road and lanes 3 (0.50%). Table 4 shows that in 63 (10.43%) cases out of 604 cases alcohol was a contributory factor for the fatal head injury due to RTA. It is observed from Table 5 that among the extra-cranial injuries, Scalp Abrasion 594 (98.34%) was found in majority of fatal head injury cases. Scalp laceration, 563 (93.21%) out of 604 cases, was the second most common extra-cranial Injury observed in our study. The least extra-cranial Injury noted in the present study was scalp contusion, that is, 463 cases (76.66%) out of 604 total cases. Table 6 shows that sub-dural haemorrhage 367 (60.76%) is the most common intra-cranial haemorrhage observed in the present study followed by sub-arachnoid haemorrhage 248 (41.06%) and intra-cerebral haemorrhage 195 (32.28%). The least number of intra-cranial haemorrhages observed was brain stem haemorrhage, that is, 54 cases (8.94%) out of 604 cases.

Discussion

In our study (Table 1), the incidence of sex of victims involved in RTA causing fatal head injuries is shown. Males outnumbered females by a very good margin. Males accounted for 84.77% (512 cases) of total fatalities. While for females, this figure was 15.23% (92 cases). Similar studies conducted in the United Kingdom - Kortor JN, et al.,[1] (64.50%), and Kumar A, et al.,[2] (88.22%), Kaul A, et al.,[3] (75.05%) also observed that a maximum number of victims were males which is similar to this study. Also, it was determined that the age group of 21–30 years had the largest number of fatal head injuries due to RTA (180, 29.80%), followed by the age group of 31–40 years (146, 24.17%). It demonstrates that the third decade,

Table 1. Distribution of Victims of Fatal Head Injuries Due to RTA Among Different Age Groups and Sex (*N* = 604).

Age Group (Years)	Male	Female	Total
0–10	7 (1.16%)	7 (1.16%)	14 (2.32%)
11–20	54 (8.94%)	9 (1.49%)	63 (10.43%)
21–30	153 (25.33%)	27 (4.47%)	180 (29.80%)
31–40	126 (20.86%)	20 (3.31%)	146 (24.17%)
41–50	89 (14.74%)	18 (2.98%)	107 (17.72%)
51–60	55 (9.11%)	5 (0.83%)	60 (9.93%)
>60	28 (4.64%)	6 (0.99%)	34 (5.63%)
Total	512 (84.77%)	92 (15.23%)	604 (100.00%)

Table 2. Type of Victims of Fatal Head Injuries Cases Due to Road Traffic Accidents (*N* = 604).

Type of Victim	No. of Cases	%
Pedestrians	51	8.44
Pedal cyclist	38	6.29
Two-wheeler occupants	317	52.48
Three-wheeler occupants	15	2.48
Four-wheeler occupants	152	25.17
Occupants of slow-moving vehicle like rickshaws, Tonga, bullock carts etc	31	5.13
Total	604	100.00

Table 3. Distribution of Fatal Head Injury Victims Due to Road Traffic Accidents on the Basis of Site of Accident (*N* = 604).

Site of Accident	No. of Cases	%
Main road	320	52.98
Lane	49	8.11
Turning off the main road	158	26.16
Turning of lane	69	11.42
Junction of main roads	5	0.83
Junction of main road and lanes	3	0.50
Total	604	100.00

along with the fourth, is the most susceptible age group for fatal head injury due to RTA.

According to the Ministry of Road Transport and Highways,[4] India's most exposed road users are walkers, bikers, and two-wheeler riders, who account for around 40% of all deaths. Analysis of data from our study (Table 2) shows that the majority of casualties were two-wheeler occupants with 317 instances (52, 48%), followed by four-wheeler occupants with 152 cases (25, 17%). With only 15 (2.48%) instances, three-wheeler riders were the least likely to get a fatal head injury as a result of a collision. Similarly, Mahender, G & S, Thamizharasan,[5] reported 57% of the victims of RTA were of two-wheelers.

In the present study (Table 3), the majority of the accidents responsible for fatal head injury occurred on main roads 320 (52.98%) which includes National and State Highways, followed by turning of main road 158 (26.16%). The least number of accidents that contributed to fatal head injury occurred in junctions of main roads 5 (0.83%) and in junctions of the main road and lanes 3 (0.50%). This finding is in correspondence with Kaul et al.[3] Similarly, Ranjan et al.,[6] also noted in their study that 83.05% of the Fatal RTA took place on highways. National highways have been constructed in rural regions in recent times as part of the national highway development programme. People living in this area are not yet adapted to such roads. Many times they are not repaired and fatalities happen on these roads, especially of farmers and pedestrians. Incidence of vehicular accidents on national highways was observed as 56.6%, Kaul A et al.[3] High speed, bad driving, and large vehicles like trucks and swiftly moving two-wheelers may be to blame for the high frequency of fatal head injuries that result from traffic accidents on roads in the Prayagraj area.

A common risk factor for RTAs is drunken driving. In a systematic review done by Das et al., 2012, 2%–33% of the injured and 6%–48% of killed RTA victims had consumed alcohol or drugs. In our study (Table 4), 63 (10.43%) cases out of 604 cases of alcohol were a contributory factor for the fatal head injury due to RTA. It is well proven that drinking impairs a driver's ability to operate a motor vehicle. Also, impairment increases as blood alcohol concentration rises. In addition, the risk of accidents is greater for younger and older drivers with the same blood alcohol concentrations (WHO, 2020).[7] Drunk driving is well acknowledged to be very risky. The more alcohol in a person's bloodstream, the more severe the consequences of intoxication and the greater the risk of accident. In the current study (Table 5), scalp abrasion 594 (98.34%) was present in the vast majority of instances of fatal head injury. Scalp laceration was the second most prevalent extra-cranial injury seen in our study, accounting for 563 (93.21%) of 604 cases. Scalp contusion, with 463 instances (76.66%) out of 604 total cases, was the least prevalent extra-cranial injury seen in this study. Similar to Ranjan et al.[6] it was observed that in 86% of instances, abrasions were seen, followed by lacerations in 75% of cases and contusions in 58% of cases. They also noted that abrasions constituted the

Table 4. Presence of Contributory Factor (Alcohol) in Fatal Head Injury Victims Due to Road Traffic Accidents (*N* = 604).

Contributory Factor: Alcohol	No. of Cases	%
Yes	63	10.43
No	541	89.57
Total	604	100.00

Table 5. Pattern of Distribution of Extra-cranial Injuries in Fatal Head Injury Cases Due to Road Traffic Accidents (*N* = 604).

Extra-cranial Injuries	Present	Absent	Total
Scalp abrasion	594 (98.34%)	10 (1.66%)	604
Scalp contusion	463 (76.66%)	141 (23.34%)	604
Scalp laceration	563 (93.21%)	41 (6.79%)	604

Table 6. Pattern of Distribution of Intra-cranial Haemorrhages in Fatal Head Injury Cases Due to Road Traffic Accidents (*N* = 604).

Intra-cranial haemorrhages	Present	Absent	Total
Extra-dural haemorrhage	112 (18.54%)	492 (81.46%)	604
Sub-dural haemorrhage	367 (60.76%)	237 (39.24%)	604
Sub-arachnoid haemorrhage	248 (41.06%)	356 (58.94%)	604
Intra-cerebral haemorrhage	195 (32.28%)	409 (67.72%)	604
Intra-ventricular haemorrhage	115 (19.04%)	489 (80.96%)	604
Brain stem haemorrhage	54 (8.94%)	550 (91.06%)	604

highest percentage (86%) of all injuries amongst motorbikes as the victim was dragged on the road in roadside accidents. The injuries were caused by significant blunt forces observed in hit-and-run instances, crush injuries caused by the collision of the car, and uneven road surfaces. In contrast to the findings of the present study Jha, Saurav et al.[8] reported, that in decreasing frequency, the scalp exhibited laceration, contusion, and abrasion at 59.7%, 27.3%, and 23.4%, respectively.

In our present study (Table 6), sub-arachnoid haemorrhage 248 (41.06%) and intra-cerebral haemorrhage 195 (32.28%) were the next most frequent types of intra-cranial haemorrhage reported in the present research, respectively. Intra-ventricular haemorrhage 115 (19.04%) and extra-dural haemorrhage 112 (18.54%) were seen in a number of instances that were practically the same. Brain stem haemorrhage was associated with the lowest number of intra-cranial haemorrhages, with 54 cases (8.94%) out of 604 cases. Similar results were noted in a study by Kumar et al.,[2] Menon et al.,[9] Das et al.[10] Tomar et al.,[11] in which they observed that sub-dural haemorrhage was the most common intra-cranial Haemorrhage in RTA followed by sub-arachnoid haemorrhage, intra-cerebral haemorrhage and least by extra-dural haemorrhage. Arulmathikannan et al.,[12] also had a similar observation, except that they observed that intra-ventricular haemorrhage was the third most common intra-cranial haemorrhage in RTAs. The findings of Sharma et al.[13] match our study as it shows that sub-dural haemorrhage and sub-arachnoid haemorrhages are the leading intra-cranial haemorrhage. However, it refutes our finding by showing a higher percentage of extra-dural haemorrhage than that of intra-cerebral haemorrhage. Modi et al.[14] observed that sub-dural haemorrhage was the most common intra-cranial haemorrhage as seen in our study, that study contrasts our study by showing extra-dural haemorrhage as the next mostly found intra-cranial haemorrhage whereas in our study the next most common intra-cranial haemorrhage was sub-arachnoid haemorrhage.

Conclusion

1. Road users should get this education since they are frequently injured in RTAs, making it urgently necessary.
2. To educate individuals on how to drive safely, we need an integrated curriculum. It is important to teach young children how to cross roadways and utilise sidewalks safely.
3. Road signs and bicycle safety should be taught to middle school students. High school students will study response times, defensive driving, and the perils of drinking.
4. To control traffic, the agencies in charge of issuing permits must enact stringent laws and regulations and invest in new technologies. Applicants should be required to undergo a first aid course before receiving a licence.
5. There is no doubt that implementing pedestrian-friendly routes, designating separate lanes for heavy and light

cars, and strictly enforcing traffic laws would help to reduce the number of traffic accidents and fatalities.
6. Automobile fatalities are an unavoidable scourge of modernisation. They are the cost of our quick travel between sites.
7. Newspapers and television in particular are more successful in educating the public.
8. This emphasises how important it is to strictly enforce the laws limiting the limitation of vehicle speeds.
9. To identify regional safety issues, the authorities and the local population should collaborate.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

Permission from the institutional ethical committee was obtained.

Informed Consent

Written informed consent was taken from blood relatives of the deceased after explaining the purpose and procedure of the study.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Original Article

Digital Photocopies and Laser Printouts: Examination and Identification

Journal of Indian Academy of Forensic Medicine
46(3) 341–348, 2024

DOI: 10.1177/09710973251316354
journals.sagepub.com/home/iaf
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Abstract

Color photocopiers and printers have rapidly gained popularity and accessibility, making them effective tools for altering or copying original documents. Such devices enable the safe and intelligent usage of color photocopies and printouts because of their high output, good resolution, automatic feed, and sorting capabilities. Examining these fake documents often presents difficulties for specialists because they seem just like authentic paperwork. Additionally, due to the similarity in how digital photocopiers and laser printers operate, papers created using such procedures have a similar appearance. To help a document expert identify forgeries created using such methods, this work tries to compile a list of physical features that can considerably distinguish between color digital photocopies and color LaserJet prints.

Keywords

Digital photocopy, laser printouts, alterations, variations, printed documents

Received 14 October 2023; **accepted** 25 February 2024

Introduction

Every document has information that can be altered to serve a malicious goal. With the development of digital technology, it is now simple to copy or edit a whole document.[1] Security papers could be used in illegal operations, including making counterfeit money,[2] counterfeit passports, ransom letters, terrorism, etc., with easy access to photocopiers and prints. People who utilize these technologies for illegal activities have benefited from the development of colored digital photocopiers and color printers, which offer good resolution and produce documents that resemble the originals.

As a result, there are many questions that document examiners must answer, like whether a particular document is the original or a copy. Which type of reproduction—a photocopy or a printout—is made? Color laser printers create patterns of yellow dots that are almost imperceptible to the human eye and can be used to identify the printer.[3] The unique dot pattern corresponds to a certain laser printer or photocopier's serial number.[4,5] Due to their identical operation modes, it may be difficult to discern between laser-printed and photocopied documents.[6,7]

This study examined colored digital photocopied documents and colored laser prints of documents based on their physical and instrumental analyses to identify any significant differences.

Materials and Methods

Sample Procurement

For the study, 30 photocopies and laser prints from 10 original security papers, including certificates, mark sheets, and letterheads, were gathered. The samples consist of 10 original documents printed in color on colored photocopies and colored laser prints. Black-and-white digital photocopies and laser printouts were also acquired to investigate the substantial alterations further. Printouts from a Canon device were used for all Xeroxing and printing. The factors examined included the samples' general appearance, UV features, watermark, text and background clarity, micro printing, and documentation size.

The study's primary goal was to identify characteristics that can meaningfully distinguish a photocopy from a Xerox. It also examined a feature called tracking dots, which are small yellow dots that appear randomly on the page and create a pattern. The size of these dots varies from printer to

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printer, and they are only visible in documents printed on laser printers. These dots link a printed page to a printer.

Analysis

The analysis was done by comparing digital photocopies and laser printouts with their respective original documents, based on different parameters and security features, including:

1. Dimensions of the document
2. Presence of watermark
3. Presence of security features
4. The appearance of the background
5. The sharpness of the seal
6. Clarity of the background writings
7. Color of the document
8. Microprinting
9. Margin design
10. Perforations along the side of the document
11. The color of the goldenseal and the sharpness of its edges
12. Dimensions of tracking dots
13. Blackening of paper

Statistics such as correlation, chi-square value, and *P* value were used to interpret the data quantitatively. To determine the usefulness of various characteristics and security measures in distinguishing between original papers, photocopied documents, and computer printouts, the significance of the data was tested at alpha = 0.05 and 0.01 levels.

Materials and Instruments used:

1. Scale
2. Stereomicroscope
3. VSC 40

Each color printout and photocopy was compared to its corresponding original document. The intricate details of the color photocopy and printout can be seen under a stereomicroscope.

Observations

There was a decline in the quality of printed materials, evidenced by the clarity of character edges, seal clarity, microprinting, margin design, and other factors (Figures 1–7). It is understood that none of the replicated documents will have visible security elements, such as watermarks or UV fluorescence (Figures 4 and 5). Tracking dots were also identified and measured to determine the printer that produced the document (Figures 8 and 9). The dimensions of the tracking dots varied for each printer.

One can observe that the quality of margin design, micro printing (Figures 1 and 2), and background design (Figure 3) shows more deterioration in the color printout than the color photocopied document. In color photocopied documents, the images and writings appear as a matrix of various small dots.

The quantitative interpretation of specific attributes was conducted based on statistical variables, including

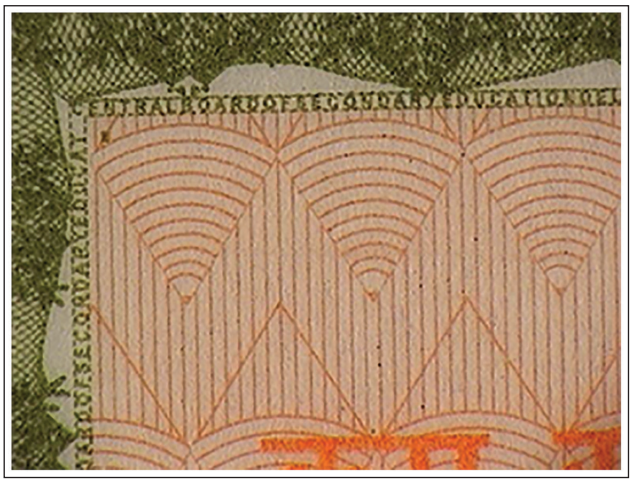

Figure 1. Margin Design and Microprinting in the Original Document.

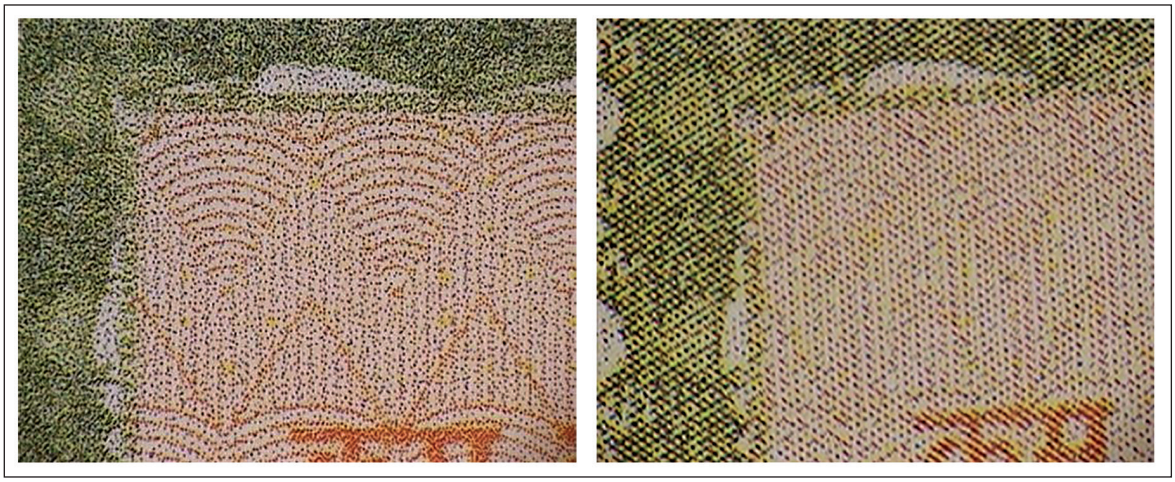

Figure 2. Margin Design and Microprinting: Slightly Visible in the Photocopied Document (Left), but in the Color Printout (Right), the Microprinting Appears Just Like Some Pattern of Lines.

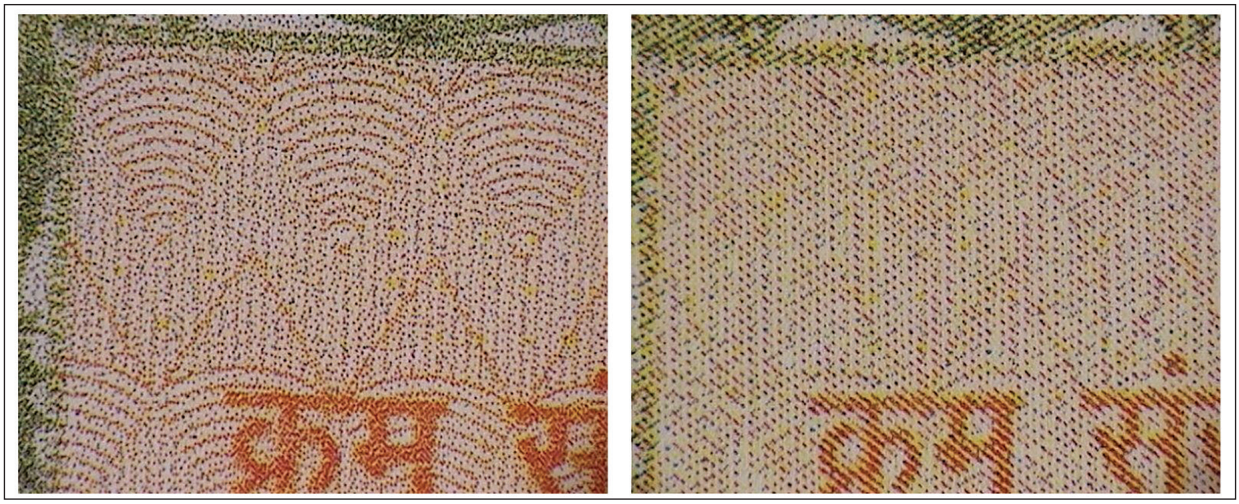

Figure 3. The Difference in Background Design and Writings Between Color Photocopied Document (Left) and Color Printout (Right).

Note: Writings appear proper with a matrix of dots on the left and appear as striations in the color printout.

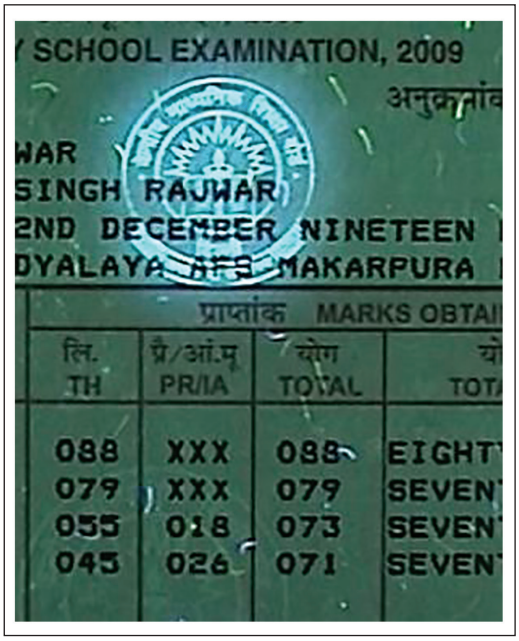

Figure 4. Presence of UV Features in Original Document.

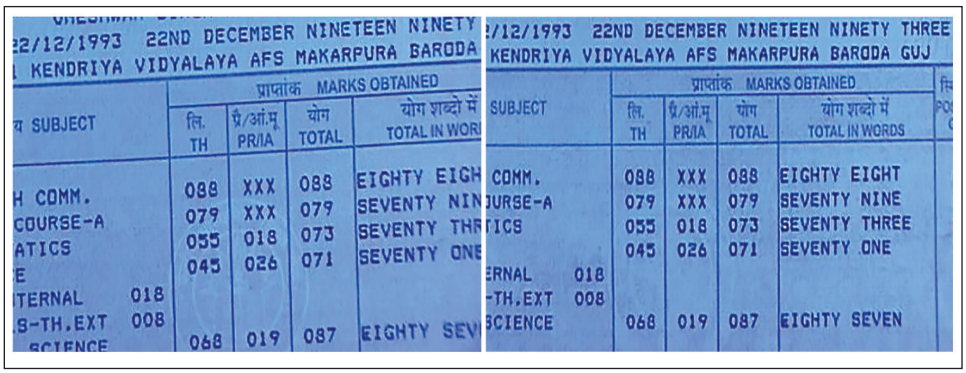

Figure 5. Absence of UV Features in Color Photocopied (Left) Document and Color Printout (Right).

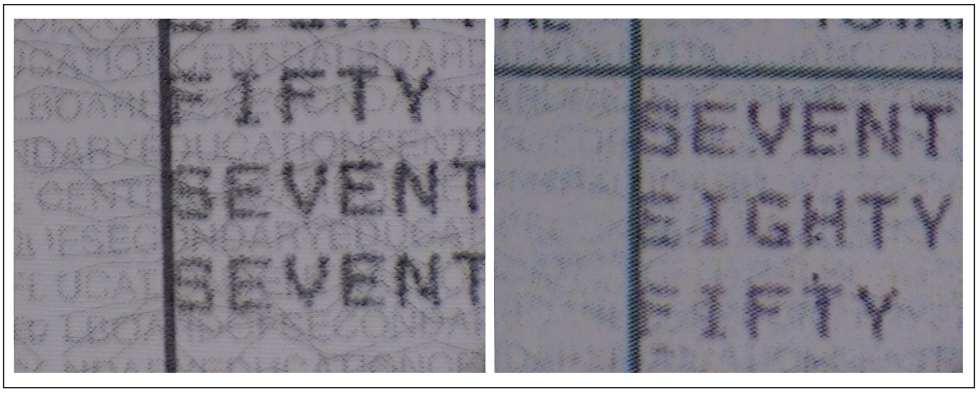

Figure 6. A Comparison of Background Appearance and Appearance of Text in Colored Digital Photocopy (Left) and Laser Printout (Right).
Note: In laser printout, the background may become slightly visible to absent.

Table 1. Descriptive Stats for Colored Digital Photocopy.

Characteristics	Correlation	Null Hypothesis (*H0*)	Alternate Hypothesis (*H1*)	χ^2	*P* Value	Conclusion
Background	0.98	Background does not show variation	Background shows variation	1.090	.579	Null hypothesis is accepted
Seal	0.99	Seal does not show a variation	Seal shows variation	1.111	.573	Null hypothesis is accepted
Watermark	−1	Presence of a watermark does not show a variation	Presence of a watermark shows a variation	7.777	.005	Null hypothesis is rejected
Background writings	0.88	Background writings do not show variation	Background writings show variation	2.4	.301	Null hypothesis is accepted
Color of the document	−1	Color of the document does not show a variation	Color of the document shows a variation	7.77	.005	Null hypothesis is rejected
Microprinting	−0.85	Microprinting does not show variation	Microprinting shows variation	8	.018	Null hypothesis is rejected
Security features	−1	Security features do not show variation	Security features show variation	5.6	.017	Null hypothesis is rejected
Latent image	1	Latent image does not show variation	Latent image shows variation	0	1	Null hypothesis is accepted
Margin design	0.91	Margin design does not show variation	Margin design shows variation	1.333	.513	Null hypothesis is accepted
Punching holes	1	Latent image does not show a variation	Latent image shows a variation	0	1	Null hypothesis is accepted
Color of golden seal	0.68	Color of the golden seal does not show a variation	Color of the golden seal shows a variation	4	.135	Null hypothesis is accepted
Edges of golden seal	0.68	Edges of the golden seal do not show variation	Edges of the golden seal show variation	4	.135	Null hypothesis is accepted

Table 2. Descriptive Stats for Colored Laser Printout.

Characteristics	Correlation	Null Hypothesis (*H0*)	Alternate Hypothesis (*H1*)	χ^2	*P* Value	Conclusion
Background	−0.84	Background does not show variation	Background shows variation	7.904	.019	Null hypothesis is rejected
Seal	0.99	Seal does not show a variation	Seal shows variation	1.111	.573	Null hypothesis is accepted
Watermark	−1	Presence of a watermark does not show a variation	Presence of a watermark shows a variation	7.777	.005	Null hypothesis is rejected
Background writings	0.88	Background writings do not show variation	Background writings show variation	11.333	.003	Null hypothesis is rejected
Color of the document	−1	Color of the document does not show a variation	Color of the document shows the variation	14	0.0001	Null hypothesis is rejected
Microprinting	−1	Microprinting does not show variation	Microprinting shows variation	5.6	.017	Null hypothesis is rejected
Security features	−1	Security features do not show variation	Security features show variation	5.6	.017	Null hypothesis is rejected
Latent image	0.68	Latent image does not show a variation	Latent image shows a variation	4	.135	Null hypothesis is accepted
Margin design	0.68	Margin design does not show variation	Margin design shows variation	0.684	.684	Null hypothesis is accepted
Punching holes	1	Latent image does not show a variation	Latent image shows a variation	1.4	.236	Null hypothesis is accepted
Color of golden seal	0.68	Color of the golden seal does not show a variation	Color of the golden seal shows a variation	4	.135	Null hypothesis is accepted
Edges of golden seal	0.68	Edges of the golden seal do not show variation	Edges of the golden seal show variation	4	.135	Null hypothesis is accepted

Table 3. Descriptive Stats for Black-and-white Digital Photocopy.

Characteristics	Correlation	Null Hypothesis (*H0*)	Alternate Hypothesis (*H1*)	χ^2	*P* Value	Conclusion
Background	−1	Background does not show variation	Background shows variation	6	.014	Null hypothesis is rejected
Seal	1	Seal does not show a variation	Seal shows variation	1.2	.273	Null hypothesis is accepted
Watermark	−1	Watermark does not show variation	Watermark shows variation	6	.014	Null hypothesis is rejected
Background writings	−1	Background writings do not show variation	Background writings show variation	6	.014	Null hypothesis is rejected
Color of the document	−1	Color of the document does not show a variation	Color of the document shows a variation	6	.014	Null hypothesis is rejected
Microprinting	−1	Microprinting does not show variation	Microprinting shows variation	3	.083	Null hypothesis is accepted
Security features	−1	Security features do not show variation	Security features show variation	3	.083	Null hypothesis is accepted
Margin design	0.5	Margin design does not show variation	Margin design shows variation	2	.367	Null hypothesis is accepted
Punching holes	1	Latent image does not show a variation	Latent image shows a variation	0	1	Null hypothesis is accepted
Color of golden seal	0.5	Color of the golden seal does not show a variation	Color of the golden seal shows a variation	2	.367	Null hypothesis is accepted

(Table 3. continued)

(Table 3. continued)

Characteristics	Correlation	Null Hypothesis (*H0*)	Alternate Hypothesis (*H1*)	χ^2	*P* Value	Conclusion
Edges of goldenseal	0.5	Edges of the golden seal do not show variation	Edges of the golden seal show variation	2	.367	Null hypothesis is accepted
Photograph	0.5	Photograph does not show a variation	Photograph shows variation	2	.367	Null hypothesis is accepted
Blackening paper of	1	Blackening of paper does not show variation	Blackening of paper shows variation	1.2	.273	Null hypothesis is accepted

Table 4. Descriptive Stats for Black-and-white Laser Printout.

Characteristics	Correlation	Null Hypothesis (*H0*)	Alternate Hypothesis (*H1*)	χ^2	*P* Value	Conclusion
Background	−0.866	Background does not show variation	Background shows variation	6	.049	Null hypothesis is rejected
Seal	−1	Seal does not show a variation	Seal shows variation	3	.083	Null hypothesis is accepted
Watermark	−1	Watermark does not show variation	Watermark shows variation	6	.014	Null hypothesis is rejected
Background writings	−0.866	Background writings do not show variation	Background writings show variation	6	.049	Null hypothesis is rejected
Color of the document	−1	Color of the document does not show a variation	Color of the document shows a variation	6	.014	Null hypothesis is rejected
Microprinting	−1	Microprinting does not show variation	Microprinting shows variation	3	.083	Null hypothesis is accepted
Security features	−1	Security features do not show variation	Security features show variation	3	.083	Null hypothesis is accepted
Margin design	0.5	Margin design does not show variation	Margin design shows variation	2	.367	Null hypothesis is accepted
Punching holes	1	Latent image does not show a variation	Latent image shows a variation	0	1	Null hypothesis is accepted
Color of golden seal	0.5	Color of the golden seal does not show a variation	Color of the golden seal shows a variation	2	.367	Null hypothesis is accepted
Edges golden seal of	0.5	Edges of the golden seal do not show variation	Edges of the golden seal show variation	2	.367	Null hypothesis is accepted
Photograph	1	Photograph does not show a variation	Photograph shows variation	0	1	Null hypothesis is accepted
Blackening of paper	1	Blackening of paper does not show variation	Blackening of paper shows variation	1.2	.273	Null hypothesis is accepted

correlation, chi-square values, and P values. The significance of the findings was examined at alpha levels of 0.05 and 0.01 to ascertain how well the selected attributes distinguished between colored laser and digital photocopies (Tables 1–4).

Results and Discussions

By studying and comparing samples of colored digital photocopies and colored laser printouts of the same document, it was discovered that these two types of documents differ and that specific characteristics can be utilized to tell a color digital photocopy from a color laser printout apart.

By examining security characteristics like watermarks and UV features like UV fluorescence and optical fibers, one may also readily tell the difference between an original document and a colored photocopy or colored reprint.

This investigation gathered 30 photocopies and laser prints of 10 original security documents and checked for details, including letterheads, mark sheets, and certifications. The samples consist of 10 original documents printed in color on colored photocopies and colored laser prints. Black-and-white

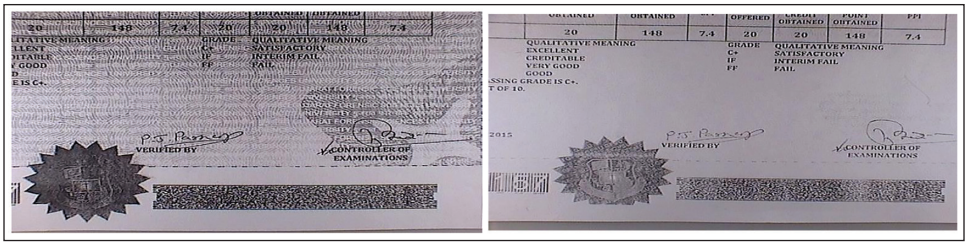

Figure 7. The appearance of seal, background, and blackening of paper in black and white digital photocopied (Left) and laser printout (right). Background writings which can be seen in photocopy are entirely absent in laser printout.

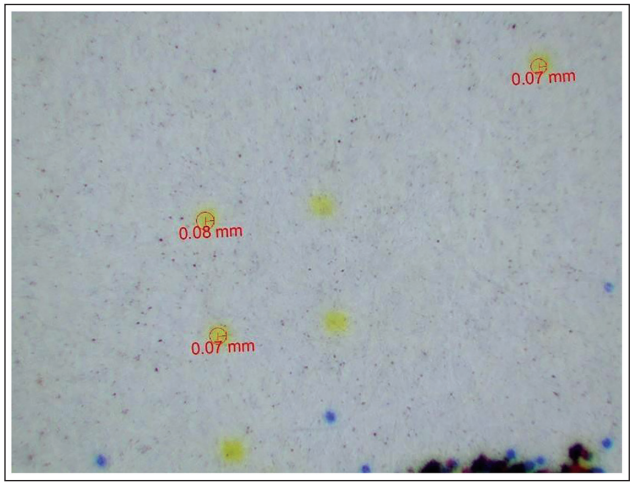

Figure 8. The Dimension of Tracking Dots in Samples Taken from Canon Printer Was Found to Be 0.07 ± 0.01 mm.

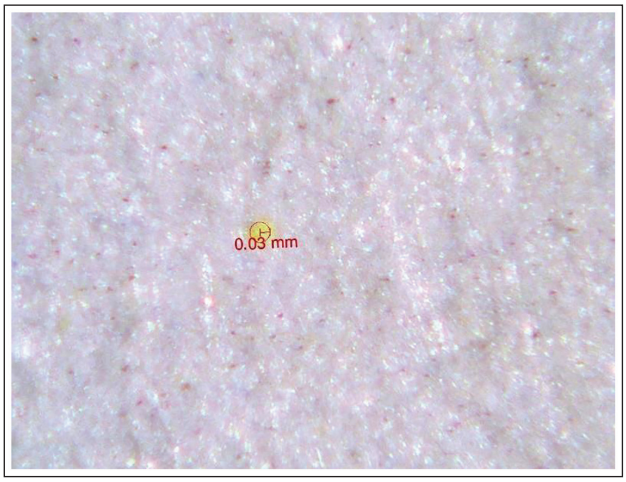

Figure 10. The Dimension of Tracking Dots in Komiko Printer Varies Ranges from 0.03 ± 0.01 mm.

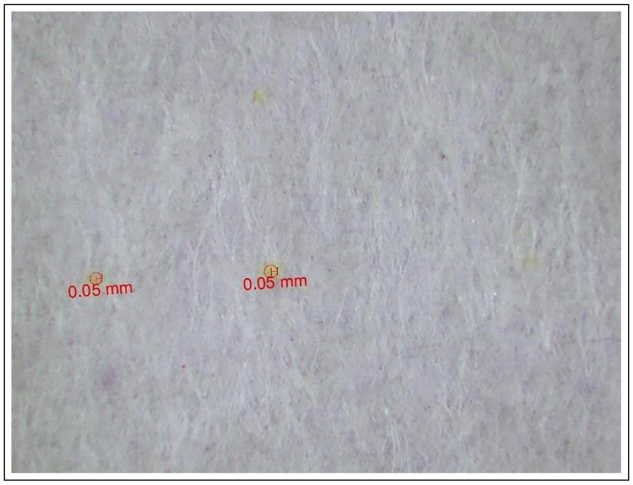

Figure 9. The Dimension of Tracking Dots in hp LaserJet Printer Comes out to Be 0.05, Which Can Vary till ± 0.01 mm.

digital photocopies and black-and-white laser printouts were also acquired to investigate the substantial alterations further. Whether the provided document is a colored photocopy or printout, the accuracy of the characters/features that can be utilized to identify the source of a reproduced colored document was tested at 0.05 and 0.01.

When photocopied documents and laser printouts were compared, it became clear that certain characteristics, including background clarity, margin design, written or printed text appearance, and microprinting, could be used to determine whether a given document was printed or photocopied.

The qualities indicated above, and the paper's blackening also apply to laser printouts and black-and-white digital photocopies. In digital black-and-white photocopies, excessive paper blackening and incorrect toner deposition can be seen. In contrast, toner deposition will be even, and blackening will be reduced in a laser printer (Figure 7).

Conclusions

We concluded that if the examiner follows the correct, well-designed methodology, he can successfully ascertain the origin of the produced documents, that is, whether it is a digital photocopy or laser printout. This is after examining samples of digital photocopied documents and laser printouts of various documents.

Even though every duplicate digital photocopy and laser printing may initially appear to be comparable to the layperson, if one looks closely, variances can be seen.

The quality of the colored digital photocopy is sharper and clearer than that of the laser printer. Even the written or printed language varies between both sorts of paper. However, the appearance of the background, clarity, margin design, and microprinting are the most noticeable modifications to the text.

When using a colored digital copier, the microprinting is clear, and the text is somewhat legible. Although it still looks like tiny oblique bars when printed with a laser, microprinting cannot be seen with a colored laser. In contrast to laser printing, where the toner particles do not appear to link effectively to make the proper contours of the design, margin design is more evident in colored digital printing.

The same is true of how the background appears in the text (as seen in Figure 10). Even though the background and text on a colored photocopy appear grainy, they are clearer and sharper than on a laser printout.

The same characteristics can be seen in digital photocopies and laser prints that are in black and white. The blackening of the paper, which is less than nonexistent in a laser printer and more substantial in a digital photocopy, is still another thing that can be observed. Additionally, tracking dots will only be seen under UV in papers created using a laser mechanism or in laser printing. The size of these dots varies between printers made by various manufacturers; therefore, each printer maker will have a unique specification for the dots.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

No ethical approval was required for this study as it involved analysis of the author's own documents.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Informed Consent

Informed consent was not applicable as the study did not involve any human participants.

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Estimation of Age Among Eastern Indian Population Based on Modified Cameriere's Method from Measurement of Area in Pelvic Radiographs

Journal of Indian Academy
of Forensic Medicine
46(3) 349–352, 2024

DOI: 10.1177/09710973251316356
journals.sagepub.com/home/iaf
Sage

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Abstract

Forensic estimation of biological age is essential as routine forensic practice, especially in cases of mass disaster, and illegal immigration to countries. Criminal, civil, and other legal cases claim determination of age. Modified Cameriere's approach applied to estimate sex on the German population showed quite low predictive value. Fifty-two pelvic radiographs of the eastern Indian population from both genders of age between 18 and 25 years were evaluated. The area of iliac crest radiographs was measured and a linear regression model was established. The model for male patients explained 25% of the total variance (R2 = 0.25 males); whereas, only 15% (R2 = 0.15) in females. The predictive value of this model was compared with others, and the cause of low statistical validity was explained. However, this is the first of its kind study conducted on the Asiatic population and needs to be replicated on a larger sample size.

Keywords

Forensic science, forensic anthropology, pelvic bone, age estimation

Received 22 May 2024; **accepted** 14 September 2024

Abbreviation

ICA: iliac crest area; IW: iliac wing.

Introduction

Forensic estimation of chronological age is essential for the purpose of human identification in case of mass disaster, or illegal immigration to countries. In criminal, civil and other cases of legal purpose determination of age threshold is a pre-requisite.[1]

Cameriere et al. introduced forensic age diagnostics between 2006 and 2009, by means of area measurements from the apposition of secondary dentine (dental radiographs) and ossification of carpal skeleton (wrist radiographs).[2–7] Thus biological age could be determined as a linear function of different ratios, for example, an area ratio of root pulp to tooth; and mineralized bone centers to carpal bones.[7]

Wittschieber et al. (2013) modified Cameriere's approach toward a different skeletal landmark, iliac crest apophysis (ICA).[7] Authors claimed that the said region due to its late completion of maturation during human development can be a good predictor for determination of chronological age.[7]

The aim of the present study was to investigate whether the modified Cameriere's approach can be applied in sex estimation from an area of pelvic radiographs on the East Indian population.

Materials and Method

One hundred twenty-seven pelvic radiographs of the eastern Indian population from both genders of age between 18 and

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25 years were evaluated. The radiographs were taken during an emergency diagnosis at Calcutta National Medical College, Kolkata between periods December 2021 and June 2022.

Pelvic radiographs were done in standard procedure, patient lying, anterior/posterior path of rays. Approximately 75 kV was used with a digital luminescence radiography system. Radiographs having projection artifacts, fractures, and superimposition of foreign material or with intestinal loops were excluded. Image evaluations were done at standard picture archiving with a communication system (PACS) workstation using software: GE Centricity RIS-I 4.2 plus.

Area Measurements

Analogically area ratios were determined consisting of the ICA and IW, in order to access degree of apophyseal iliac crest ossification. First, the iliac crest is identified. Subsequently, the ossification centers of ICA were defined by manual segmentation in order to obtain the area (in millimeters) of ICA.

Second, the area of IW was measured. The upper rim of the iliac bone was defined, beginning from the angular point of the lateral convexity of the iliac bone and ending at the medial point where the iliac wing projection crosses the sacral bone. Both points were connected to close the area, as semi-circular.

Finally, the ratio between the area of the iliac crest apophysis and the area of the iliac wing was calculated by linear regression equation.

Statistical Analyses

In order to find out the relation between age and ICA/IW ratio, linear regression models were calculated. Age was the dependent variable. Intra-class correlation coefficients were determined to evaluate inter and intra-observer reliability.

Results

Of 127 pelvic radiographs, the area of an ICA could be determined in 52 cases (30 males and 22 females) at least on one side. In 40 cases, projection artifacts, fractures and superimposition of foreign material or intestinal loops prevented area measurements. In 35 of the 127 cases, ICA was not assessable because it was not ossified yet, or it was already in the final stage of complete fusion with the iliac bone. No statistically significant differences were found between the right and left pelvic sides (P = .142). Hence, in the following paragraphs, only the right pelvic side is regarded.

The regression models, describing age as a linear function of percentage, yielded the following equations for the ICA/IW ratio:

Males: Age = 11.563+22.352× (ICA/IW) based on 30 cases;
Females: Age =15.632+14.963× (ICA/IW) based on 22 cases.

Table 1. Distribution of Cases and Statistical Analysis.

No. of Cases	52	R^2 Value	Standard Error of Estimate
Males	30	0.25	2.65
Females	22	0.15	2.96

Table 2. Summary of Correlation Coefficients and Statistical Significance.

Intra-class Coefficient	Inter-class Coefficient	*P* Value
0.856	0.825	P = .538

The model for male patients explained 25% of the total variance (R^2 = 0.25 males); whereas, only 15% (R^2 = 0.15) in females. The standard error of the estimate is 2.65 years in males and 2.96 years in females. Differences between males and females were not statistically significant (P = .538). Calculation of intra-class correlation coefficients revealed good agreements intra and inter-observer agreement (0.856 and 0.825, respectively). A summary of the results is shown in Tables 1 and 2.

Discussion

The present study is based on the area measurements following the method applied by Cameriere et al.[2,5] and modified for pelvic radiographs by Wittschieber et al. (2013),[7] the ratio of iliac crest apophysis and iliac wing to generate a linear regression equation.[7]

For males, only 25% of the total variance can be explained by the regression model. For females, it is only for 15%, which shows that the correlation between subjects' chronological age to the ratio of ICA/IW is very poor (R^2 = 0.25 in males; R^2 = 0.15 in females). The limiting aspect of this model for the eastern Indian population is practically not approachable for forensic diagnosis of age.

A similar study, by Wittschieber et al. (2013) on the German population; showed 38% (R^2 = 0.38) of total variance is explained by the model for male subjects, compared to only 20% (R^2 = 0.20) for females.[7] The standard error of estimate is 2.00 years in females, and 1.91 years in males. The study was conducted on pelvic radiographs (N = 102, males = 52, females = 50).[7]

Another study by Bartolini et al. (2018), showed a moderate correlation with age in young Italian adults (N = 497 pelvic radiographs; age groups 10 and 25 years), and the method may be applied as a supplementary tool for ≤14 years of age to complement its forensic requirements.[8]

Other studies conducted on apophyseal ossification of iliac crest to the forensic estimation of age, from radiographic examination show a wide spectrum of variation, low to moderate and up to par.[9–12] However, population-based further studies are claimed to ascertain the reproducibility of the method toward better forensic diagnosis.

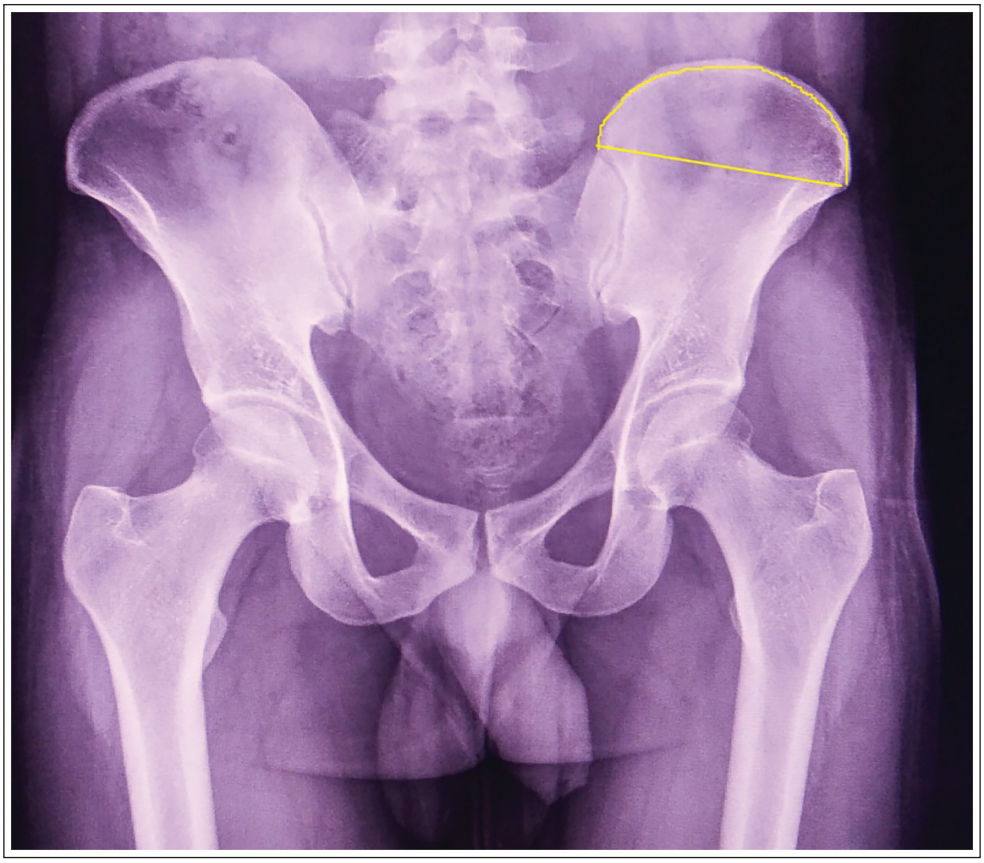

Figure 1. Showing the Area Measurements by Cameriere's Method in Pelvic Radiograph (Area Outlined with Yellow Color).

Conclusion

As seen from the study, of pelvic radiographs done by modified Cameriere's method for measurements of iliac crest area it was found that the predictive value in the Indian model was lower than the study done on German subjects by similar methods (Figure 1), but in either case the predictive value continued to be quite low which makes this difficult to be used as a single test in practical forensic investigation and practice. However, it can be used as an adjunctive technique to augment the results obtained by conventional methods. Therefore, we propose from this study that the method if used on larger samples in multicenter studies, can probably improve its chances of being considered as a standalone test which can be useful to forensic application. However, a certain degree of reservation has to be kept in mind while applying this test under present circumstances. This is the first study of its kind on the Asiatic population and thus is the first point of comparison with European counterparts which lends special significance to its conduct.

Author's Contribution

Soumeek Chowdhuri: Origin of concept, data analyses, editing of manuscript. Biswajit Sukul: Editing of manuscript. Debraj Acharya: Data collection. Somasish Ghosal: Literature survey, manuscript writing. All authors approved the final draft of the manuscript.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The study was conducted after taking ethics approval from Institutional Ethics Committee Calcutta National Medical College.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Original Article

Estimation of Stature as Odontometric Parameters Using Carrea Index of Bataknese Students in Universitas Sumatera Utara

Journal of Indian Academy
of Forensic Medicine
46(3) 353–358, 2024

DOI: 10.1177/09710973251316347
journals.sagepub.com/home/iaf
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Abstract

Identification of disaster victims becomes difficult to perform if only certain body parts of the dead are found. Some certain circumstances where the skulls or jaws are the only part left, odontometric examination is carried out to help the identification process. Teeth can be an option to identify individuals, since no one is similar by their tooth. Moreover, it is also one of the hardest tissues of our body allowing its resistance from damage. The aim of this study is to determine the percentage of success in estimating body height (BH) in odontometric measurement using the Carrea index for Bataknese students aged 18–25 years. Thirty males and 30 females were selected and their BH was assessed using a staturemeter. The estimated height was obtained by measuring the teeth on the model using a digital caliper according to the stipulation of the Carrea index. The average height and estimated height of males were significantly higher than females. Estimation between right and left height for each sex did not show a significant difference. The percentage of success in estimating height using the Carrea index for males (66.7%) was higher than for females (63.3%), but the result showed no significant difference ($P > .05$). The correlation between height and estimated height was analysed using the Pearson Correlation test exhibiting a moderate correlation (r = 0.430–0.459). It concludes that the percentage of success using Carrea index in this study showed a good correlation to estimate height for both males and females in the Bataknese.

Keywords

Body height, teeth, odontometry, ethnicity

Received 29 August 2023; **accepted** 18 February 2024

Introduction

Forensic identification aims to assist investigators in determining the unknown victims that need to be identified.[1] Identification of victims becomes less difficult to do if they can be identified physically or even if their fingerprints can be probably performed. In cases of natural disasters such as tsunamis, volcanic eruptions, and non-natural disasters, such as transportation accidents, industrial accidents, mutilations, bomb explosions, and other cases where only the remains of the victims are found, the identification process becomes more complicated.[2]

In the condition, where the body remains only the head and oral cavity, odontometric examination is one of the options. Height measurement is an important parameter for determining a person's identity since this data is comparable to their antemortem data helping to simplify the identification process.3–5most often the personal identity of the deceased is a mystery. The stature, sex and other parameters in such scenarios are ascertained using the physical evidence present at the crime scene. One of the key methods of ascertaining the sex and stature is by using the human bones. The method of achieving accuracy in estimation of stature from bones has been well established in past. There are several regression formulae for conducting such estimation. However, it must be kept in mind that these regression equations can vary depending upon the population and region. Thus, it is very necessary to study a particular population thoroughly before formulating regression equations for that specific population patch. In this paper, we have penned down the study of KORI POPULATION, who are native to Kanpur region of Uttar Pradesh state, in India. In this study, we have observed the statistics of 202 individuals (106 females and 96 males

Teeth can be considered as a means of identification since there is no exact same condition of teeth between one individual and the other in the oral cavity. In addition, the tooth is

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the hardest tissue preventing it from damage.[6,7] the dentition has seldom been applied. The present study has ventured to ascertain the usefulness of tooth crown measurements in stature prediction. Buccolingual and mesiodistal dimensions of all teeth (except third molars The odontometric parameter used to estimate height is the measurement of the mesiodistal dimension of the six maxillary anterior teeth. There was a positive correlation between the six maxillary anterior teeth and height, while the highest correlation was shown by the canines, and the regression equation was obtained. However, these equations vary depending on the population or ethnicity of the subject studied so they can only be applied to the same specific population.[8]

Some researchers selected a method with a formula called the Carrea index by measuring the mandibular anterior teeth. Several studies have been conducted to estimate height using this formula. It is easier to apply in different populations.[9,10]

Ethnic diversity affects the dimensions of the teeth.[11] The Bataknese is the largest group in North Sumatera. However, no study has been conducted on the estimation of height using the Carrea index in this ethnicity.[12] Therefore, the aim of the study was to estimate the height using the Carrea index on Bataknese students at Universitas Sumatera Utara.

Materials and Method

This research was a descriptive–analytic study with a cross-sectional design. Sixty Bataknese students from Universitas Sumatera Utara were used in the study, which consisted of 30 males and 30 females obtained by purposive sampling.

Inclusion Criteria

Two generations of Bataknese males and females, aged 18–25 years, with complete mandibular anterior teeth without any abnormalities. The subjects were also willing to become research subjects.

Exclusion Criteria

Teeth with caries or filling affecting mesiodistal dimensions, mobility, attrition on the surface, undergone orthodontic treatment, and growth abnormalities such as gigantism or dwarfism were excluded from the study.

Methodology

After the subject received an explanation and signed an informed consent, the height was measured using a stature meter. Body height (BH) was measured from the heels to the top of the head in an upright standing position, the Frankfort plane parallel to the floor, the shoulders relaxed, the arms at the sides of the body, and the feet flat on the floor. The position of the head, back of the shoulders, arms, buttocks and heels against the wall where the stature meter was installed.

Next, the mandibular anterior teeth were cast using alginate and filled immediately with a dental stone. After hardening and obtaining a mandibular teeth cast model, measurements were taken using a digital caliper, consisting of:

1. *Arch*: sum of each mesiodistal width of teeth I1, I2, and C on one side of the mandible from the labial direction.
2. *Chord*: measure the distance from mesial I1 to distal C in the lingual direction.

The measurement results were calculated using the Carrea index to determine the estimated minimum and maximum height. The calculation results were obtained in millimeters and then converted into centimeters.

Carrea Index Formula[10]

$$\text{Max BH} = \frac{arch\ (\text{mm}) \times 6 \times 3{,}1416 \times 100}{2}$$

$$\text{Min BH} = \frac{cord\ (\text{mm}) \times 6 \times 3{,}1416 \times 100}{2}$$

Estimated minimum and maximum height obtained based on the Carrea index, then compared with the actual sample height, with the following requirements:

1. Successful estimation: If the sample's actual height was within the range of estimated minimum and maximum height
2. Unsuccessful estimation: If the sample's actual height was not within the range of estimated minimum and maximum height

Data were analysed using the SPSS 20.0 program, consisting of an independent t-test to analyse the difference in average height and the difference in average estimated height between males and females, one way ANOVA test to analyse the difference in average estimation of height using the Carrea index between the right and left sides of the mandible for each sex, Chi-square test to determine the percentage of success of estimating height using the Carrea index between males and females, and Pearson Correlation test, to analyse the correlation between height and estimated height using the Carrea index.

Results

Table 1 shows the average and standard deviation of height between males and females in the Bataknese. Males have an average height higher than females. Males height (169.41 ± 5.38 cm) and females height (158.93 ± 4.44 cm) were analysed using the independent t-test showing that there was a significant difference with a P value = .000 ($P < .05$).

Table 2 shows the mean and standard deviation of estimated height, namely the maximum and minimum heights on

Table 1. Difference of Average Height Between Males and Females in Bataknese.

Measurement	N	Height: $\bar{x}$ ± SD (cm)	P
Males	30	169.41 ± 5.38	.000*
Females	30	158.93 ± 4.44	

Note: Independent *t*-test, *significant $P < .05$.

Table 2. Difference of Average Height Estimation Using the Carrea Index Between Right and Left Sides of Mandible for Each Sex in Bataknese.

Measurement		Males $\bar{x}$ ± SD (cm)		P	Females $\bar{x}$ ± SD (cm)		P
		Right	Left		Right	Left	
Carrea index	Max height	171.17 ± 6.37	171.92 ± 6.52	.651	166.55 ± 6.48	167.82 ± 6.64	.455
	Min height	163.44 ± 7.39	163.49 ± 6.02	.979	157.70 ± 7.70	159.18 ± 7.70	.460

Note: One-way ANOVA test, *significant $P < .05$.

the right and left sides of the mandible in males and females. The maximum height of the right males (171.17 ± 6.37 cm) was lower than the maximum height of the left males (171.92 ± 6.52 cm), but there was no significant difference with a $P = .651$ ($P > .05$). Likewise, the minimum height of the right males (163.44 ± 7.39 cm) is lower than the minimum height of the left males (163.49 ± 6.02 cm), but there was no significant difference with the $P = .979$ ($P > .05$). The maximum height on the right of the females (166.55 ± 6.48 cm) was lower than the maximum height on the left of the females (167.82 ± 6.64 cm), but there was no significant difference with a $P = .455$ ($P > .05$). Likewise, the right minimum height of females (157.70 ± 7.70 cm) is lower than the left minimum height of females (159.18 ± 7.70 cm), but there is no significant difference with a $P = .460$ ($P > .05$).

Table 3 shows the mean and standard deviation of estimated height, namely the maximum and minimum heights for males and females. The maximum height for males (171.54 ± 6.33 cm) is higher than the maximum height for females (167.19 ± 6.52 cm), analysed with the independent T-test showing that there is a significant difference with the $P = .011$ ($P < .05$). Likewise, the minimum height for males (163.47 ± 6.32 cm) is also higher than the minimum height for females (158.44 ± 7.67 cm), analysed by independent T-test showing that there is a significant difference with a $P = .007$ ($P < .05$).

Table 4 shows the distribution of success and unsuccess in estimating height between males and females in the Bataknese. Of the 30 male subjects, 20 subjects (66.7%) showed success, while 10 subjects (33.3%) showed no success. From a total of 30 female subjects, 19 subjects (63.3%) showed success, while 11 subjects (36.7%) showed unsuccess. Based on this, it can be seen that the percentage of success in estimating height for males is higher than for females, but there is no significant difference ($P = 1.000$). Of the total successful subjects 39 subjects (65%), while 21 subjects (35%) were unsuccessful.

Table 5 shows the results of the correlation analysis or correlation between height and estimated height, namely the maximum height and minimum height obtained using the Carrea index on the right and left sides of the mandible in the Bataknese. There is a significant correlation between height and right maximum height with a $P = .000$ and a correlation coefficient of r = 0.459. There is a significant correlation between height and minimum right height with a $P = .000$ and a correlation coefficient of r = 0.441. Likewise, there is a significant correlation between height and left maximum height with a $P = .000$ and a correlation coefficient of r = 0.441, while on the left minimum height, there is a significant correlation with height with a $P = .001$ and a correlation coefficient of r = 0.430. According to Colton, the strength of the correlation between the two variables can be divided into four areas, namely r = 0.00–0.25 indicating no correlation/weak correlation; r = 0.26–0.50 indicates a moderate correlation; r = 0.51–0.75 indicates a strong correlation; and r = 0.76–1.00 indicates a very strong correlation.13 Therefore, the four estimation variables for height, namely right maximum height, right minimum height, left maximum height, and left minimum height show a moderate correlation for height.

Discussion

In this study, the average male height was 169.41 ± 5.38 cm, while the average female height was 158.93 ± 4.44 cm. There is a difference in the average height of 10.48 cm between the males and females who were sampled in this study. The results of the study were analysed using an independent t-test showing that there was a significant difference in average height between males and females ($P < .05$). The current study corresponds to other studies by Rekhi et al. and Putri et al. that found the average height of males is higher than females.[9,10]

Table 3. Difference of Average Height Estimation Using the Carrea Index Between Males and Females in Bataknese.

Measurement	N	Maximum height (cm)	P	Minimum height (cm)	P
Males	30	171.54 ± 6.33	.011*	163.47 ± 6.32	.007*
Females	30	167.19 ± 6.52		158.44 ± 7.67	

Note: Independent *t*-test, *significant $P < .05$.

Table 4. Successful Distribution of Height Estimation Using the Carrea Index Between Males and females in Bataknese.

	Success		Unsuccess		Total	
Prediction	N	%	N	%	N	%
Males	20	66.7	10	33.3	30	50
Females	19	63.3	11	36.7	30	50
Total	39	65	21	35	60	100
P			1.000			

Note: Chi-square test, *significant $P < .05$.

Table 5. Correlation Between Height and Estimated Height Using the Carrea Index in Bataknese.

Height	Pearson correlation	Right maximum height	Right minimum height	Left maximum height	Left minimum height
		0.459	0.441	0.441	0.430
	P	0.000*	0.000*	0.000*	0.001*
	N	60	60	60	60

Note: Pearson Correlation test, *significant $P < .05$.

In general, males tend to be taller than females. Height growth is followed by a distinctive pattern called the growth spurt phase. Males have a faster growth rate at around the age of 12–14 years than females.[14] Furthermore, the closure of the growth plate in females occurs at the age of 16, while in males it occurs around the age of 18.[15,16]

An individual height is also influenced by sex chromosomes. In normal circumstances, the Y chromosome affects height more than X chromosome due to the presence of a gene called CYP19 on the Y chromosome. This gene has an influence on the development of the androgen hormone involved in determining male height.[17]

In this study, the maximum and minimum mean values of heights between the right and left sides of the mandible in males and females showed no significant difference ($P > .05$). Other studies also showed no significant difference.[10]

There is no significant difference in tooth dimensions between the right and left sides. Basically, the human body has a symmetrical appearance, but when measurements were taken on a large number of corpses or living subjects, it exhibited that the two parts of the human body are asymmetrical.[18] However, the assessment of both sides of the teeth showed the distinction in size, although not statistically significant.[19,20]

In this study, males had higher maximum and minimum heights than females, analysed by one-way ANOVA showed that there was a significant difference ($P < .05$). This is also in accordance with the study conducted by Sruthi et al. which has also shown higher maximum and minimum height for males than females.[21]

Our study indicates that males have larger tooth dimensions or sizes than females, which can be attributed to differences in the sex chromosomes of the two. The Y chromosome influences the formation of enamel and dentin, whereas the influence of the X chromosome on tooth growth appears to be limited to the formation of enamel. This difference in the influence of the X and Y chromosomes may explain why males tend to have larger teeth than females.[22]

In this study, the percentage of success in estimating height in males was higher than in females, but there was no significant difference ($p > .005$). It correlates with other studies showing the percentage of success for males (94.03%) is higher than for females (87.5%).[9] Sruthi et al. also found that the percentage of success for males (81.8%) was higher than for females (73.1%).[21] Similarly, a study in a Brazilian population demonstrated a higher percentage of success for males (81.3%) than females (76.0%).[23]

This difference in the percentage of success can be caused by differences in the number of subjects and races that were used as research subjects. In previous studies, the number of subjects studied was more than in this study, so the more subjects the higher the percentage of success. Even though there was a difference in the percentage of success with previous studies, overall there was no significant difference ($P > .05$)

so it can be concluded that the Carrea index method can be used for both males and females.

The correlation between height and estimated height was analysed using the Pearson Correlation test (Table 5) showing a positive correlation and moderate strength of the correlation. The *P* value between height and maximum right height, right minimum height, left maximum height, and left minimum height indicated that these four variables had a significant correlation with height ($P < .05$). Another study also reported a moderate strength with r-values ranging from 0.409 to 0.455 and $P < .05$.[10] Sruthi et al. found a strong correlation between height and right and left maximum height with r-values of 0.880 and 0.847 and moderate strength of correlation between height and right and left minimum height with r-values of 0.457 and 0.444 and $P < .05$.[21]

A positive correlation indicates a correlation between height and teeth dimensions, where the taller a person indicates the greater the teeth dimensions. Theoretically, the correlation between height and teeth may be seen based on the similarity of the process of formation or embryology between teeth and long bones.[6] The dentin layer which forms the bulk of the teeth and determines the dimensions of the tooth, originates from the ectomesenchymal layer, while the long bones, which are most often used in measuring height, originate from the mesodermal, these two tissue layers are basically mesenchymal tissue (connective tissue) which have in common in structural composition, namely the organic matrix formed from collagen and the inorganic matrix formed from hydroxyapatite crystals. Although teeth and long bones are both derived from mesenchymal tissue, there are differences in the timing of completion of their growth. This is what might make the dimensions of the dental crown only have a moderate correlation with height.[24,25]

Conclusion

Our study demonstrated that the height and estimated height of males and females showed a significant difference, although the estimated height between the right and left sides did not have a significant difference. In addition, the height and estimated height demonstrated a significant correlation and moderate correlation strength (r = 0.430–0.459). It indicates that the Carrea index can be applied in estimating the height to determine the body's stature for optometry purposes. Further study is required relating to odontometric height estimation using the Carrea index in other ethnic and investigation in a larger population.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The study was approved by Institutional Ethics and Research Committee.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

An informed Consent has been obtained from the subject.

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Original Article

Estimation of Stature from Percutaneous Length of Ulna in Living Indigenous Meiteis (An Ethnic Group in North East India)

Journal of Indian Academy of Forensic Medicine
46(3) 359–364, 2024

DOI: 10.1177/09710973251316359
journals.sagepub.com/home/iaf
Sage

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Abstract

Stature estimation has an important role in establishing the personal identity of unknown human remains. Establishing the identity of an individual from mutilated, decomposed and amputated body fragments is a challenging task. Various body parts may be used for the estimation of stature. In forensic practice, when mutilated remains are brought for examination, stature estimation is important for identification purposes. In the present study on 110 indigenous Meitei subjects, the percutaneous length of the ulna was studied to correlate with the stature. A positive correlation was observed between stature and percutaneous length of the ulna, and there was no statistically significant difference between the right and left ulna. The correlation coefficient (*r*) for both sexes together is 0.7335 and the regression equation is Y = 65.42911 + 3.773632X with a *P* value of <.001. For males, the r is 0.5814 and the regression equation is Y = 110.262 + 2.206518X with a *P* < .01. For females, the r is 0.3143 and the regression equation is Y = 123.8984 + 1.338234X with a *P* < .01. The simple linear regression equations derived from the study may be used for the estimation of height from the ulna in forensic practice in this part of the world, especially in mutilated remains.

Keywords

Indigenous Meitei, ulna, percutaneous length, mutilated remains, stature, regression equation

Received 01 January 2024; **accepted** 14 May 2024

Introduction

Stature is a basic and interesting aspect of a person's identity. While everyone appreciates a tall stature, history does not lack short-statured personalities who are actually very famous. Napoleon Bonaparte and Charlie Chaplin are striking examples. It also has an important role in establishing the personal identity of unknown human remains.[1] Measurement of the height or stature of a living, walking individual is easy. However, in decomposed and mutilated remains and even in frail and debilitated bedridden patients, determination of stature becomes a challenging task. Establishing the identity of an individual from mutilated, decomposed and amputated body fragments has become important in recent times, due to natural disasters (such as landslides, earthquakes, cyclones and floods) and man-made disasters (such as riot deaths, ethnic clashes, acts of terrorism, bomb blasts, wars, etc.)

Different equations for estimation stature have been established for Whites and Blacks, and males and females. The equations that were derived by Trotter and Gleser in the early 1950s for Americans were being continuously revised using data from different sources.[2]

Pearson estimated the stature from long bones by formulating regression equations. He also found that these formulae are population-specific and should not be applied to individuals of different population groups. Therefore, regression

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formulae need to be formulated for each specific population.[3] The present study has been designed to formulate a regression formula for the indigenous Meitei population (an ethnic group in North East India) to establish stature from the percutaneous length of the ulna.

Materials and Methods

The present study was a cross-sectional study done on a sample of 110 indigenous Meitei subjects (an indigenous Meitei is one who is preceding three generations both on the mother's and father's sides are Meiteis) with the age group of 21–25 years. The study was conducted in the Forensic Medicine & Toxicology Department of a tertiary care teaching institute in Northeast India. The subjects included students of the institute and subjects brought to the Department of Forensic Medicine and Toxicology for medico-legal works. A standard stadiometer was used for measuring the height, and a pair of spreading callipers for measuring the percutaneous length of the ulna.

Considering a dropout rate of 5%, a total of 55 males and 55 females, aged 21–25 years were studied, based on a previous study.[4]

The sample size is calculated from the following equation:

Total Sample size (n) = $[(Z_\alpha + Z_\beta)/c]^2 + 3$, therefore ($n$) equals to 50.

$Z_\alpha = 1.960$ (95% confidence level)
$Z_\beta = 1.282$ (90% power)
$c = 0.5 \times \log [(1 + r)/(1 - r)]$ equals to 0.4722
$r = 0.44$ (from the study done by Pandey A et al.[4])

Written informed consent was obtained from each study participant.

The standing height (stature) of the subject was measured in standing position, without shoes, on a standard stadiometer with both feet in close contact with each other with the trunk straight along the vertical board, and the head adjusted in Frankfurt-Horizontal plane (eye-ear plane). The measurement was taken in centimetres by bringing the horizontal sliding bar to the vertex.

For measuring the percutaneous ulnar length (PCUL) of the right ulna, the study subject was asked to place the elbow in flexion and the palm spread over the opposite shoulder to relax the soft tissues and make the bony landmarks prominent. Then, two points were marked by a skin-marking pencil. The apex of the olecranon was marked as the upper point and the distal point of the styloid process as the lower point and the distance between them was measured with the help of spreading callipers to determine the PCUL. All the measurements were taken by the same investigator with the same instrument to avoid any technical and/or inter-observer error and to maintain reproducibility. The measurements were taken at a fixed time (between 12:00 and 14:00) to avoid diurnal variation.

Data entry was done using Windows-based SPSS version 21.0 (Armonk NY: IBM Corp). Descriptive statistics, including the mean, standard deviation, minimum, maximum, percentage and frequency, were calculated. Analysis of differences in stature and ulnar length between male and female subjects was done by unpaired t-test. Karl Pearson's correlation coefficients (r) were derived between ulnar length and stature, and standard error (SE) and coefficient of determination (R^2) were calculated. Single linear regressions were derived to estimate stature from the ulnar length. A P value of .05 or less was considered significant. The data obtained was compared with other similar studies.

Results

Altogether, 55 male and 55 female ethnic Meitei subjects in the age group of 21–25 years were studied. The observations are analysed separately for both right and left ulna in each sex, on all subjects and results are tabulated.

Table 1(A) and Figure 1 show the mean height and ulnar length for both sexes. The mean height is 157.4230 cm with a standard deviation of ±4.3671 cm. The mean length of the right ulna is 25.0533 cm with a standard deviation of ±1.0914 cm. The mean length of the left ulna is 25.0513 cm with a standard deviation of ±1.0255 cm. The mean height of males is 169.8100 cm with a standard deviation of ±4.7530 cm and the mean length of the right ulna is 26.9993 cm with a standard deviation of ±1.2327 and the length of the left ulna is 26.9873 with a standard deviation of ±1.2523 cm (Table 1(B) and Figure 2). The mean height of females is 157.4230 cm with a standard deviation of ±4.3671 cm and the mean length of the right ulna is 25.0533 cm with a standard deviation of ±1.0914 and the left

Table 1. Showing the Mean and SD for All the Parameters.

A. Both Sexes Together		
Parameters (cm)	**Mean**	**SD**
Height	157.4230	4.3671
Length of ulna (right)	25.0533	1.0914
Length of ulna (left)	25.0513	1.0255
B. Male Cases		
Parameters (cm)	**Mean**	**SD**
Height	169.8100	4.7530
Length of ulna (right)	26.9993	1.2327
Length of ulna (left)	26.9873	1.2523
C. Female Cases		
Parameters (cm)	**Mean**	**SD**
Height	157.4230	4.3671
Length of ulna (right)	25.0533	1.0914
Length of ulna (left)	25.0513	1.0255

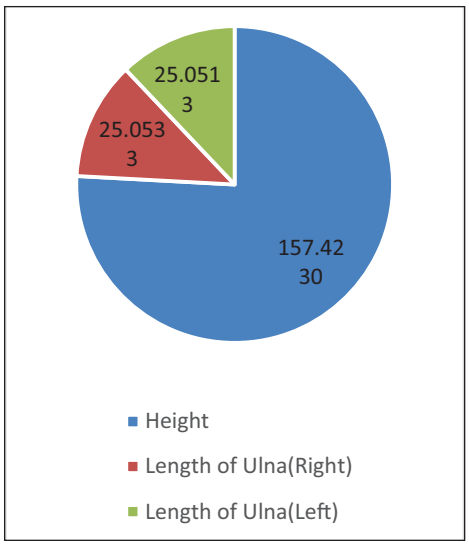

Figure 1. Showing Mean Height and Lengths of Right and Left Ulna for Both Sexes Together.

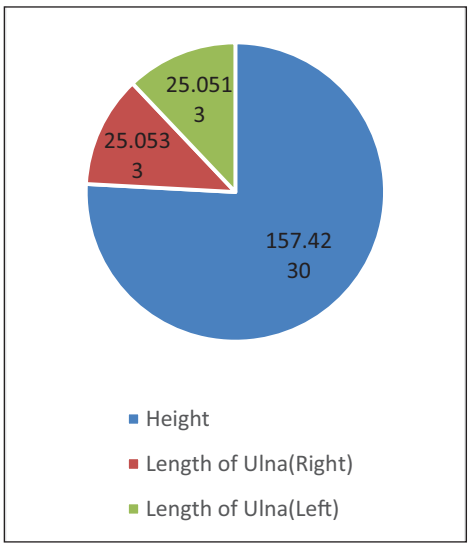

Figure 3. Showing Mean Height and Lengths of Right and Left Ulna for Females.

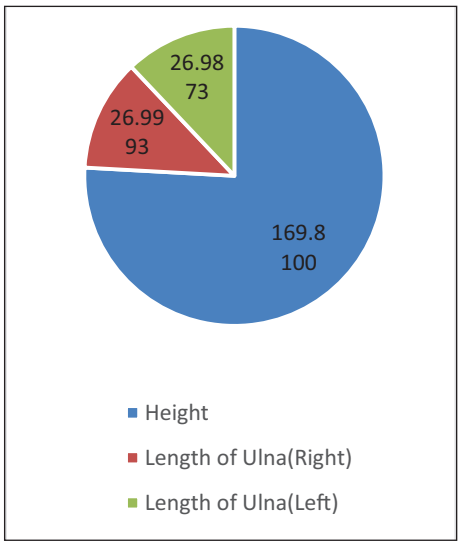

Figure 2. Showing Mean Height and Lengths of Right and Left Ulna for Males.

ulna is 25.0513 with a standard deviation of ±1.0255 cm (Table 1(C) and Figure 3).

Table 2 shows the comparison of the length of the right and left ulna. The *P* value for both sexes together is 0.9738, for males, it is 0.9616 and for females, it is 0.9925. Since $P > .05$, it was found that the difference in length of the right and left ulna is statistically insignificant in males, females and both sexes together. For further statistical analysis, the length of the left ulna was considered, as per the recommendation of the International Agreement for Paired Measurement at Geneva (1912).[5]

Pearson's r was used to examine the relationship between the length of the ulna and height. The r between total height and length of the ulna was found to be statistically significant and positive in both males and females.

Table 2. Comparison of the Length of the Right and Left Ulna.

	Independent *t*-test
Subject	***P* Value**
Both sexes together	.9738
Male	.9616
Female	.9925

Note: $P > .05$; it was found that the mean value of the length of the right and left ulna in the study group is statistically insignificant in males, females, and both groups combined. For further statistical analysis, the length of the left ulna will be considered, as per the recommendation of the international agreement for paired measurements at Geneva (1912).

Table 3 shows the correlation between height and ulnar length which are positive and statistically highly significant ($P < .01$), that is, if the length of the ulna increases or decreases, the height of the subject also increases or decreases and vice versa. Regression analysis was performed for the estimation of stature using the length of the ulna as the independent variable. Table 3 also shows the regression equation for height with length of ulna in males, females and both sexes together. The r for both sexes together is 0.7335 and the regression equation is $Y = 65.42911 + 3.773632X$ with a *P* value of <.001.

For males, the r is 0.5814 and the regression equation is $Y = 110.262 + 2.206518X$ with a $P < .01$.

For females, the r is 0.3143 and the regression equation is $Y = 123.8984 + 1.338234X$ with a $P < .01$.

Y = Height/Stature (cm) X = Length of ulna (cm). 65.42911, 110.262 and 123.8984 are intercepts (constants) for both sexes together, male and female, respectively.

Table 3. Regression Equation for Height with Length of the Ulna in Males, Females and Both Sexes Together.

Subject	Correlation Coefficient (*r*)	Regression Equation	*P* Value
Both sexes together	0.7335	Y = 65.42911 + 3.773632X	<.01
Male	0.5814	Y = 110.262 + 2.206518X	<.01
Female	0.3143	Y = 123.8984 + 1.338234X	<.01

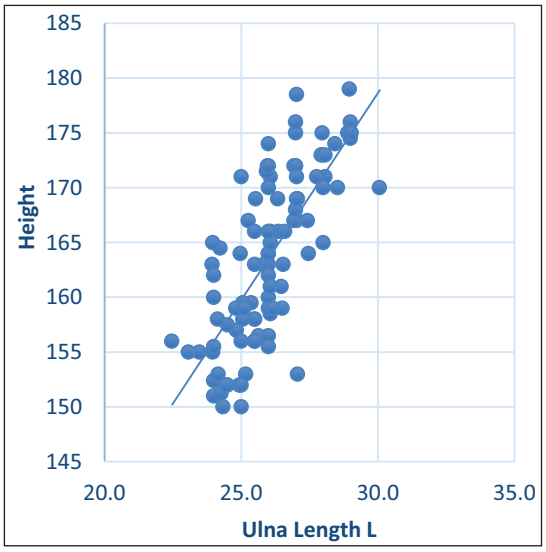

Figure 4. Correlation of Height with Length of Ulna in Both Sexes Together.

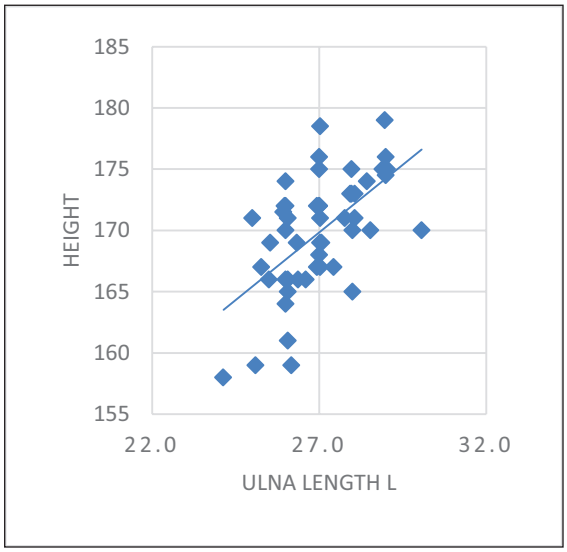

Figure 5. Correlation of Male Height with Length of Ulna.

From the above table, it is seen that the regression formula within a region also varies between the male and female populations of that region.

Figure 4 shows a positive correlation between the length of the ulna on the X-axis and the height of subjects on the Y-axis, indicating that an increase in the length of the ulna leads to an increase in the total height of both subjects

Figure 5 shows a positive correlation between the length of the ulna on the X-axis and the height of female subjects on the Y-axis, indicating that an increase in the length of the ulna leads to an increase in the total height of a male subject.

Figure 6 shows a positive correlation between the length of the ulna on the X-axis and the height of female subjects on the Y-axis, indicating that an increase in the length of the ulna leads to an increase in the total height of the female subject.

Figures 7, 8 and 9 show the procedure of taking the measurements and the equipment used.

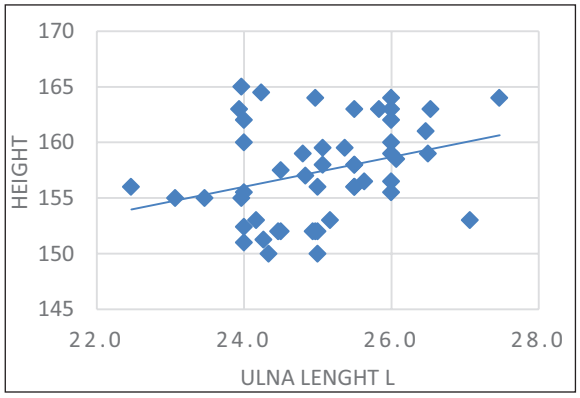

Figure 6. Correlation of Height with Length of Ulna in Females.

Discussion

Stature is an essential feature of identification. In mass disasters, the whole body is not always available. Therefore, the estimation of stature from mutilated body parts assumes a role of paramount importance. Clinically, it has a role in the calculation of body mass index, which is used for the assessment of nutrition. However, its measurement is not always practical in mutilated and decomposed bodies and in old or frail bedridden patients who cannot stand or those who are suffering from vertebral column deformities. In such cases, formulae based on the ulnar length provide an alternative stature predictor.[6]

Trotter and Gleser affirmed the requirement of different regression equations among different races after studying different races for the relationship between lengths of long bones and stature.[7] In addition to ethnic differences, secular trends can also influence body proportions. This fact has been reinforced by many studies all over the world.[2]

Figure 7. Taking Standing Height with a Stadiometer.

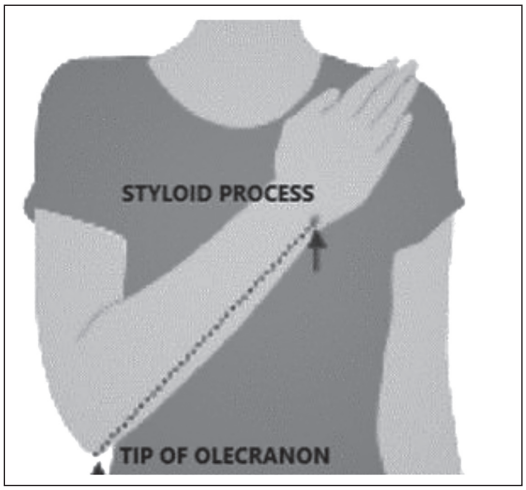

Figure 8. Procedure for Taking the Percutaneous Ulnar Length.

A study for the estimation of stature from the upper limb measurements in the Turkish population developed regression formulae to estimate stature.[8] The results of this study indicated a positive correlation between upper limb measurements and stature, which was highest for ulnar length. Thummar B et al.[9] derived a regression equation for the estimation of stature from the length of the right and left ulna in both males and females. Allbrook[10] also derived regression formulae for the estimation of stature from the length of ulna in British and East African males and formulated that stature = 88.94 + 3.06 (ulna length) ± 4.4 (SE). Ilayperumal[11] derived regression

Figure 9. Spreading Callipers.

equations for stature estimation from the length of the ulna in both males and females in the Sri Lankan population.

The need to identify the age group, race and area a particular person belongs to before applying the regression equation particular to that area and to that age group to identify the stature of the individual was stressed by Laxmi et al.[12]

The present study deals with observations on the correlation of standing height with the length of the ulna in subjects between 21 and 25 years of age. We chose the ulna because, compared to other bones of the upper limb, it is easier to get a more precise measurement of ulnar length in living subjects. The ulna has easily identifiable surface landmarks, making the measurement possible.[3]

The relationship between stature and the length of long bones is also influenced by sex among other things.[1] Thus, the need for a sex-specific stature estimation formula is proved beyond doubt.[11]

The average height of adult males within a population is significantly higher than that of adult females.[13] The result obtained in this study agrees with the above statement.

In the present study, there was no statistical difference between the length of right and left ulna within each gender. The regression formulae for the estimation of stature by left ulna were derived, as the results from our study samples failed to prove that the differences in length between the right and left bones are significant.

The correlation coefficient (r) between the total height and ulna length was found to be positive, indicating a strong relationship between the two parameters. The positive correlation suggests if the length of the ulna increases or decreases, the height of the subject also increases or decreases and vice versa.

There has been a study in an Indo-Mauritian population to estimate the stature from PCUL, hand length and hand breadth and the regression models were formulated.[14] The results indicated

that the percutaneous length of the ulna (forearm length) and hand length can be efficiently used for stature dimension.

Another study identified a meaningful relation between the stature and upper limb dimensions ($P < .05$) in the Iranian population.[15] In the present study, for both sexes together, $r = 0.7335$ and the regression equation is Y = 65.42911 + 3.773632X with a P value of <.001.

For males, $r = 0.5814$ and the regression equation is Y = 110.262 + 2.206518X with a $P < .01$. For females, $r = 0.3143$ and the regression equation is Y = 123.8984 + 1.338234X with a $P < .01$, where Y = Height/Stature (cm), X = Length of ulna (cm) and 65.42911, 110.262, 123.8984 are intercepts (constants) for both sexes together, male and female, respectively.

Though a few similar studies have been done in the region, these were on other tribes[16,17] and hence, the present study has been done to establish regression formulae for Meitei subjects.

More regression formulae for more ethnic groups will make identification much easier in the future.

Conclusion

In the present study, an attempt was made to document a relationship between the ulna and height of indigenous Meitei subjects in the age group of 21–25 years. A positive correlation was found between stature and the length of the ulna, with no statistically significant difference between the right and left ulna. The derived simple linear regression equations can be used for estimating height from the ulna and vice versa. Thus, the data of this study may be of practical use in medico-legal investigations. Furthermore, in times of crisis, such as communal riots, the regression formulae derived here will be useful in a preliminary identification of the victims. Although stature cannot establish the complete identity of an individual, it can definitely save a lot of work in building up the basic sketch of a missing person or a suspect in a crime, and even in ruling out certain persons as suspects in a particular offence. With the advancement in imaging techniques, computerisation of personal data and fast internet connectivity, the regression formulae of specific population groups, like those in the present study, can be computerised. In the future, personal identification may be achieved in a matter of a few seconds, even in this part of the country.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

Ethical clearance was taken for this study.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

The informed consent has been obtained from the participants for the study.

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India Urgently Needs Medical Autopsy: It Will Help the World

Journal of Indian Academy
of Forensic Medicine
46(3) 365–371, 2024

DOI: 10.1177/09710973251322022
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Abstract

No death should go unexplained is what has been proved as a golden rule in preventing lot many future deaths in medical science. Medical autopsy done in unexplained death has helped to unravel many secrets and subsequently protected many lives. Western countries like the USA and many European countries practice medical autopsy and have successfully done favour to their citizens. India is at a juncture where it cannot avoid medical autopsy in the name of cultural, religious and legal framework anymore. We will present our argument in this article in favour of the same. For the purpose of this article, we have done a review of literature, websites of WHO, United Nations and COVID Dashboard to understand the present scenario in India. Once we could understand this, we could come up with a solution to improve the current scenario.

Keywords

Medical autopsy, virtual autopsy, sudden unexplained death, verbal autopsy

Received 23 November 2023; **accepted** 30 March 2024

Introduction

India since independence has been trying to make health policy which was centred on providing basic healthcare to its public. It has been working slowly and steadily up the ladder in healthcare, taking baby steps. While doing so for the first 60 years of its independence it gave more focus to public health care facilities, medicines, nutrition, sanitation and so on. While basic needs were taken care of, research and development and up gradation of healthcare were never prioritised. For legal needs, post-mortems are performed in every country. But this post-mortem is more for solving the case and is done only when the law permits. The last two decades have shown that we need to now break the shell and move ahead in all these neglected fields which also include medical autopsy. In India, religion takes precedence when someone dies and so thinking or talking of taking the body for medical autopsy itself creates an environment of argument and restlessness among the people. But the moot question is, 'Why avoid a scientifically proven technique to solve the unexplained death?' Even during the COVID pandemic and events post-COVID where there is an increase in the percentage of unexplained deaths, the importance of medical autopsy has been established.

Historical Background

It would have started way earlier but as early as 1,500, the church asked for an autopsy on conjoined twins to find if they had the same soul or not.1 Almost all detailed books of pathology, histopathology and anatomy exist because then people thought of doing autopsies and finding out the truth about many diseases that were the cause of suffering in the world. As early as 1800, Mr Karl Rokitansky has performed more than 30,000 autopsies and has helped others perform 75,000 autopsies which led to the largest database of pathological findings.[1,2] The reason for performing autopsies on unexplained deaths can easily be understood by the fact that in 1912 Mr Richard Cabot after studying 3,000 autopsy reports concluded that more than 50% diagnoses made were incorrect.[1] In 1951, when the Joint Commission of Hospital

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Accreditation came into existence it made a revolutionary criterion. It is said that to have good quality hospital care and accurate death audit, a hospital should have a minimum of 20% of medical autopsy.

A Helping Hand

In the medical fraternity not, a single soul will deny the fact that autopsy and dissection have provided us with insight into the human body in the form of anatomy and pathology. Throughout the globe, the first year of dissection classes has helped shape doctors with invaluable knowledge about the human body. In all the countries where it is allowed, medical autopsy has become the backbone of research in unexplained death where they use direct observation of the pathology, radiology and biochemistry reports, molecular biology and tissue histopathology to unravel the reasons behind the death. With the advent and propagation of transplants, cadaver transplants have saved millions of lives across the globe.[3] Every court of law in the world relies completely on good forensic evidence provided by the autopsy or post-mortem. The last decade has even seen an increase in virtual autopsy which is saving a lot of time and may help overcome the religious and cultural barriers.

A Death

A human can die broadly in two ways. It can be an unnatural death due to accidents or homicide. He or she can die naturally because of known or unknown reasons. In case of unnatural deaths law permits and even asks for post-mortem to get the reason of death on paper as forensic evidence to prosecute. Here since it is enforceable and hence there is no resistance from any corners be it religious or cultural. In case of natural death, a person may die for a known reason like due to a disease he or she is suffering from or acutely he suffers from. He or she may die in a hospital or outside hospital. The death in the hospital in majority of the time is observed by the doctor and hence largely the cause is determined and noted on the case paper. Mostly doctors are sure about the cause of death. The reasons behind death outside the hospital may not be known but when a person is brought to the hospital, the history of the patient helps in determining the cause of many such deaths. And so, in all such cases, medical autopsy is not required even in countries which do such autopsy regularly.

The grey area is for deaths of undetermined cause, be it in hospital or outside hospital. There are many deaths that happen in hospitals where even after all diagnostic tools and expert reviews reason for suffering and eventually death is not clear. Such unexplained death is an emotional burden for the families as they always want an answer for the reasons for suffering and death. It is an academic burden on treating doctors to know if they missed something, if they could have done better to manage the patient and above all whether they can learn from this undetermined death to save another life. It is also important for hospitals which target to provide good quality of care whereby every death audit helps to improve the same.

In death which happens outside hospitals where there is suspicion, in many countries post-mortem is performed to ascertain the absence of foul play. However, the overall rate of such autopsies is also very low across the spectrum.[4] In law, such cases which are brought dead are to be considered medico-legal but due to religious and cultural beliefs and lack of legal will, the majority of cases are sent back without even reporting in the hospital database.[4,5] This has led to a probable change in population of world then we will find substandard death certificates which mislead the overall death registry.

Another aspect of death and the diagnosis provided by the doctor is an observation that has been made ever since 1912. From Mr Richard Cabot[2] to the Norwegian study published in 2012[6] it is clear that more than 50% time the diagnosis mentioned on the death certificate by the practitioner is found to be wrong on autopsy reports. This has a repel effect on all the death registries of the world as a whole. WHO since 1948 has defined the underlying cause of death and the format of recording it.[7] It is followed internationally and because of the uniformity mortality statistics are widely used for medical research, monitoring of public health, evaluating health interventions and planning and follow-up of health care.[8–11] So if the death registry has an underlying cause of death which is not right then statistics will misguide nations and humanity as a whole in the wrong direction.[9–13]

From 2005 there has been a shift in recording the underlying cause of death. It is centralised whereby software integration is used. The aim of this exercise is to improve the metrics which can provide the accurate reasons behind the deaths and non-fatal diseases.[14] It combines the underlying cause of death provided by the death certificate and autopsy if provided. In such cases either it provides a combined underlying cause or a single cause whereby autopsy is given priority.[6,14]

Lack of medical autopsy and its effect on health data: Medical science for centuries has learned lots of valuable lessons from medical autopsy data and findings.[15] This data is segregated into various forms like ranking of disease-causing mortality,16 similar ranking in children, pregnant females, epidemiological studies, infectious disease-causing mortality ranking, cancer-causing mortality ranking and so on. It also helps the research fraternity to decide on the priority of research and development in markers of early detection, drug discoveries and ways to prevent such diseases. Such death registries[5,17] also help local, national and global authorities plan their health initiatives and budgets.

WHO and various national authorities have been working hard to rectify the errors in death certificates through adopting various updates in software collecting death registry data, combining death certificates with medical autopsy and also now adopting virtual autopsy techniques.[14,18–21] This whole exercise of having a robust death registry is to categorise the common

cause of death, cause of death (single or multiple factors) and preventable cause of death, death related to abuses and environmental changes and death due to lack of health infrastructure which includes healthcare facility and also manpower. This helps every country and even WHO to plan for public health programmes, to allocate money for the programmes and to direct the research personnel to work on such diseases.[16,22]

Data from India changes the whole scenario: To understand the importance of accuracy of death registry and subsequently, its utility we need to know the five most populous countries. They are India, China, the United States of America, Indonesia and Pakistan.[23] If we add Europe then its total population as a whole will put it in third position before the USA.[24] But if we follow the data and probable change in population of world then we will find the following reality. The population of Europe and China is going to decline in the next two to three decades, of the United States of America and Indonesia is going to remain more or less stable whereas India is going to remain at peak as the largest population for at least next 50 years.[23,24] So, it is clear that data emerging from India are going to affect the world at large and also India itself.

If we look at data from the death registry; Russia, the United States of America, the United Kingdom, India and China record above 75% share of deaths being registered.[22] When death is registered, a cause is given for that death. USA, Russia and a few other countries give this cause in their death registry almost 100%22 but this may be due to lack of training and lack of knowledge about the ICD (International Classification of Disease) system India records the cause of death in only 10% cases.[22] So, this makes it amply clear that only a small fraction of the population lives in countries where the death registry is up to the mark. However, the majority of the population lives in countries where there is a poor death registry.[22] Now majority of the guidelines for diagnosis of disease, management protocol and research topics are made by the countries that are minority in nature and ironically this is/had to be followed by the most populous countries. So, it is necessary for the rest of the world that India on an urgent basis should adopt the robust death registry system. This will require teaching medical practitioners International guidelines of mentioning death according to the International Classification of Diseases (ICD).[22,25] There has to be an addition of verbal autopsy in various scenarios of unexplained death which includes multiple contributing factors.[18,19] There have to be coordinated efforts to start medical autopsies in India. The policymakers will have to take the lead and frame a policy of medical autopsy.[26] To save time and prevent surgical procedures in many of the autopsies even virtual autopsy is need of the hour.[27]

COVID Pandemic: Medical Autopsy Changed Everything

COVID was caused by to novel virus so the disease pathology, clinical manifestations and management were not defined. Initial days it was managed as interstitial pneumonia and acute respiratory distress syndrome (ARDS).[28] There were no defined guidelines for management, patients were given symptomatic treatment and as they deteriorated doctors across the world used treatment protocols defined by their hospitals or that they knew by experience. But the deterioration kept increasing and so did the death rate. If we go by data COVID-19 started in December 2019, by the end of April 2020 almost 3 million people across the globe were affected by it and approximately 210,000 have died of it.[29] This was looking dangerous as the mortality was even higher than the seasonal flu.[30] So, there was a need for urgent research to find the actual pathogenesis of the ongoing pandemic. The most perplexing part was that the countries that had set protocols for autopsy refrained from doing the same on deaths related to COVID.

Though it was almost five months of the onset of the pandemic worldwide there were only three reported articles which described the autopsy findings in death in COVID patients.[31,32] Once the medical autopsy findings came, doctors and scientists got real insight into the characteristics of COVID-19 and its pathogenesis.[33] With this new insight provided because of autopsy, it was clear that COVID-19 had multiple pathogenesis of inflammatory disease, acute respiratory distress syndrome, coagulopathy and multi-organ disease. This was assisted by various biomarkers like C reactive protein, D-dimer.[34,35] Because of this investigation various phases of COVID-19 were decided and so was the treatment protocol.

India also saw devastating effects during COVID-19 and the pattern followed by COVID-19 was different from the rest of the world. The first wave lasted for months due to the strict lockdown policy of the government.[36,37] Since the legal requirement of ordering a post-mortem is clear in India where a post-mortem is done only if there is suspicion, for research purposes there is no proper infrastructure, the consent for performing an autopsy even if research is permitted is not forthcoming and due to fear of transmission to examiners medical autopsy is never performed for academic purposes. So, world was slowly catching up on medical autopsy during COVID times, and India was lacking behind. The first published data on medical autopsy on COVID deaths was done in late September 2020 in Rajkot.[38] Another such study was done at Bhopal but published in 2022.[39] After this the second wave was the deadliest of all which was called as delta wave throughout the world. It caused complete collapse of the healthcare system in India. It was a rapid rise and rapid fall wave in India. During this worst phase, India saw more than 20 million cases and about 4 lakh deaths.[40] Along with the delta wave simultaneously India faced epidemic of mucormycosis in COVID patients.[41–43] It was clear till now that India was seeing different patterns in both waves than the whole world. There were little to no minimal reports of mucormycosis in world other than India. It is a firm belief that medical autopsy would have been of great help in finding out the

pathogenesis of this combined attack on India. There was a lack of knowledge regarding this coexistence of two infections and their pathogenesis due to a lack of autopsies. This led to delayed detection of mucormycosis and so delayed treatment.[44]

Surge in Sudden death: Research is impossible without medical autopsy.

Sudden unexplained death is known to be the leading cause of death across the world. Globally the cases are almost in the range of 0.6–0.8 per 100,000 population.[45,46] The definition of sudden death is provided by the World Health Organisation, which defines them as sudden, unexpected, natural deaths either within one hour of symptom onset or, if unwitnessed, within 24 hours of having been last seen alive and symptom-free.[47,48]

In India post-COVID, this surge in sudden death in young adults has been attributed to post-COVID complications or COVID-19 vaccine complications.[49] It is also attributed only to cardiac causes leading to this death either as myocardial infarction or cardiac arrest.[49] Pre-COVID all the data suggested that there are multiple reasons behind sudden death46 but to find the real reasons the best option is autopsy. This autopsy is a combination of verbal autopsy and medical autopsy.[50–53] When the matter is of children and young adults, knowing the real reason behind unexplained death is utmost importance to plan an investigation, preventive strategy and also treatment strategy.[50]

Final Argument

In modern healthcare, it is very clear that nothing can be taken for chance in healthcare. If the technology is available then it should be used to ascertain the real cause behind any medical catastrophe. This always helps from various points of view like epidemiological data, social/cultural issues/prevention plans, national health policy and finally hierarchy of research.

1. By having a proper death registry, ranking of mortality factors can be known and hence research in those areas can be prioritised. India needs to understand the importance of registry and its utility considering its vast population. If the data that originates from a country like India is not correct or half correct then the final global data will also be same. In that case, the future planning of research and development will be in wrong direction. Another point to understand is that India is relatively a young country and so next few decades there will rise in population and also health-related problems. So, correcting this death registry will make India research-centric. This data in the death registry also helps in formulating the guidelines for treating various chronic diseases which should also be India-centric. But for all this medical autopsy what is needed.[4] Without a medical autopsy the death registry as proven in past will be inaccurate.
2. During the COVID pandemic refraining from doing medical autopsy led to an increase in morbidity and mortality due to no clear-cut guidelines for management of the disease. When the autopsies were done in some of the developed countries it proved a guiding factor in knowing the pathogenesis of the disease. But in India, since there is no legal clause, lack of proper infrastructure, lack of forensic examiners and religious/cultural issues[54,55] it was not in the policy to perform autopsy.[4] Over a period of time very minimal research has happened in medical autopsy even during the pre-COVID era. A real medical autopsy will need collaboration with molecular biology testing, toxicological screening and histopathological examination.[56,57] But looking towards the threats of pandemics we are going to face in future we need an urgent policy shift towards medical autopsy and the same will require development of infrastructure where such autopsy can be performed, expert manpower for performing this autopsy properly and pathology/radiological backup to provide with accurate diagnosis.[2,58,59] One thing is for sure by neglecting medical autopsy human race tends to loos! as morbidity and mortality increase.
3. [3]Sudden unexplained death is a burden that is faced by every nation and India is not protected. In fact, looking at the young population, an epidemic of sudden unexplained death is a catastrophe.[60] The most important aspect in this category of death is that the majority of people do not reach the hospital alive. So, the data or death registry will not mention deaths that happen outside a hospital or at home. But to ascertain the correct cause of such death microscopic, macroscopic and toxicological findings are of utmost importance. This is possible only through medical autopsy. Along with medical autopsy if verbal autopsy is also used then the results are accurate. This will always help society at large to prevent such events in young people.[61]

Solution

Every country in the world has a facility for post-mortem to solve crime. However, a medical autopsy requires various things.

1. Policy: Government of India will have to come up with policy amendments where medical autopsy is allowed to doctors in case of undetermined death.
2. Religious/cultural awareness: The biggest hurdle that even developed countries face is getting consent from the relatives for the autopsy. It is considered a sign of disrespect to the dead if autopsies are done. The same is true for the Indian population. Even in the case of crime or suspected crime, many a time people frown upon in

name of post-mortem. But a larger section of people has to realise that doing medical autopsy in cases of undetermined death will help them get the answers about their relatives and will bring emotional closure.

3. Infrastructure: Hospitals, both private and government will have to establish infrastructure for the autopsy. Joint Commission International and NABH (National Accreditation Board for Hospitals) will have to add riders for performance of medical autopsies to improve quality care and proper death audit.
4. Pathology and radiological backup: This is the most essential infrastructure backup required for accurate medical autopsy. Biochemistry, molecular biology, histopathology and toxicology are required for diagnosis. Along with this radiology backup of X-rays, CT scans, MRI and 3D imaging are needed for results.
5. Manpower: Even though all the above are available, expert forensic examiners are most important in this whole exercise. To train them the first thing that is required is to increase the education facilities across the country. The term 'autopsy' derives from the Greek 'autopsia' meaning 'to see for oneself' and for this, an expert forensic examiner is required.
6. Combine various autopsies: Medical autopsy, verbal autopsy and virtual autopsy are various types of autopsy available to us. All have their own pros and cons. India is a vast and diverse country. In an urban setup where the population is receptive to medical autopsy, it can be performed. But if there are cultural and religious issues then virtual autopsy can be performed as surgical methods can be avoided by this. In remote places and rural areas where there is a shortage of infrastructure then verbal autopsy can be performed.

Conclusion

Autopsies, for centuries, have helped mankind in solving the secrets of human bodies. For centuries it has solved crimes and helped the law punish the guilty. In modern times the use of medical autopsy should be mandatory to unravel various undetermined causes of morbidity and mortality. Advancements in autopsy like virtual autopsy and utilising the age-old methods of medical autopsy and verbal autopsy will help countries like India to draft its health policy which includes epidemiological surveys, public health care and medical guidelines to prevent and treat diseases and research and development. It is an urgent need for the country and also for the world that India urgently upgrades its policy and infrastructure for medical autopsy.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval and Informed Consent

Not applicable.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Original Article

Isolation of Pure Cultures of Skin Micro-organisms to Revolutionize Criminal Investigations—A Pilot Study

Journal of Indian Academy of Forensic Medicine
46(3) 372–378, 2024

DOI: 10.1177/0971097325131637 9
journals.sagepub.com/home/iaf
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Abstract

The current investigation explores the possibility of using skin microbiomes to solve criminal cases. The study investigates the skin microbial samples as a marker from four professions, that is, garbage collectors (GC), morgue staff (MW), construction workers (CW), and housekeeping staff (HK). The findings show the cluster-wise separation of *Bacillus* spp. in four different professions. The heat map, scatter plot and cluster dendrogram show the discrete pattern of separation of 16S rDNA on the basis of occupation. The results clearly demonstrate that the CW and GC samples may share some common features that are not shared by the MW and HK samples. Most of the CW samples are related to each other in most of the branches and related to most of the GC samples. This suggests that the bacterial communities on the palms of CW and GC samples are more similar to each other than they are to the other groups. The cluster dendrogram shows some of the HK and MW samples together in the branch. This similarity can help in establishing the link between the corroboratory evidence and the suspect and/or crime scene. However, more samples should be studied for involving it in a full-fledged criminal investigation. Studies on transient and resident bacterial communities on surfaces are crucial. This study shows the promising method of skin microbiome for forensic applications. With continued research and development, this technology could become a valuable and cost-effective tool for criminal investigations.

Keywords:
Cluster analysis, *Bacillus* spp., forensic microbiome, profession-wise separation

Received 12 June 2023; **accepted** 09 November 2023

Introduction

The skin acts as a vital barrier between the human body and the external environment, with its diverse microbiota contributing to skin health. The topographical and temporal diversity of the human skin microbiome was investigated using genomic techniques in a study carried out by Grice et al.[1] To make microbial forensics viable for investigations, rigorous validation and ethical consideration[2] and the establishment of reliable methods and protocols are required. Forensic practitioners require proficiency and standardized training. The human skin is home to a wide variety of bacteria that are easily transferred to surfaces through touch and are resistant to environmental stresses. Skin microbiomes differ from person to person but remain stable over time, with potential forensic applications as unique "fingerprints." Personal contact with environmental sources can cause bacterial communities on the skin to persist on surfaces for days to weeks. Microbial DNA fingerprinting from touched surfaces could help forensic investigations by providing information on individual hosts, including their geographic origins. This method may be useful in cases where there are no matching DNA profiles of individuals. Molecular characterization of bacteria from crime scene exhibits, understanding bacteria's role in fluid degradation, and investigating spatial and temporal variations in human bacterial microflora are all part of the exploration of microbial forensics.[3] The molecular characterization of mitochondrial DNA of different species can be used to rule out the origin of the degraded blood samples.[4] Microbial profiling currently lacks the accuracy required for forensic trace

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evidence, necessitating additional research to identify potential limitations and effective mitigation strategies.[5] Amorim's 2010 proposal for microbial forensics shows promise in solving sexual offenses by linking perpetrators and victims years after the incident using bio-indicators such as HIV (Human Immunodeficiency Virus) and HCV.[6] As Budowle and Skopp illustrate, clear protocols, technique validation and dependable databases are critical before broad usage in forensic investigations.[6] Few of the researchers delve into unprecedented detail to examine the skin microbiota in health and illness. Comparative investigations of microbiome sequencing data can produce ideas regarding disease-causing microbes, which can guide targeted culture, whole-genome sequencing, and functional research for dysbiosis and pathogen treatment development.[7]

With the help of extensive sequence databases, the 16S rDNA gene serves as a molecular marker for bacterial identification. Understanding of human microbiota, emphasizing that, contrary to popular belief, the number of microbial cells in the body is comparable to somatic cells. The microbiome, which represents the DNA content of these microbes, outnumbers the diversity of the human genome. The emphasis is on microbial forensics, specifically skin microbiome analysis and on individual variations and potential forensic applications. Molecular sequencing advances, particularly next-generation sequencing, improve forensic capabilities. The skin microbiome, which is diverse and influenced by a variety of factors, provides a distinct microbial signature that could aid in human identification, complementing traditional forensic methods such as fingerprint and DNA analysis.[8]

Forensic applications by demonstrating individual microbiome persistence into the early postmortem period and the traceability of microbial communities on surfaces back to individuals.[9] Using targeted sequencing of microbial markers results indicate that microbial strain composition is more individualizing than phylogenetic relationships, emphasizing the potential of microbial composition for precise identification, possibly reflecting host-environment interactions that maintain a distinct microbial profile.[10] Bacterial abundance in source communities predicted transmission and residence times, demonstrating that transient encounters with environmental sources can drive skin microbiome variability if sufficient biomass is present.[11]

Overall, the study provides a thorough overview of the difficult and time-consuming task of defining bacterial species. It emphasizes the significance of employing multiple methods of analysis and the need to take into account factors such as recombination and ecological niche.[12] The skin's microorganisms, known as the cutaneous microbiota, are thought to play important roles in the prevention and treatment of skin diseases. This culture-independent genetic profiling sheds light on potentially novel human cutaneous microbiota components.[13] Current and past studies in microbial applications of forensic sciences promise betterment and more accurate investigation techniques like DNA or any biological or chemical trace evidence analysis. The crucial reason behind it is a universal distribution of microbes and their persistence for a longer time and the change occurs when drastic environmental changes occur.[14] They are even unique to a particular person and even to a body fluid and body part.[15] This aspect can be used for identifying burglaries. The need for research and development and method validations, standardization and ethical considerations are required to present microbes as evidence in the courts.[16,17] The study suggests that human-associated microbes show variations in personal discrimination. The detailed study of microbial and non-microbial study together will prove even better to link a suspect to the evidence and crime scene. This field of investigation does not only depend on microbial techniques, but it needs the dependencies on science like genomics, phylogenetics, bioinformatics, etc. while presenting the evidence for criminal and microbial outbreaks.[18] Post anthrax letter case in 2001 in US news agency, immediately after the Twin tower blast, the microbial accenting in an investigation has increased.[19] To start the full-fledged microbial forensic lab, instruments and techniques like gene sequencing, hybridization, microarrays, spectrophotometry, and PCR and expertise are required.[20] The application of traces of touch microbiome will require the study in the direction of research in the cult of how the exchange of hand microbes is happening between the touched surface, the persistence of these microbes in various surface types and contamination of other bacteria. Rigorous practice is required to improve the gap between laboratory-controlled experiments and regular forensic analysis. This requires an understanding of the strength, sensitivity, and shortcomings of microbial forensic techniques. At the University of California, Microbial DNA profiling was done to identify the individual on the basis of the microbial signature associated with the objects that they touch. They found that plastic and ceramic objects were linked more accurately to the individuals with the help of microbial signatures.[21] In another type of experiment of mock burglary crime scene set up in households in Chicago and Florida, they could find significant changes in the microbial signatures across time on the household items to the people.[22] The airborne dust in the dormitory was used to predict the gender on the basis of microbial composition. This technique holds a promising approach in identifying the place where the indoor crime has occurred which was occupied by male or female.[23] Meta-analysis of bacterial 16S rRNA proved to be a much more accurate technique to identify the patterns in indoor environments. However, the validation will require rigorous study in various conditions for results comparisons and to enhance the reliability of these results by setting up methodologies.[24] we spend the majority of our time in indoor environments. Consequently, environmental exposure to microorganisms has important implications for human health, and a better understanding of the ecological drivers and processes that impact indoor microbial assemblages will be key for expanding our knowledge of the built environment. In the present investigation, we combined

recent studies examining the microbiota of the built environment in order to identify unifying community patterns and the relative importance of indoor environmental factors. Ultimately, the present meta-analysis focused on studies of bacteria and archaea due to the limited number of high-throughput fungal studies from the indoor environment. We combined 16S ribosomal RNA (rRNA Also, attempts are going on to track the micro-organisms to their source in the context of epidemiology and forensic criminal investigations to implement them in regularized investigation techniques.[25] The research is also going on to complement microbial DNA with human DNA to support the forensic investigations associated with individualization.[26] One of the studies suggests that the changes in the hand microbial community are dependent on the sex, which hand you use often and hand wash frequencies. The deep study of this will also help in identifying the individuals and their daily routines.[27] Microbial community structures on items and palm prints are successfully matched with corresponding palm skin in research.[28] The environmental changes, urbanization, and altered dietary patterns are important for maintaining a balance between environmental and human microbiomes.[29] According to the findings, human-associated microbial communities have enough variation to distinguish individuals over time. As microbiome data is linked to individuals without additional identifying information, ethical implications arise, calling into question the assumptions of complete privacy.[30] Microbial signatures may include ethnicity, which could be useful as evidence in forensic investigations.

Methodology

Isolation of Bacteria from Hands

A total of 40 impressions of hands were collected on labeled Nutrient Agar (NA) plates from the people of four different professions (10 each, i.e., garbage collectors [GC], morgue staff [MW], construction workers [CW], and housekeeping staff [HK] staff) and plates were incubated for 24 hours at 37ºC for the growth of bacteria. Isolates showing similar colony characteristics were selected for further studies.

Isolation of Bacteria from Mobile

Sterile cotton swabs were rubbed on the phones separately in the areas where most of the finger contact occurs and were streaked onto NA plates separately. Plates were then incubated for 24 hours at 37ºC. Isolates showing colony characteristics similar to those from hand impressions of respective individuals were selected for further studies.

Identification of Bacteria

The selected isolates were subjected to gram's staining for preliminary identification. The isolates were then subjected to DNA Isolation and 16S RDNA sequencing for identification up to the species level.[31]

DNA Isolation and PCR Amplification

The DNA from the selected bacterial cultures were isolated using the Phenol-Chloroform method.[32] Bacterial 16S rDNA was amplified using primers 27F forward and 1492R reverse sequence[33] and obtained a 1550 bp long sequence.[34] The amplified DNA samples were subjected to Sanger sequencing and then identification of the bacteria was done by NCBI-BLAST.[35]

These sequences were then used for clustering according to the species from different professions[36] and establishing the phylogenetic relatedness to visualize the diversity of the species.

Sequence Processing

The genetic relatedness and clustering of the sequences were established with the help of R Studio by using the packages like seqinr, magrittr, dplyr, ggpubr, gplots, tidyverse, cluster, factoextra, seqinr, adegenet, ape, ggtree, DECIPHER, viridis, ggplot2.[37] The sequences were aligned. The distance matrix calculation, alignment and graphical representation were obtained by writing codes for each step. Then used for plotting clusters, a phylogenetic tree in R studio for establishing relationships between the isolated sequences.

Results and Discussions

Out of 40 persons sampling bacteria from hands and mobile, a total of 250 isolates were selected with similar colony characteristics from person's hand and mobile of all the professions. The majority of them were gram-positive cocci in clusters and few were gram-positive rods in chains and gram-negative coccobacilli in singles.

A total of 23 isolates which were sequenced were then further analysed by the scatter plot for four professions, that is, GC, CW, HK, and MW. The GC cluster shows overlap with all other clusters of the professions. The variability in all four professions could be due to the professions that they work in. For example, the reason GC overlaps with other professions is due to the reason that GC collects garbage from all other professions and hence the transfer of the organism occurs. After GC, the graph shows the distribution of morgue workers as they handle the bodies from vast areas and there is no clear demarcation from where the bodies come in the morgue. Then it is clearly observed that CW and housekeeping are very well confined to their works and hence show the clustering of the professions (Figure 1).

The reason behind the clustering of the *Bacillus* spp. bacteria present on the hand can be mainly due to materials that they are exposed to, for example, GC and CW are exposed to

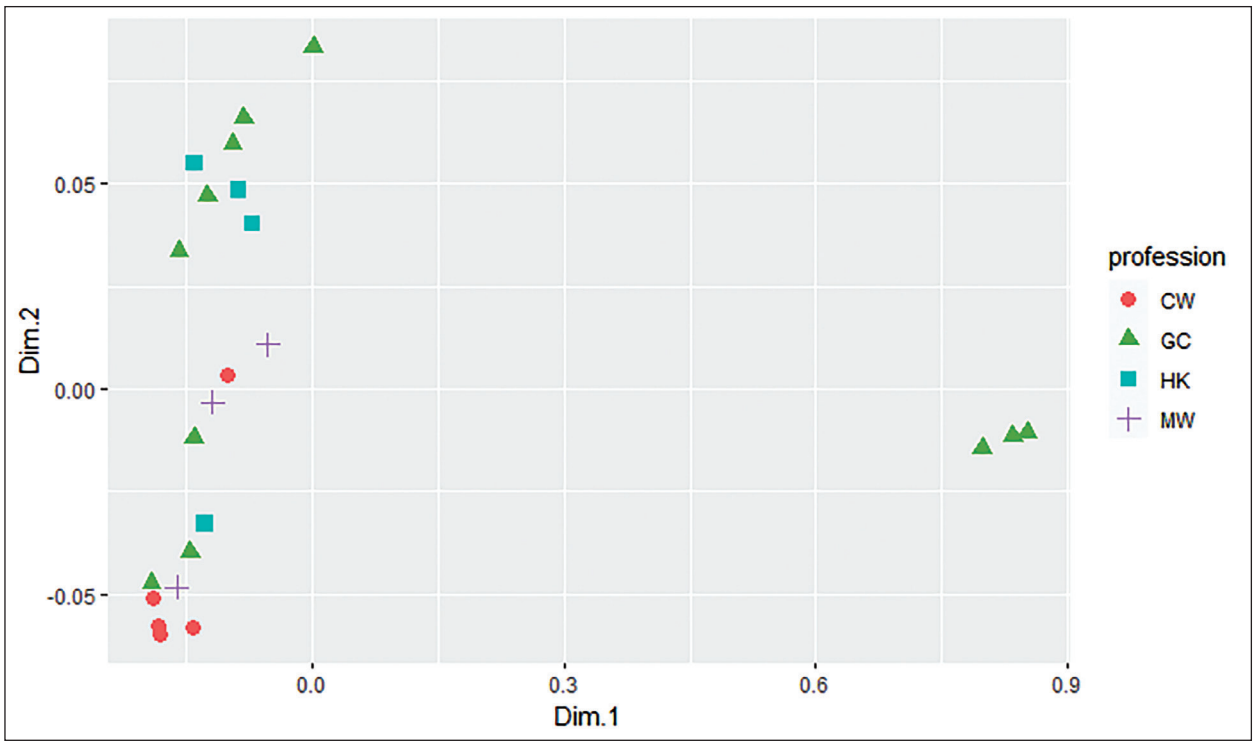

Figure 1. MDS Plot of the 16S rDNA Sequences.

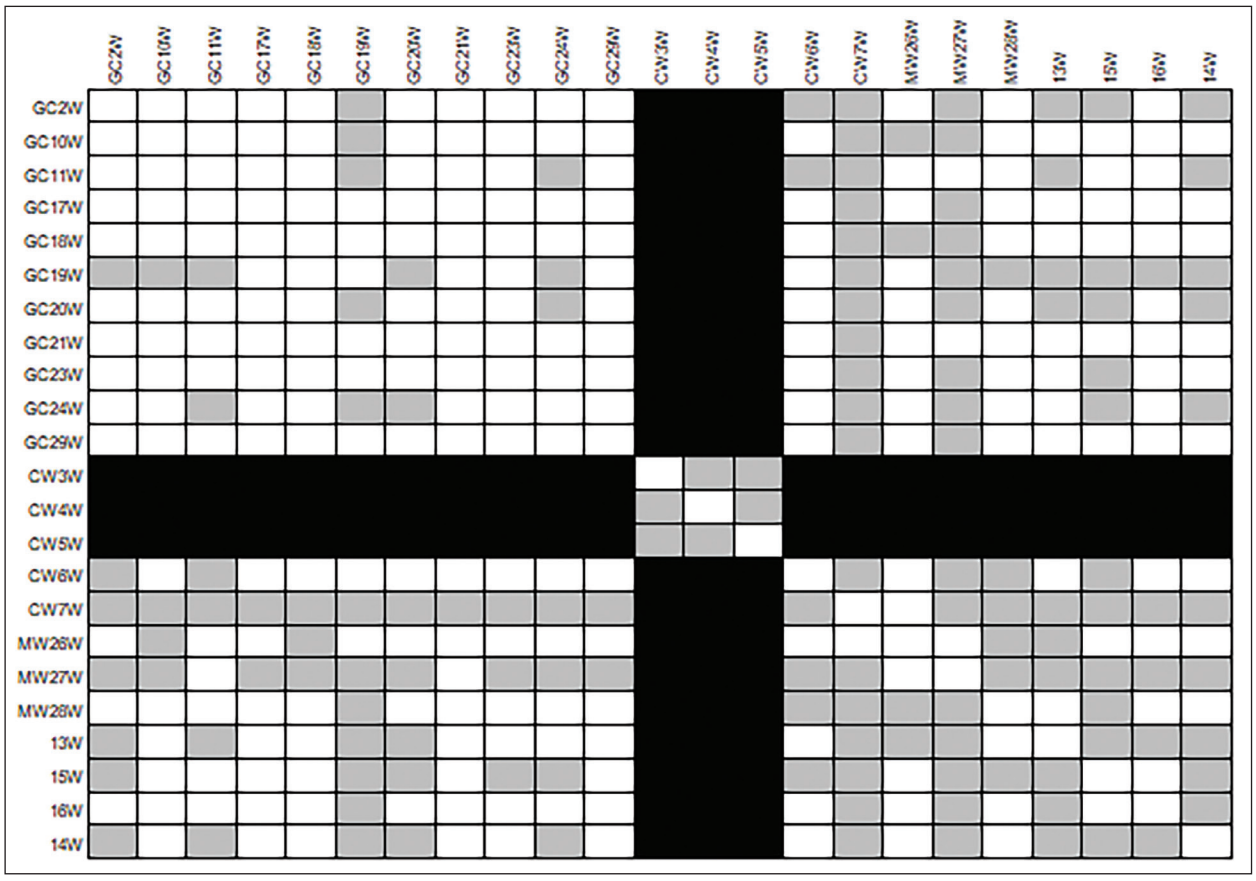

Figure 2. Heatmap of the 16S rDNA Sequences.

soil, outdoor dust environment, etc. The hygiene maintained by individuals, lifestyle, location, etc. might have contributed to the formation of the clusters on the basis of profession. For example, finding bacteria typical of morgue workers on a tool could suggest use in that setting. A study conducted on hair and pubic hair microbiota of different hair types and geolocations in California and Maryland found that the microbiota falls into two different clusters according to the places that they belong to. This was represented by non-metric multidimensional scaling plots.[38]

Heatmap

The specific types of bacteria involved in these similarities can further refine the identification of potential suspects. The heat map generated shows the similarities, slight similarities and dissimilarities on the basis of color demarcation. Dark black colors represent greater dissimilarity, while light white or white colors represent greater similarity and gray colors represent slight similarity among the sequences. The key findings state that the heatmap also shows some interesting relationships between the different types of *Bacillus* spp. among CW. For example, the CW samples appear to be more similar to the GC samples than they are to the MW or HK samples. This suggests that the CW and GC samples may share some common features that are not shared by the MW and HK samples. The bacterial colonies which were seen evidently in GC, MW, and CW, were not observed in HK evidently. Still, we found a few difficult to interpret and compare with other professions. The collected bacteria from HK showed similarity with all other professions as they touched various objects including dust, organic waste, etc. GC samples show more similarity to HK and CW samples as the nature of their work includes dealing with organic waste, which leads to the transfer of bacteria from their workplace to their hand (Figure 2).

A similar type of analysis was conducted to find out the probability of finding the personal objects with the skin microbiome of the deceased people, where they had rightly predicted the owner of the object.[9] The sequencing of the selected bacteria with similar colony characteristics in terms of color and shape has provided insight into the use of specific bacteria as the markers of the professions. Similar-looking colonies from the suspect's hands can be collected and compared with the collected microbial swabs from the objects of the crime, where the chances of handling the object are high, like a doorbell, door handle, phones, etc. The careful sample collection and analysis will help us exclude the suspect. For example, finding a bacterial profile similar to HK samples on a weapon could suggest the involvement of someone from that profession. The presence of matching or slightly similar bacterial communities between samples (like objects and hands) can strengthen evidence of contact or proximity.

Cluster Dendrogram

The dendrogram shows three main clusters at a height of about 0.10 on the y-axis. Most of the CW samples are related

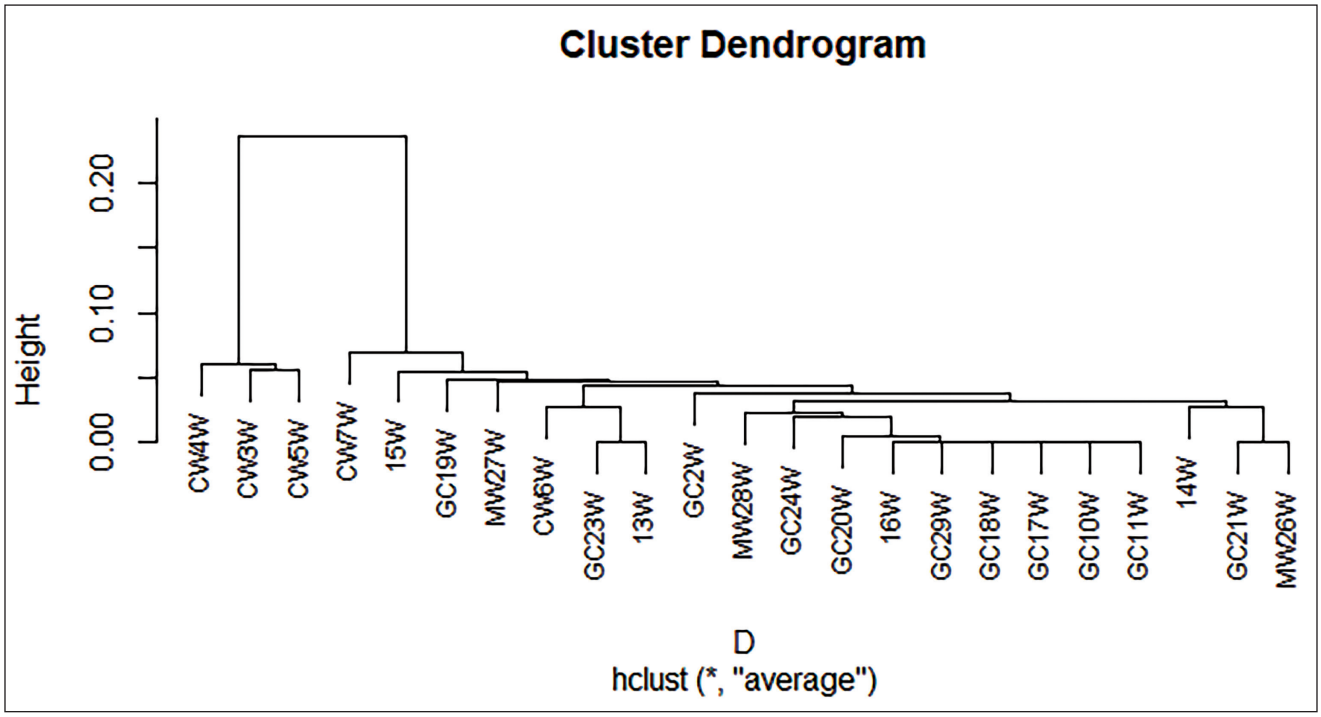

Figure 3. Cluster Dendrogram of the 16S rDNA Sequences.

to each other in most of the branches and to most of the GC samples. This suggests that the bacterial communities on the palms of CW and GC are more similar to each other than they are to the other groups. The cluster dendrogram shows some of the HK and MW samples together in the branch. This suggests that the bacterial communities on the palms of HK and morgue workers are more similar to each other than they are to the other groups (Figure 3).

Locard states that every object leaves a trace on the person who is touching it and the person contributes the traces to the object.[39] The above results support the fact that the person exhibits a microflora similar to their workplace.[40] The bacterial evidence, when aligned with other investigative findings, can strengthen the case against a suspect or provide support for a specific timeline of events. the unique bacterial profiles of different groups offer a new avenue for investigation, potentially identifying previously unexamined suspects or locations.

Acknowledgments

We thank Dr. Syed Dastager and his laboratory, without whose engagement this study would not have been successful. We would also like to thank the volunteers who contributed by providing the samples.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The ethical clearance was approved by the University Ethics Committee under the reference number JU-EC-/022-SC/FS/PhD-JUL2023.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

All participants provided written informed consent prior to enrollment in the study.

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Morbidity and Survival Probability in Burn Patients

Journal of Indian Academy
of Forensic Medicine
46(3) 379–382, 2024

DOI: 10.1177/09710973251316353
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Abstract

Burn constitutes a major public health problem, especially in low or middle-income countries where over 95% of all burn deaths occur. According to the World Health Organisation, an estimated 1,95,000 deaths every year are caused by burns, the vast majority occur in low and middle-income countries. The present medico-legal study aimed to assess the cause of death and rate of survival related to different types of burn injuries. This autopsy-based descriptive study was carried out at the mortuary of People's College of Medical Sciences & Research Centre (PCMS & RC), Bhopal, and Medico-legal Institute, Bhopal. Statistical analysis was done using chi-squared, Student's t-test, and Kaplan-Meier for survival where applicable. Primary causes of death were reviewed from 125 autopsy reports. Percentages of patients that died from sepsis, hypovolemic shock or multi-organ failure were calculated by comparing to the total number of deaths. The period of Survival and Extent of Burns in burn victims is compared. Eight (6.4%) victims survived more than 10 days after sustaining burns, among them four victims having TBSA 50%–70%. Septicaemia is the leading cause of death after burn injury. Period of Survival was higher in 50%–70% of burn victims.

Keywords

Burns, autopsy, survival, shock, medico-legal

Received 05 October 2023; **accepted** 10 January 2024

Introduction

Burn constitutes a major public health problem, especially in low or middle-income countries where over 95% of all burn deaths occur.[1] Fire-related burns alone account for over 3 lakh deaths per year.[2] However, deaths are only part of the problem, for every person who dies as a result of their burns; many more are left with lifelong disabilities and disfigurements.[2]

According to the World Health Organisation, an estimated 1,95,000 deaths every year are caused by burns, the vast majority occur in low and middle-income countries. Non-fatal burn injuries are a leading cause of morbidity.[3]

The causes of death in a burn victim[4] include: (a) Primary or neurogenic shock due to pain, sepsis, toxaemias, etc., (b) More than half of deaths from burns occur within the first 48 hours usually from secondary shock, due to fluid loss from the burned surface (Circulatory collapse may occur with 15% of burns of total body surface area [TBSA]). (c) Asphyxia is a result of oedema of the glottis and pulmonary oedema due to inhalation of smoke containing carbon mono-oxide and carbon di-oxide, if the person dies in a burnt house. In smoke inhalation apart from CO, the other factors that contribute to death are oxygen deprivation, cyanide, free radicles (inactivate surfactants, thus preventing oxygen from crossing the alveoli into the blood), and non-specific toxic substances, (d) Toxaemia, due to absorption of various metabolites from the burnt tissue persists up to three to four days, (e) Sepsis is the most important factor in deaths occurring four to five days or longer after burning. (f) Biochemical disturbances are

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secondary to fluid loss and destruction of tissue, such as hypokalaemia. (g) Acute Renal Failure, due to lower nephron nephrosis occurs on the third or fourth day. (h) Gastrointestinal disturbances, such as acute peptic ulcerations, dilation of the stomach, haemorrhage into intestine. (i) Oedema of glottis and pulmonary oedema due to inhalation of smoke containing CO and CO_2, if the person dies in a burnt house. (j) Accident occurring in an attempt to escape from a burning house or by injuries due to falling masonry, timber or other structures on the body. (k) Pyaemia, gangrene, tetanus, etc. (l) Fat embolism is rare. (m) Pulmonary embolism from thrombosis of veins of the leg due to tissue damage and immobility. (n) Multisystem failure. (o) Death may occur years after recovery from the malignant transformation of a burn scar (Marjolin's ulcer).[5]

The magnitude of burn-related fatalities in India is alarming. In 2019, more than 23,000 fire-related deaths were estimated in India, which is about 20% of the global mortality burden. However, this is an underestimate as not all such deaths are reported.[6]

Burns have got their individual place in medico-legal practice. A forensic expert has to face a number of questions in the Court of Law on medico-legal examination reports on burn cases.[7] A thorough and accurate examination and assessment of these cases are of utmost importance.

The medico-legal points that demand consideration in burn cases are whether the lesions found are due to burns, the nature of the agent causing burns, the area of burns over the body, the cause of death, whether they are antemortem or post-mortem in nature and whether burns are suicidal, homicidal or accidental.[1]

The present medico-legal study aimed to assess the cause of death and rate of survival related to different types of burn injuries.

Material and Methods

This is an autopsy-based descriptive study carried out at the mortuary of People's College of Medical Sciences & Research Centre (PCMS & RC), Bhopal, and Medico-legal Institute, Bhopal. The study was approved by the Institutional Ethical Committee.

The material for this study thus comprised all types of burn death cases brought to the mortuary of both places. A total of 125 autopsies were conducted to burn victims' bodies, including deaths due to flame burns, contact burns, scalds, and electric burns. The inclusion criteria adopted were autopsies of burn victims' dead bodies. The deaths due to causes other than burns and autopsies of decomposed bodies were excluded. The variables taken into account were age, sex, education, occupation, marital status, TBSA, causes of burn, pattern of burn, circumstances of burn injury, period of survival, etc.

Each case was allotted a serial number. The data for the study were collected from individual autopsies of all burn victims in a pre-designed proforma. The data thus collected from individual autopsies were further analysed using SPSS software version 20 and appropriate statistical tests.

Observation and Results

The present study includes a total of 125 autopsies of burn victims, brought to the mortuary of PCMS & RC, Bhopal, and Medico-legal Institute, Bhopal. All the observations were carefully documented from hospital case records, police inquest reports, history obtained from the relatives of the deceased, meticulous post-mortem examination, and Histopathology and Forensic Science Laboratory reports. The observations thus encountered of all this data are presented here in various tables and statistical diagrams for easy understanding and interpretation.

Relationship Between Period of Survival and Extent of Burns in Burn Victims

In the present study, it is found that the maximum number of burn victims (58%–46.4%) have survived from four to seven days, among these 58 burn victims, four had TBSA >90%. No victims had TBSA less than 30%, survived four to seven days.

Eleven (8.8%) victims died within 24 hours of sustaining burns, among them five victims had TBSA 70%–90%, five victims had TBSA more than 90% and only one victim had TBSA less than 10%. Eight (6.4%) victims survived more than 10 days after sustaining burns, among them four victims having TBSA 50%–70% (Table 1).

Relationship Between Period of Survival and Causes of Death in Burn Victims

The cause of death was septicaemia in maximum-81 (64.8%) victims, followed by cardiac arrest in 19 (15.2%), hypovolaemic shock in 14 (11.2%), neurogenic shock in 9 (7.2%), suffocation due to inhalation of fumes in 1 (0.8%), and acute tubular necrosis (ATN) in 1 (0.8%) victim (Table 2). Further in the study, it was found that the maximum (58) victims, who died due to septicaemia, survived four to seven days. Among 19 burn victims who died due to cardiac arrest, 18 died on the spot and one died within 24 hours of sustaining burns. Among 14 burn victims who died due to hypovolaemic shock, 10 victims died within 24 hours and four victims survived one to three days of sustaining burns. All nine burn victims of death due to neurogenic shock and only one victim, who died of suffocation due to inhalation of fumes, died on the spot. One

Table 1. Relationship Between Period of Survival and Extent of Burns in Burn Victims.

Survival Period	<10%	10%–30%	30%–50%	50%–70%	70%–90%	>90%	Total
Spot	15	3	1	1	2	6	28 (22.4%)
<24 hours	1	0	0	0	5	5	11 (8.8%)
1–3 days	0	0	3	7	3	1	14 (11.2%)
4–7 days	0	0	17	26	11	4	58 (46.4%)
8–10 days	0	1	0	2	3	0	6 (4.8%)
>10 days	0	1	2	4	1	0	8 (6.4%)
Total	16	5	23	40	25	16	125

Table 2. Relationship Between Period of Survival and Causes of Death in Burn Victims.

Causes of Death	Spot	<24 Hours	1–3 Days	4–7 Days	8–10 Days	10 Days	Total
Neurogenic shock	9	0	0	0	0	0	9 (7.2%)
Cardiac arrest	18	1	0	0	0	0	19 (15.2%)
Suffocation	1	0	0	0	0	0	1 (0.8%)
Hypovolaemi c shock	0	10	4	0	0	0	14 (11.2%)
Septicaemia	0	0	10	58	6	7	81 (64.8%)
Toxaemia leading to ATN	0	0	0	0	0	1	1 (0.8%)
Any other	0	0	0	0	0	0	0 (0%)
Total	28	11	14	58	6	8	125

victim of burns died due to ATN was survived for more than 10 days after sustaining burns (Table 2).

Discussion

Survival Period in Relation to Extent of Burns

Out of total 125 victims of death due to burns autopsied, maximum 58 (46.4%) victims had survived four to seven days, followed by 28 (22.4%) victims died on spot, 14 (11.2%) victims survived one to three days, 11 (8.8%) victims had survived less than 24 hours, 8 (6.4%) victims had survived more than 10 days, and 6 (4.8%) victims had survived 8–10 days after sustaining burns. Out of a total maximum of 58 (46.4%) victims, who survived four to seven days, the maximum was TBSA 50%–70% (26 victims), followed by TBSA 30%–50% (17 victims), TBSA 70%–90% (11 victims), and TBSA more than 90% (four victims). Out of total 28 (22.4%) victims, who died on spot, 15 (53.57%) were having TBSA less than 10% (electric burn cases), 6 (21.42%) having TBSA more than 90%, 3 (10.71%) having TBSA 10%–30%, 2 (7.14%) having TBSA 70%–90%, 1 (3.5%) having TBSA 30%–50%, and 1 (3.5%) having TBSA 50%–70%. Out of a total 14 (11.2%) victims, who survived one to three days, 7 (50%) were having TBSA 50%–70%, 3 (21.42%) were having TBSA 30%–50%, 3 (21.42%) were having TBSA 70%–90%, and 1 (7.14%) was having TBSA more than 90%. Out of a total of 11 (8.8%) victims, who survived less than 24 hours, 5 (45.45%) had TBSA 70%–90%, 5 (45.45%) had TBSA more than 90% and only one (9.09%) was having TBSA less than 10%. Out of total 8 (6.4%) victims survived more than 10 days, 4 (50%) were having TBSA 50%–70%, 2 (25%) were having TBSA 30%–50%, 1 (12.5%) was having TBSA 10%–30%, and 1 (12.5%) was having TBSA 70%–90%.

Out of total 6 (4.8%) victims, who survived 8–10 days, 3 (50%) had TBSA 70%–90%, 2 (33.33%) having TBSA 50%–70%, and only one (16.66%) victims was having TBSA 10%–30% as shown in Table 1. That means maximum number of victims-84 (67.2%), who were having extensive (more than 30%) burns had survived more than 1 day probably due to early availability of treatment, and they had died due to different causes, maximum-81 (64.8%) due to septicaemia. This is followed by 10 (8%) victims having extensive burns, who died before 24 hours of sustaining burns due to hypovolaemic shock, and 10 (8%) victims having extensive burns have died on the spot. Out of a total of 28 (22.4%) victims, who died on the spot, 18 (64.28%) had less than 30% burns, and 10 (35.71%) had more than 30% burns. The findings in relation to the survival

period were consistent with the findings of Prakash I. Babladi et al. (1998–2002),[8] Sunil P. Tapse et al. (2008),[9] Anju Rani et al. (1998–2010)[10] and B.L. Chaudhary et al. (2006–2010).[11]

Causes of Death in Relation to Survival Period

Out of a total of 125 deaths of burn victims autopsies, the cause of death in most of the cases (64.8%) was septicaemia, followed by 19 (15.2%) deaths due to cardiac arrest, 14 (11.2%) deaths due to hypovolaemic shock, 9 (7.2%) deaths were due to neurogenic shock, only one (0.8%) was due to suffocation as a result of inhalation of fumes, and one (0.8%) death was due to toxaemia leading to ATN. Out of a total of 28 on-spot deaths, the cause of death was cardiac arrest in 18 (64.28%), neurogenic shock in 9 (32.14%), and suffocation in only one (3.5%) victim. Out of a total 11 deaths of within an hour period, the cause of death was hypovolaemic shock in 10 (90.90%) and cardiac arrest in only one (9.09%) victims. Out of a total of 14 victims, who died in one to three days, the cause of death was septicaemia in 10 (71.42%), and hypovolaemic shock in 4 (28.57%) victims. Out of a total of 58 victims, who survived four to seven days, the cause of death was septicaemia in all (100%) cases. Out of a total of six victims, who survived eight to 10 days, the cause of death was septicaemia in all (100%) cases. Out of a total of eight victims, who survived for more than 10 days, the cause of death was septicaemia in 7 (87.5%), and toxaemia leading to ATN in only one (12.5%) victims, as shown in Table 2. Studies by other authors have observed similar results, the cause of death was septicaemia in the majority of cases in the study of Prakash I. Babladi et al. (1998–2002),[8] Dr Mrs S. Dhillon et al. (1999–2003),[12] Anju Rani et al. (1998–2010),[10] B.L. Chaudhary et al. (2006–2010),[11] and Harish D et al. (2011–2013).[13]

Conclusions

Septicaemia is the leading cause of death after burn injury. Period of survival was higher in 50%–70% of burn victims.

Consent to Participate

Not applicable.

Consent for Publication

Not applicable.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The study was approved by the Institutional Ethical Committee, People's College of Medical Sciences and Research Centre, Bhopal (Reference number: PCMS/OD/2013/3808).

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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Original Article

Pattern of Ligature Mark in Hanging—An Autopsy-based Study

Journal of Indian Academy
of Forensic Medicine
46(3) 383–390, 2024

DOI: 10.1177/09710973251322016
journals.sagepub.com/home/iaf
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Abstract

The most important and evident external finding of hanging is a ligature mark, which is a pressure abrasion. A ligature mark can tell so much about the material causing it and its antemortem origin if looked into with utmost care. This cross-sectional study makes a prompt and sincere attempt to study the pattern of ligature marks in hanging deaths and their relation to the materials producing it. The present cross-sectional study enrolled 210 cases of hanging deaths brought for autopsy to the mortuary wing of Government Medical College, Thiruvananthapuram, between March 2021 and October 2022. The classic non-continuous ligature mark which is situated over and above the level of thyroid cartilage was observed in the majority of the cases. Imprint pattern of the ligature material, grooving, the continuity of the ligature mark, and peri-ligature injuries showed a significant association with the consistency and type of ligature material used. The thyroid cartilage fractures and the cervical spine fractures showed a significant association with the position of the knot.

Keywords

Autopsy, hanging, ligature mark

Received 04 June 2023; **accepted** 09 October 2023

Introduction

The principal external sign of hanging is a ligature mark which is a pressure abrasion caused by the loop of ligature around the neck. A classic ligature mark seen in hanging death appears as a groove encircling the neck and obliquely placed above the level of the thyroid cartilage, often showing discontinuity at the point of suspension which is the highest point of ligature mark on the neck. But atypical marks like horizontal ligature marks, absent ligature marks, and multiple ligature marks are also reported in hanging deaths though in small proportions especially in partial hanging, when soft ligatures are used or when multiple loops are used. Solving the puzzle in such a case needs expertise. Eccentricities of ligature marks and the reason behind them must be evaluated and validated carefully in the medicolegal investigation of hanging deaths. The signs of vitality of the ligature mark, the patterns imprinted by the ligature material on the mark, and the peri-ligature injuries, though subtle, are changes that should be looked upon with utmost care and precision. In the present study, a prompt and sincere attempt is being made to study the pattern of ligature marks in hanging deaths and their relation to the material producing it and the associated internal injuries.

Materials and Methods

The cross-sectional study enrolled 210 cases of hanging deaths brought for autopsy to the mortuary wing of Government Medical College, Thiruvananthapuram, between March 2021 and October 2022. The study commenced after obtaining the institutional ethics committee clearance. Data was recorded using semi-structured proforma and analysed using SPSS software version 25.0. The χ^2 test and Fisher's

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exact test were used to test the association between categorical variables and a $P < .05$ was considered significant.

Observations and Discussion

The majority of the victims were males (87.14% of cases). All cases were suicidal hanging. Most of the victims preferred their homes and their premises as a place of hanging (87.3% of cases). The body was seen suspended completely in 62.86% of cases. The victims preferred a soft ligature material over a hard ligature material in 54.76% of cases, agreeing with a previous study by Jayaprakash S and Sreekumari K.[1] However, when we measured the frequency of the type of ligature in the sample, plastic rope (41.4%) which is a hard ligature material outnumbered all others. This was in agreement with observations of Tumram et al.,[2] Pradhan A et al.[3] and Ambade et al.[4] Lungee (32.9%) was the second most common ligature material preferred by the victims of hanging in the present study population. Soft materials like saree, shawl, and lungee are daily worn clothes and other soft materials like thorthu and bed sheets are easily available at home making them the favourite ligature material of choice. Plastic ropes are also used for various purposes in daily living and hence are easily available at home compared to other hard materials (Table 1).

The width of the ligature varied from 2 cm to 260 cm. The thinnest hard material observed had a total circumference of 1 cm and the thinnest soft material observed had a width of 2 cm (Table 2). In the case of the thinnest soft material, which was the border piece of a lungee, the suspension was partial and the victim was standing with feet flat on the ground.

In 82.4% of the cases, a single loop of ligature was seen around the neck constituting the majority. Multiple loops were observed in 17.6% of cases of which 32 cases had double loops, four cases had four loops, and a single case had six loops. It has been observed that when the width/total circumference of the ligature material was 2 cm or less, cases with multiple loops outnumbered cases with a single loop, deviating from the norm that single loops are common in hanging. As the width of ligature material increases the frequency of multiple loops showed a decline in the study sample. Though uncommon, multiple loops are not a rare event in suicidal hanging. It could be a reinforcing method adopted by a desperate victim when he/she is unsure about the load-bearing strength of a thin ligature material. Thin ligature materials commonly used are hard materials. Ambade et al. noted a higher incidence of multiple loops when hard materials are used.

The most common knot observed in the present study was a slip knot (87.6%) similar to the results of other studies by Jayaprakash S and Sreekumari K,[1] and Ambade et al.[4] but differing from the observations of Sharma et al.[5] who observed fixed knot in the majority. Other knots noted in the study sample were half-knot (9%), cow-hitch knot (2.4%), Hangman's knot (0.5%), and overhand running loop knot (0.5%). All these knots except the half-knot are slipping knots producing a running noose when placed around the neck. Half-knot is a highly unstable knot and tends to untie easily. The Hangman's knot is an example of an occupational knot. But in the single case where Hangman's knot was observed; the occupation of the victim was not related to the knot.

As depicted in Figure 1, the most common position of the knot observed in the present study was left subaural (30.5%) followed by right subaural (18.6%). The least common position was the face (0.5%) followed by the submental (6.7%). Typical hanging with a knot over the occiput was seen in 16.2% of cases. The knot was observed in the left and right occipital positions in 13.8% of cases each. The left subaural as the most common knot position was also noted in a previous study by Ambade et al.[4] The left subaural region being an easily accessible site for a right-handed individual might be the reason for its higher frequency observed in the sample population.

Table 1. Distribution of the Type of Ligature Material by Gender.

	Male		Female		Total	
Type of Ligature Material	**No.**	**%**	**No.**	**%**	**No.**	**%**
Lungee	67	36.6	2	7.4	69	32.9
Shawl	6	3.3	11	40.7	17	8.1
Bed sheet	16	8.7	0	0	16	7.6
Saree	4	2.2	6	22.2	10	4.8
Thorthu	1	0.5	2	7.4	3	1.4
Plastic rope	81	44.3	6	22.2	87	41.4
Cotton rope	4	2.2	0	0	4	0
Coir rope	2	1.1	0	0	2	0
Plastic thread	2	1.1	0	0	2	0
Total	183	87.14	27	12.86	210	100

Note: Fisher's exact test value: 56.472, $P < .01$.

Table 2. Distribution of the Number of Loops Around the Neck by Width/Total Circumference of the Ligature.

Width/Total Circumference of Ligature Material	Number of Loops Around the Neck								Percentage	
	1		2		4		6			
	No.	%	No.	%	No.	%	No.	%	No.	%
Less than or equalto 2 cm	10	5.8	18	56.2	4	100	1	100	33	15.7
Greater than 2 cm but less than or equal to 5 cm	53	30.6	11	34.4	0	0	0	0	64	30.5
Greater than 5 cm	110	63.6	3	9.4	0	0	0	0	113	53.8
Total	173	82.4	32	15.2	4	1.9	1	0.5	210	100

Note: Fisher's exact test value: 69.950, $P < .01$.

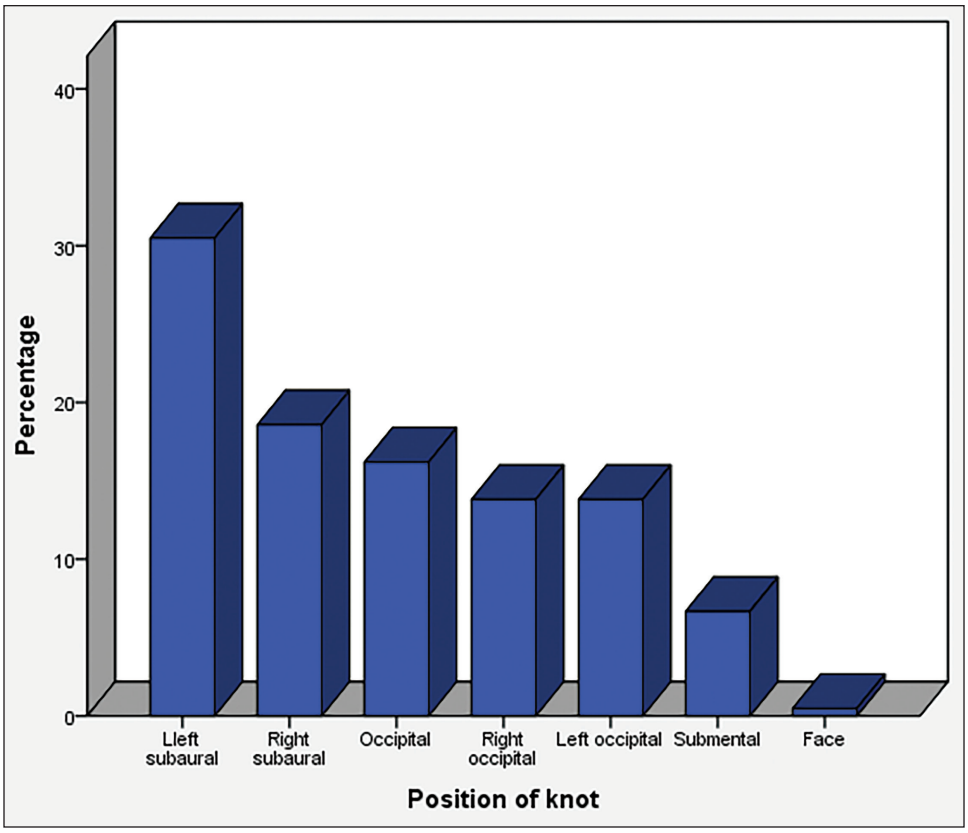

Figure 1. Bar Diagram Showing the Distribution of the Position of the Knot.

Apart from multiple loops the victim often uses restraint knots using the free ends or other materials either to reinforce the knot forming the loop to prevent the slippage of the knot or to tie the multiple free ends together when multiple ligature materials are used. In the present study, such knots were absent in the majority of the cases (71.4%). In the cases where restraint knots were present, they were simple knots either single or multiple, and in most of the cases, they were observed to be placed on either of the free ends just distal to the knot forming the loop on the neck.

Measures taken to prevent escape or to reduce pain in cases of suicidal hanging were observed to be adopted by four male victims in the present study. Two of them used mouth gags: a piece of a lungee and a handkerchief respectively. The purpose of such measures could be to prevent calling out for help. However, such findings are very rare in suicides. So, all other possibilities of a foul-play must be excluded before declaring it as a desperate attempt of the victim to prevent escape from the act of hanging.

Padding the neck with soft cloth was adopted by the other two male victims. One of them used a kitchen towel to place as a cushion between a loop made of plastic rope and the neck ensuring complete encirclement of padding material around the neck. The resulting pressure abrasion was a broad mark having a weaving pattern of the cloth. In the other case, the male victim used thorthu (a type of bath towel) as a cushion

between the neck and the loop made of plastic rope, but the padding did not encircle the neck completely and did not have the desired cushioning effect due to slippage of the material. Padding the neck with a soft cloth is done to reduce the pain during hanging. This practice is also reported in cases of autoerotic hanging.

Demirci et al.[6] observed the practice of using a scarf as a padding material commonly by female victims and male victims used the collar of their shirt as padding material. The present study observed male victims to have taken some measures to reduce pain or to prevent escape. A broad ligature mark or absent ligature mark when the alleged ligature used is a hard material, a remote possibility of padding of the neck must be ruled out before alleging a foul play. In none of these cases in the present study, ligature restraints in other parts of the body were noted whereas Demirci et al.[6] observed ligature restraints in some cases.

The ligature mark was single in 99.5% of the cases agreeing with the existing literature. In one case, it was three in number. In the only case exhibiting multiple ligature marks two plastic ropes were wound three times around the neck by crossing the ends of the rope in the midline on the front and back of the neck finally ending in a half-knot at the back aspect of the neck. So, there were three ligature marks merging at some point in their course at three different levels in the neck. Though 17.6% of cases used multiple loops multiple ligature marks were observed in only one case (0.5%). In all other cases, the marks made by individual loops around the neck were merging all around their course and an intervening strip of skin appeared as a slightly raised transverse reddish ridge between two grooves making it difficult to distinguish the two marks as separate. But the presence of such a ridge is difficult to miss and we can predict the multiplicity of loops around the neck and the consistency of the ligature material accurately when hard materials are used. But soft and broad materials often show a single ligature mark even when multiple loops are used and predicting the multiple nature of loops is difficult in such cases.

The colour of the ligature mark varied as pale, reddish, pale brown, and dark brown in the study sample. Dark brown pressure abrasions accounted for 59% of cases. The colour of the ligature mark showed a significant association with the consistency of the ligature material used. When a hard ligature material was used the majority showed a dark brown ligature mark (93.7%) followed by a pale brown mark (5.3%) and a reddish mark (1.1%%). Soft ligature materials were associated with a pale brown mark (46%) followed by a dark brown mark (30.4%) and a pale mark (23.5%). In none of the cases, a pale mark was observed whenever a hard ligature material was used. Hard ligatures due to the roughness of their surface abrades the skin more compared to a soft and smooth material. Abraded skin in the pressure abrasion loses moisture gets a parchment look and appears much darker and drier with time.

The mark was non-continuous in 53.81% of the cases and continuous in 46.19% of the cases. Tumram et al.,[2] Ambade et al.[4] and Jayaprakashs S and Sreekumari K[1] also observed a classic non-continuous ligature mark in the majority of the cases. When the ligature material used was soft, the majority of the victims showed a non-continuous mark (70.4%) in the present study. However, when a hard ligature material was used, a continuous mark was seen in the majority of the victims (66.3%). This association between the consistency of ligature material and continuity of ligature mark was significant ($P < .01$ for Pearson χ^2: 28.27).

The mark was situated over and above thyroid cartilage in the majority (63.3%) and was obliquely placed in 99.05% of cases. The mark was situated above the level of the thyroid cartilage in 31.9% of cases and over the thyroid cartilage in 4.3% of cases. The mark was situated below the thyroid cartilage in only one case. The mark may appear transverse or below the level of the thyroid cartilage, when the point of suspension is low or when the noose made of thin and hard material tightens around the neck immediately after suspension of the body, making the upward slipping of the noose impossible or when the thin and hard ligature materials are wound around the neck multiple times by crossing the ends of the ligature material.

Grooving was present in 30.5% of study subjects. When the ligature material was a hard one, more than half of the victims showed grooved ligature marks (61.1%). When a soft ligature material was used, grooving was present in 5.2% of cases. A significant association was present between the consistency of ligature and the grooving of the ligature mark. Tumram et al.[2] observed grooved ligature marks in 53.7% of cases and hard materials like rope were used as the ligature material in all such cases.

The most common imprint pattern noted was the oblique fibre pattern of rope, seen in 31.9% followed by the weaving pattern of cloth in 2.4% of cases in the present study (Table 3). Among the cases with an oblique fibre pattern of rope, 94% used a plastic rope and 6% used a cotton rope as a ligature material. Weaving pattern of cloth was seen only in five cases of which the majority was produced when thorthu (a type of bath towel) was used as a ligature (three cases or 60%). The bed sheet was the other soft material imprinting its pattern to the ligature mark, seen in one case (20%). Interestingly the weaving pattern of cloth was observed when the ligature material used was a plastic rope in one case (20%), where a kitchen towel was used for padding the neck. So, it is not always the ligature that imprints its pattern in the ligature mark. Any material that gets entrapped between the ligature and the neck can influence the imprint pattern of the ligature mark. Tumram et al.[2] observed imprint patterns of ligature in 32.5% of cases, similar to the findings of the present study. Jayaprakash S and Sreekumari K[1] observed an imprint pattern of rope in 4.2% of cases.

Peri-ligature injuries like blisters, abrasions, ecchymosis and nail marks were observed in 21% of cases (Table 4). The commonest peri-ligature injury observed was blister (17.1%) followed by abrasion (2.9%). Ecchymosis and nail marks

Table 3. Distribution of Imprint Pattern of the Ligature on the Ligature Mark by the Type of Ligature Material.

	Imprint Pattern of the Ligature							
	Absent		Oblique Fibre Pattern of Rope		Weaving Pattern of the Cloth		Total	
Type of Ligature Material	No.	%	No.	%	No.	%	No.	%
Plastic rope	23	16.7	63	94	1	20	87	41.4
Coir rope	2	1.4	0	0	0	0	2	1
Cotton rope	0	0	4	6	0	0	4	1.9
Plastic thread	2	1.4	0	0	0	0	2	1
Thorthu	0	0	0	0	3	60	3	1.4
Bed sheet	15	10.9	0	0	1	20	16	7.6
Shawl	17	12.3	0	0	0	0	17	8
Saree	10	7.2	0	0	0	0	10	4.8
Lungee	69	50	0	0	0	0	69	32.9
Total	138	65.7	67	31.9	5	2.4	210	100

Note: Fisher's exact test: 170.275, $P < .01$.

Table 4. Distribution of Peri-ligature Injuries by the Consistency of Ligature Material.

	Consistency of Ligature					
	Soft		Hard		Total	
Type of Peri-ligature injury	No.	%	No.	%	No.	%
Blister	6	5.2	30	31.6	36	17.1
Abrasion	3	2.6	3	3.2	6	2.9
Ecchymosis	0	0	1	1.1	1	0.5
Nail mark	0	0	1	1.1	1	0.5
Absent	106	92.2	60	63	166	79
Total	115	54.76	95	45.24	210	100

Note: Fisher's exact test: 29.834, $P < .01$.

were rarely observed (0.5% of cases each). The majority of the cases (79%) did not show any peri-ligature injuries. When a hard ligature material was used 37% showed peri-ligature injuries compared to 7.8% where a soft ligature material was used. Blisters were more commonly associated with a hard ligature material (31.6% of cases that used hard ligature material) than a soft material (5.6% of cases that used a soft ligature material). Abrasions showed almost equal distribution among the two groups. Blisters were commonly seen either along the upper border (50%) or within the mark (47.2%). The majority of the abrasions were seen merging with the ligature mark (66.6%) and were situated either above or below the ligature mark (33.3% each). Abrasions not merging with the ligature marks were observed only in two cases. In one case the abrasion was situated below the ligature mark and in the other case, it was situated above the ligature mark.

A significant association was present between the type of peri-ligature injuries with the consistency of the ligature material and between the type of peri-ligature injury and the location of the peri-ligature injury in the present study. Blisters are produced due to heat generated by friction between the loop of ligature and the skin of the neck. The maximum amount of friction is seen along the upper border in the case of single or multiple loops and the intervening skin trapped between the loops in case of multiple loops and hard ligature material tends to exert more friction than soft. This might be the reason why blisters are more commonly associated with hard ligature material than soft materials and their peculiar locations. Abrasions merging with the ligature mark might be due to the slippage of ligature upwards during the act of hanging due to the gravitational drag by the weight of the body. Jayapraksh S and Sreekumari K[1] also noted blisters along the margins in 2.1% of cases when the synthetic rope was used as ligature material. Tumram et al.[2] also noticed peri-ligature injuries like blisters, abrasions, and ecchymosis when hard materials like ropes were used and abrasions and ecchymosis were noted with soft ligature material. Tumram et al.[2] noted peri-ligature blisters on the upper border and abrasions below the ligature mark in the majority of the cases. The presence of peri-ligature injuries strongly suggests an

Table 5. Distribution of the Appearance of the Subcutaneous Tissue by the Consistency of Ligature Material.

The Appearance of Subcutaneous Tissue	Consistency of Ligature Material				Total	
	Soft		Hard			
	No.	%	No.	%	No.	%
Pale	41	35.7	5	5.3	46	21.9
Pale and dry	72	62.6	90	94.7	162	77.1
Normal	2	1.7	0	0	2	1
Total	115	54.76	95	45.24	210	100

Note: Fisher's exact test value: 32.968, $P < .01$.

Table 6. Distribution of Infiltration of Blood on the Lower End of Sternocleidomastoid Muscle by the Degree of Suspension.

Degree of Suspension	Infiltration of Blood in the Lower End of the Sternocleidomastoid Muscle								Total	
	Intact		Right		Left		Both			
	No.	%	No.	%	No.	%	No.	%	No.	%
Complete hanging	123	62.4	0	0	2	66.7	7	77.8	132	62.9
Standing with feet flat on the ground	30	15.2	0	0	0	0	0	0	30	14.3
Standing with toes touching the ground	20	10.2	0	0	0	0	0	0	20	9.5
Standing with knees partially flexed	11	5.6	1	100	0	0	0	0	12	5.7
Kneeling	13	6.6	0	0	0	0	2	22.2	15	7.1
Found lying on the ground due to breakage of ligature	0	0	0	0	1	33.6	0	0	1	0.5
Total	197	93.8	1	0.5	3	1.4	9	4.3	210	100

Note: Fisher's exact test value: 29.008, *P* value: .026.

antemortem origin but abrasions can happen during the perimortem period or resuscitation. Ecchymosis situated below the level of ligature mark is more likely to be antemortem as it will not be influenced by stasis of blood in the engorged blood vessels due to constriction by the loop of ligature.

Salivary dribble mark, an antemortem sign of hanging was observed in 18.6% of cases in the present study. A salivary dribble mark was observed in none of the cases when the knot was submental in position or on the face. It was present on the right side when the knot was left subaural (75%), left occipital (15%) or occipital (5%) in position. Salivary dribble was seen on the left side when the knot was right subaural (57.1%), occipital (7.1%) or right occipital (35.7%) in position. Ambade et al.[4] noted salivary dribble in only 11.8% of cases. Evidence of excessive salivation is more of a crime scene finding than a postmortem room finding. A long postmortem interval and manipulation of the dead body by external agencies such as the removal of clothes worn by the victim and wiping the body of the victim often result in the loss of this finding. This might be the reason behind such variation in the frequency of distribution among different studies. So, educating the investigating officers regarding the significance of such findings and the importance of recording and preservation of such findings is necessary from the medicolegal point of view.

The subcutaneous tissue underneath the pressure abrasion was pale and dry in the majority of the cases (77.1%) (Table 5). When a soft ligature material was used the subcutaneous tissue appeared pale and dry in 62.6% of cases, pale in 35.7% of cases, and normal in 1.7% of cases. Among the victims who used hard ligature material, the subcutaneous tissue appeared pale and dry in 94.7% of the cases and pale in 5.3% of cases. Only two cases showed normal subcutaneous tissue and the ligature material used was a soft one in both cases. There was a significant association between the consistency of ligature material and the appearance of subcutaneous tissue. Ambade et al. noted pale and dry subcutaneous tissue in 78.7% of hanging deaths. Jayaprakash S and Sreekumari K[1] noted that in 95.8% of hanging deaths, the subcutaneous tissue was pale and dry. The observations of the present study are consistent with the findings of previous studies.

Sternocleidomastoid muscle showed infiltration of blood in the lower end in 6.2% (13 cases) of cases in the present study (Table 6). In 4.3% of cases, both sternocleidomastoid muscles showed infiltration of blood in their lower end. In

Table 7. Distribution of Fracture of the Thyroid Cartilage to the Position of the Knot.

	Fracture of Thyroid Cartilage							
	Intact Thyroid Cartilage		Fracture of Right Superior Horn		Fracture of Left Superior Horn		Total	
Position of Knot	No.	%	No.	%	No.	%	No.	%
Right subaural	39	19.5	0	0	0	0	39	18.6
Left subaural	60	30	0	0	4	66.7	64	30.5
Right occiput	27	13.5	2	50	0	0	29	13.8
Left occiput	27	13.5	0	0	2	33.3	29	13.8
Submental	12	6	2	50	0	0	14	3.7
Occiput	34	17	0	0	0	0	34	16.2
Face	1	0.5	0	0	0	0	1	0.5
Total	200	95.2	4	1.9	6	2.9	210	100

Note: Fisher's exact test value: 19.806, *P* value: .020.

1.4% of cases, only the left sternocleidomastoid showed infiltration of blood in its lower end, and in 0.5% of cases, only the right sternocleidomastoid muscle showed infiltration of blood in its lower end. Most of the cases showing infiltration of blood in the lower end of the sternocleidomastoid muscle belonged to the group of complete hanging (9 out of 13 cases), agreeing with the results of Hejna and Zatopkova.[7] Hejna and Zatopkova[7] stated that there is a significant association between the position of the knot on the neck and the completeness of suspension with the occurrence of haemorrhage. A significant association was noted between the degree of suspension and infiltration of blood in the lower end of the sternocleidomastoid muscle in the present study. Among the 13 cases with infiltration of blood in the sternocleidomastoid muscle, a hard ligature material was used in nine cases and a soft ligature material was used in four cases. Sivasuthan S et al.[8] noted rupture of the lower end of the sternocleidomastoid in 62% of cases and attributed it as an antemortem sign of hanging. Jayaprakash S and Sreekumari K[1] noted sternocleidomastoid muscle injury in 19.2% of cases on the same side of the knot but the present study did not find any such association with the position of the knot.

In the present study, the fracture of thyroid cartilage was noted in 4.76% of cases (Table 7). All were superior horn fractures. When the left superior horn was seen fractured, the position of the knot was either left subaural (66.7%) or left occipital (33.3%). The right superior horn fracture was associated with the knot position of the right occipital and submental (each 50%). There was a significant association between the position of the knot and fracture of the thyroid cartilage in hanging deaths in the present study. Similar to the results of the present study, isolated fracture of the superior horn of thyroid cartilage was the most common type of injury encountered in deaths due to hanging in studies conducted by Jayaprakash S and Sreekumari K,[1] Zatopkova et al.,[12] Khokhlov,[9] Kurtulus et al.[10] and Nikolic et al.[11] Zatopkova et al.[12] noted the maximum incidence of fracture of the thyroid cartilage in lateral hanging (knot was on sides of the neck) which is in agreement with the present study. But, according to Nikolic et al.[13] occipital, right occipital and left occipital knot positions were commonly associated with superior horn fracture. The hyoid bone fracture was noted only in 1.5% of cases in the present study. The knot was on the back of the neck in all the cases (occipital in two cases and left occipital in one case), agreeing with Kurtulus et al.[10] that the commonest knot position was occipital in the case of hyoid fracture. A posterior knot position exerts maximum compression over the anterior aspect of the neck by the ligature material, resulting in maximum divergence stress in greater horns causing their fracture. Cervical spine fracture was observed in 2.4% of cases in the present study. All of them were associated with a submental position of knot. The fracture level was between C3 and C4 (1% of cases) and between C5 and C6 (1.4% of cases). A significant association was observed between cervical spine injury and the position of the knot. These findings tally with Nikolic and Zivkovic[14] that anterior knot position is associated with cervical spine injuries. Hyperextension and distraction of the cervical spine during hanging with a submental positioning of the knot are responsible for cervical fractures in hanging.

Conclusion

The classic non-continuous ligature mark which is situated over and above the level of thyroid cartilage was observed in the majority of the cases. Imprint pattern of the ligature material, grooving, the continuity of the ligature mark, and peri-ligature injuries showed a significant association with the consistency and type of ligature material used. The thyroid cartilage fractures and the cervical spine fractures showed a significant association with the position of the knot.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Ethical Approval and Informed Consent

The study was commenced after approval of Institution Ethics Committee, Government Medical College, Thiruvananthapuram. Prior to data collection, informed written consent was taken from next of kin of the decedent and anonymity was maintained throughout the study.

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Perception of Students Toward Traditional Teaching and Online Teaching Methods During 2nd Year MBBS

Journal of Indian Academy of Forensic Medicine
46(3) 391–396, 2024

DOI: 10.1177/09710973251316361
journals.sagepub.com/home/iaf
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Abstract

Education has been compromised by the COVID-19 pandemic. Due to the crisis, online teaching is provided as an ideal teaching and learning environment by educationists as an adjunct to traditional teaching. E-learning has become beneficial in academic and epidemiological aspects. Initially, distance education courses alone used E-learning methods, but now it has developed to be part of any formal education. To evaluate whether online methods are convenient for students compared to traditional methods.

This descriptive study period was three months with a sample size of 183 MBBS students. The questionnaire (variables) was classified into General, Academics, and Evaluation which was mailed to students as Google Form with feedback form. The Likert Scale was used to evaluate the questionnaire. A comparison was made between traditional and online teaching. Based on the data obtained, calculations were done using the Likert Scale. Among the total study participants, the majority said that the traditional teaching method was interesting, useful and more effective compared to online teaching. This study concluded that traditional teaching has more advantages such as orientation knowledge, learning skills, problem-solving, level of concentration, questioning, reflections, and feedback sessions related to clinical and practical knowledge compared to online teaching.

Keywords

Perception, e-learning, traditional teaching, online technology, knowledge, effective

Received 05 December 2023; **accepted** 20 May 2024

Introduction

In recent years, digitalization has been included in the Indian educational system. Though the start is slow, its growth is increasing every year. As developed countries have changed swiftly to a digital world, developing countries like India are adapting to the new phase of the digital world. Medical education is the prime face of Indian education seeing different kinds of challenges over the decades. From its evolution to its advancement, the field of medicine is continuously upgrading its people (faculties & students). Over the years, teachers taught with blackboards and with advancements in technology, these boards have been replaced by multimedia like PowerPoint presentations (PPT's). Faculties of the medical field are being trained with updation to keep the students on track with the subject through modern technology. This has been achieved as the system is changing from lecture-based education to a student-based education.[1] Studying MBBS is a lifelong process of learning and practice for a desirable outcome. For medical students, this outcome primarily reflects on the knowledge, skills and ability to perform, irrespective of the teaching methods.[2]

The concept of E-learning is the application of technology in education.[3] It has become a part of the curriculum along with the traditional teaching and learning methods. Online learning is one of the multifaceted modes of technology adopted by the faculty and students to cope with the pandemic lockdown.

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COVID-19 pandemic crisis has made a great impact on the educational sector, the learners were affected especially during the lockdown, imposed worldwide to stop the disease's spread. In India, 19% learners were using online methods. Coursera, an online platform for educators and learners reported that 18 million globally, in which 1.3 million in India were using online methods, thus making India the 3rd largest online user in the world.[4] Teaching–learning methods are achieved by various methods such as basic online approach, blended learning, flipped classrooms, and enhanced learning by using advanced technologies etc.[5] These variants are provided by many interactive tools which are available globally, such as Zoom, WhatsApp, WeChat, Skype etc.[6] In the Indian scenario, though global tools are used for online teaching, its limitations are more. To overcome these limitations, the Government of India has developed National portals, such as Swayam and E–PG Pathshala, where education is for everyone with very minimal limitations.[7]

Materials and Methods

The study was done for three months, conducted with 2nd-year students who were referred to the Department of Forensic Medicine and Toxicology, MGMCRI, Puducherry**.** The study design was a hospital-based cross-sectional study with a sample size of 183 (male: 80 nos. and Female: 103 nos.). Study participants were selected based on the inclusion and exclusion criteria. Volunteering students (male & Female) of 2nd year MBBS, who were above 18 years of age are included in the study. Students who are not willing to participate are excluded from the study.

Study Procedure

The study was conducted with the 2nd year MBBS students (male & female), who were willing to participate and have undergone equal time duration of online and offline (contact) classes, in the Department of Forensic Medicine and Toxicology, a written informed consent was obtained from the students. A common questionnaire was mailed to the participating students individually as a Google Form, from the Deanery of MGMCRI. The filled-in Google forms (questionnaire) were mailed back to the Deanery by the students on a given date and time. These forms were handed over to the Principal and Co-Principal investigators by the Deanery, after masking the student's identity. The investigators, after collecting all the completed Google forms, studied the replies given by the students and were automated into percentages according to the questions answered for each criterion, to know their perception. The study tool used is the Likert Scale. The Likert Scale ratings were categorized as, Good: 1; Average: 2, and Poor: 3. The variables were classified into three parts, such as general, academics, and evaluation.

Statistical Analysis

The data were collected and recorded in a systematic way. The collected data were categorized into demographic information perception variables used (General, Academics, and Evaluation) as numerical values in the form of tables. Secondary sources are used for reviewing the concept and supporting the findings. The data are analyzed by using Statistical Package for Social Science (SPSS) version 25. The results were projected in the form of tables and graphs as required.

Result

The study participants answered the questions given in the questionnaire categorized under three different parts such as Part #1: General (eight questions), Part #2: Academics (five questions), and Part #3: Evaluation (A–E five questions). The answers received from the study participants were analyzed, tabulated in the form of tables and obtained the following results. Based on the tables the graphical representation charts are prepared. In the total study participants 183 nos., the gender classification was done and it was recorded as male (43.7%) 80 nos. and female (56.3%) 103 nos. The questionnaire Part #1: General, was prepared in consideration of the following points, such as the ability to freely interact with the faculties, the needs of the students being fulfilled, the environmental set-up, support from parents, genuine tests conducted, the urge to study more, the value of book's and providing feedback to the faculties. The result was found that the majority of the study participants chose the traditional teaching method as interesting, useful and more effective, which are not found satisfactory when they attend the online teaching method as shown in Table 1.

Based on the questionnaire Part #2: Academics, the result was found that the majority of the study participants chose the traditional teaching method, based on their interest in the subject, level of knowledge gained, the integrity of PPTs, level of their effort in studying the subject and level of interest shown by the faculty, as shown in Table 2.

In this study, questionnaire Part #3: Evaluation, it was found that the majority of the study participants preferred the traditional teaching method based on the MCQs, Short Answers, Assignments, Seminar, Viva Voice, the way they are evaluated by their parents and the level of satisfaction with their performance and results when compared to online teaching method as shown in Table 3.

The majority of the study participants (80.3%) 147 nos. responded that they are more comfortable with traditional teaching (classroom teaching) out of 183 study participants in which males were 64 nos and females were counted to 83 nos. Out of 183 study participants, 13 (7.1%) preferred online teaching (E-learning), of which males were eight nos. and females were five nos. Similarly, 23 nos. (12.6%) preferred both the teaching methods (traditional teaching and online teaching) out of the total study participants, with males 4 (4%) and females 2 (2%).

Table 1. Classification of questionnaire Part #1: general.

Questionnaire—Part #1: General							
		Traditional Teaching			Online Teaching		
Sl. No.	Questions	Good	Average	Poor	Good	Average	Poor
1	Are you able to freely interact with the faculties?	113	53	17	54	105	24
2	Do you feel the needs of the students are fulfilled?	122	51	10	44	100	39
3	How do you feel about the environmental set-up?	130	35	18	69	75	39
4	How much support do you get from your parents while you are in college & at home?	123	40	20	114	37	32
5	How genuinely the tests are conducted?	126	41	16	55	82	46
6	Where do you feel the urge to study more?	138	35	10	47	72	64
7	How do you feel about the value of books while you are in?	132	36	15	80	72	31
8	How do you feel about providing feedback to the faculties?	108	61	14	83	73	27

Table 2. Classification of questionnaire Part #2: Academics.

Questionnaire—Part #2: Academics							
		Traditional Teaching			Online Teaching		
Sl. No.	Questions	Always	Sometime	Never	Always	Sometime	Never
1	Interest in the subject?	125	57	1	44	107	32
2	Level of knowledge gained?	127	56	0	36	123	24
3	Integrity of PowerPoint presentations?	123	58	2	94	69	20
4	Level of your effort in studying the subject?	124	59	0	47	107	29
5	Level of interest shown by the faculty?	158	24	1	118	56	9

Table 3. Classification of questionnaire Part #3: evaluation.

Questionnaire—Part #3: Evaluation							
		Traditional Teaching			Online Teaching		
Sl. No.	Questions	Always	Sometime	Never	Always	Sometime	Never
1	How do you feel you are evaluated in a subject through:						
1A	MCQ's	114	45	24	89	68	25
1B	Short answers	131	39	13	57	94	32
1C	Assignments	105	47	31	100	39	44
1D	Seminar	107	53	23	102	46	34
1E	Viva voice	138	29	16	115	37	31
2	How do you feel the way you are evaluated by your parents?	116	58	9	93	70	20
3	Level of satisfaction with your performance and results?	105	61	17	58	92	33

The overall result obtained from this study is found that the most effective method of teaching strongly preferred by the study participants was the traditional teaching method (classroom teaching).

Discussion

Diversity in teaching is always a major tool in traditional teaching methods, though faculties try to incorporate the same in online teaching. The use of different techniques always gains the student's attention leading to better concentration during traditional, where there is always a question of "How much?" in online mode. Students are motivated by the faculty to adhere to the subject as the goals and objectives of the topic remain the same and by providing equal opportunity to everyone either traditional or online mode of education.

Students exhibit a better level of knowledge, skills and attitude while interacting in person, whereas the seminar online

becomes a non-communicative dialect. The question and answering sessions give an idea about the understanding level of students of a particular year, educated through a traditional or Conventional method, with that of an online method.

Makhdoom et al., stated that in the online teaching method communication gap, face-to-face interaction and student-staff teamwork are not found up to the level. In addition, the online teaching method does not improve the perception of students based on the education environment.[8] In our study, the study participants summarized that they always strongly prefer the traditional teaching method (classroom teaching) of teaching in lecture halls as that makes a student more sincere and increases their concentration capabilities

Hugenholtz et al., stated in their study, that no significant difference was found between online teaching and traditional teaching of the medical doctors in constant learning was performed and reported.[9] In our study, some of the study participants said that both traditional teaching and online teaching methods are comfortable for them, but they are stressed/tired of staying home for a long time due to the pandemic COVID-19 and they need to go back to college.

The traditional teaching method has proved to be the best method of teaching when compared to the other teaching methods. The disadvantages of online teaching/E-learning are clearly stated in the studies conducted by the following authors at various periods/years. Collins et al.,[10] Scott et al.,[11] Lewis et al.,[12] Almosa et al.,[13] Marc et al.,[14] Dowling et al.,[15] Klein et al.,[16] Akkoyuklu et al.,[17] and Hameed et al.,[18] In our study, based on the study participants it is found that traditional teaching method is always preferred more when it is in consideration with the practical knowledge is more important for medical students.

Online teaching always gives on to the usage and obstruction of various websites which are used for learning. This makes the students meet the unexpected expenses in an aspect of money and time which are stated in the following authors' Collins et al.,[10] Klein et al.,[16] Hameed et al.,[18] Almosa,[13] Akkoyuklu et al.,[17] Lewis et al.,[12] Scott et al.,[11] and Marc et al.[14] In our study, the traditional teaching method is found better as the unexpected expenses in terms of money and time are avoided when compared to online teaching (E-learning).

Burdman et al.,[19] Young et al.,[20] Bettinger et al.,[21] Kaur et al.,[22] stated in their study, that classroom teaching competes for the limitations such as knowledge gained by an interaction between the teacher and students which is not meeting the level of interaction during online teaching. In our study, it is found that the traditional teaching method is best for the practical part in which the students learn better and they get exposed to the specimens and slides.

Ni et al., concluded in their study that, classroom-based teaching (traditional teaching) is the most effective and preferable method of teaching because teacher-student interaction and communication are very important while learning.[23] In our study, the study participants opted traditional teaching method as the best practice for communication between teachers and students. This method also increases comfort when face-to-face interaction occurs between teacher-students and their colleagues.

Kemp et al. and Grieve et al. stated in their study that dynamic learning attributes are found only when the students and staff interact face-to-face.[24] Xu et al., stated in their study that the communication between the students and staff has several benefits when the interaction is done face-to-face.[25] In our study, the majority of the study participants strongly preferred the traditional teaching method as it is conducted in lecture halls which makes the students more sincere and increases their concentration capabilities.

Roval et al. and Jordan et al., stated in their study that dynamic learning attributes are found only when the students and teachers cooperation, in face-to-face interactions, in teacher-student bonding and in discussions held during pre- & post-class.[26] In our study, the traditional teaching method is found to be the best teaching method because students can easily contact teachers in person, get more knowledge in hands-on training during practical sessions and they gain more time in the aspect of getting clarified to their doubts.

Kemp et al. and Grieve et al., stated in their study that the style of teaching and class structure may be adjusted to improve the retention of the students.[24] In our study, we found that as the study participants are from medical college they prefer the traditional teaching method in which the interactions between the teacher and students occur in the classroom which makes them feel comfortable because of the classroom infrastructure and the teaching style improves the concentration of students more.

Similarly, several authors Wentling et al.,[27] Marc et al.,[14] Nichols,[28] Klein et al.,[16] Hameed et al.,[18] and Algahtani et al.,[29] in their studies stated that online teaching has many advantages and benefits. They concluded that E-learning/online teaching should be considered the best education method. In addition, they said that the new technologies shall be incorporated into E-learning/online teaching in schools and in higher education according to the current development which may result in the best knowledge of the students. In our study, a very minimal study participants stated that they feel both techniques have their own advantages and disadvantages.

In other studies, the authors Urdan and Weggen,[30] Codone et al.,[31] Marc et al.,[14] Klein et al.,[16] Amer et al.,[32] and Algahtani et al.[29] stated that online teaching makes students make the speed of learning according to their capacity which results in reduction of stress and satisfies their learning. In our study, in the online teaching method (E-learning) the study participants faced internet connectivity problems and this ruined everything during the class, question-answer sessions and viva voice. They requested that during the online classes, the lectures be taken without wearing masks.

Maniar et al.[33] and Elias et al.,[34] stated that online teaching has the disadvantage that the hardware/equipment (mobile/laptop) merely relies on technology which may fail or be inadequate related to insufficient battery life or

inadequate screen size of the hardware/equipment used. In our study, we found that the majority of the study participants preferred the traditional teaching method because during online classes they may not be attentive at all times and they are facing severe problems with internet connectivity, especially during viva voice they are not able to cooperate with the clarity of voice on both sides. But Clark et al., stated in their study that the delivery of teaching content based on websites and teleconferences is found effective as classroom teaching.[35]

To overcome the disadvantages of online teaching, both the traditional teaching and online teaching methods should be combined together and it should be a mixed teaching method while handling the classes. The same was also supported by author Dodiya et al. in the study.[36,37]

Limitations

The present study sample size was limited to 2nd-year MBBS students. The sample size can be increased by including 1st, 3rd Part I & Part II MBBS students.

Conclusion

The mainstay of the program outcome and course outcome always remains the same to date, irrespective of the learning methods. Does a student who was taught by the traditional method and a student taught by the online teaching method exhibit the same level of skills and attitude at the time of practice? In our study, we concluded that the traditional teaching method (classroom teaching) is the best method of teaching and learning when compared to the online teaching (E-learning) method.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

The ethical clearance for the study was obtained from the Institutional Ethical Committee of Mahatma Gandhi Medical College and Research Institute (MGMCRI), Puducherry.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Informed Consent

Written informed consent was obtained from the study participants after explaining the study procedure.

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Study of Effective Communication Skills Among Medical Practitioners of Raichur District, North Karnataka: A Cross-sectional Study

Journal of Indian Academy of Forensic Medicine
46(3) 397–400, 2024

DOI: 10.1177/09710973251316360
journals.sagepub.com/home/iaf
Sage

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Abstract

Effective communication is an essential part of building and maintaining good physician-patient and physician-colleague relationships. It has been shown to significantly impact patients' satisfaction, care, and further, to improve healthcare outcomes. The aim of the present study was to evaluate the attitude of medical practitioners in the Raichur district toward effective communication in practice**.** It was a cross-sectional study undertaken at the urban field practice area of Navodaya Medical College, Raichur. The study included a total of 60 medical practitioners from private and government hospitals. All participants were invited to participate in the study during December 2020. The majority of the participants have a positive opinion toward greeting the patient (86.7%), informed consent (86.7%), confidentiality (90%), and explaining the medication doses (93.4%). The age of the medical practitioners was significantly associated with effective communication skills ($P < .005$). Other factors like gender and years of practice were not significant. Physician communication skills are critical in gaining patients' happiness and confidence in their doctors. Initiatives and training to generate a trained workforce might strengthen doctor-patient relationships, reducing future healthcare system disagreements and institutional mistakes.

Keywords

Effective communication, medical practitioners, Raichur, cross-sectional

Received 26 December 2023; **accepted** 11 March 2024

Introduction

Communication skills are verbal and non-verbal words, phrases, voice tones, facial expressions, gestures, and body language that you use in the interaction between persons. Effective communication is an essential part of building and maintaining good physician-patient and physician-colleague relationships. It is a central clinical function in building a therapeutic relationship. A large part of a medical career involves both verbal and non-verbal transmission of information to the patient and to the nursing team and vice versa.[1]

It has long been recognized that difficulties in the effective delivery of health care can arise from problems in communication between patient and provider, rather than from any failure in the technical aspects of medical care. Improvements in provider-patient communication can have beneficial effects on health outcomes.[2]

Communication skills are essential for medical practice.[3] Interpersonal communication skills of physicians have been shown to significantly impact patients' satisfaction, care and further, to improve healthcare outcomes. Even the WHO (World Health Organization) in its Global Competency Model has advised to include interpersonal skills in a credible and effective way as a core competency of a practicing physician.[4]

Violence against doctors or other medical fraternities hardly made any news, and there is no discussion about this in India in medical journals. About a decade back they were probably infrequent though such violence in Western countries was known.[5,6] Traditional teaching methodologies in medical colleges give the students adequate knowledge about treatment and diagnosis but

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very few address communication skills and how to deal with patients. Better communication between doctor and patient builds confidence, improves compliance, and reduces mistakes and mishaps, thereby reducing malpractice suits.[7–9]

Association of American Medical Colleges Cincinnati, the expert panel identified seven components considered to be fundamental to all encounters between clinician and patient: build the relationship, open the discussion, gather information, understand the patient's perspective, share information, reach agreement on problems and plans, and provide closure.[4–6]

The aim of the present study was to evaluate the attitude of medical practitioners of the Raichur district toward effective communication in practice and to compare the extent of communication skills with various demographic factors. There are very limited studies available on this context in Raichur district, Karnataka and the findings of this study could serve as baseline information for future studies.

Materials and Methods

Study Setting

It was a cross-sectional study undertaken at the urban field practice area of Navodaya Medical College, Raichur. Study participants were interviewed at their clinics/nursing homes. The study was conducted in December 2020. The study included all the clinical practitioners who were willing to participate in the study by giving their valid consent.

Sample Size

The study included a total of 60 medical practitioners from private and government hospitals in Raichur and their 60 corresponding patients. All doctors and patients were invited to participate in the study during December 2020.

Data Collection

The participants were requested to provide written consent and they were informed about their right to participate or withdraw from the study, and that their responses will be subjected to analysis and could be published with anonymity.

The Communication Skill Attitude Scale (CSAS) is a widely used instrument to measure the attitude of medical students toward learning communication skills and has been extensively validated. Each item in the questionnaire is accompanied by a 5-point Likert scale: 1 = "strongly disagree," 2 = "disagree," 3 = "neither agree nor disagree," 4 = "agree," and 5 = "strongly agree."

The first part of the standardized (by asking the same questions to everyone) questionnaire for doctors included questions of socio-demographics (age, year of completion of, years of experience of medical practice, working in the government or private healthcare sector) the second part included items on communication skills (Greeting the patient on arrival, Enquiring about the name and background of, Language, patient listening and attention) and the last part included—implementation of effective communication skills ("Do you think communication skills are important for a physician?" "Do you think you should be taught communication skills as a part of your curriculum?" and "Do you think you can actually learn communication skills?"

Results

In the present study, a total of 60 doctors who were private practitioner and their 60 corresponding patients were subjects for the interview for the purpose of meeting the required objective.

Discussion

In our present study (Table 1), the majority of the participants believed that greeting the patients, enquiring to know the background history, making a patient comfortable, obtaining valid informed consent, confidentiality, and educating the patient on disease outcomes and prognosis are part of good and effective communication skills.[10,11]

The capacity of a physician to speak with his patient in a nice manner is regarded as the most significant aspect of medical art, and it is essential for a physician to develop this skill. If the physician had adequate communication skills, he could get vital information regarding the patient's physical and mental condition. The medical field in developing nations is transitioning from a physician-centered to a patient-centered approach to care. Rezaei et al. found a link between physicians' interest in listening to their patients and patient satisfaction in their research.[10] A similar study done by Khatri R et al. in Nepal, poor communication has often been cited as one of the reasons for increased violence against both healthcare professionals and health facilities.[11]

More than half of the participants in our study feel that the language barrier, being accessible to patients always, lack of time to understand the mental health of patients, and the cost of treatment underlines the effective communication between treating doctor and patient (Table 1). These findings were supported by Kumari A et al.[12]

In this study, the age of the treating doctor was found to play a significant role in achieving a good and effective communication skill with patients (Table 2) ($P < .05$). Other factors, like years of practice or experience, gender, and place of work, were not found to be statistically associated ($P > .05$). A similar study done by Marambe et al. and Varna J et al. reported better communication skills among female doctors when compared to male.[13] Outside the medical context, females tend to have warmer and more engaging conversations, encourage others to open up, and express more empathy. The patient's happiness is influenced by the explanation of the diagnostic and treatment procedure. This is consistent

Table 1. Distribution of Participants' Responses for Improving Effective Communicative Skills Between Patient and Doctor.

Sl. No.	Questions	Agreement No. (%)
1	Greeting the patient on arrival	52 (86.7)
2	Enquiring about the names and backgrounds of patients	50 (83.4)
3	Taking proper steps to make the patient comfortable	50 (83.4)
4	Being a good patient listener	26 (43.4)
5	Language can become a barrier	30 (50)
6	Important to take informed consent from patients	52 (86.7)
7	Confidentiality and respect for patient's privacy	54 (90)
8	Explaining the need for admission	50 (83.4)
9	Explaining medication to the patients	56 (93.4)
10	Being accessible to all my patients - anytime	24 (40)
11	Explaining the need for all medical tests	44 (73.3)
12	Making an effort to understand health issues impacting patient's mental health and quality of life	18 (30)
13	Being disease-centric while treating a patient	26 (43.3)
14	Importance of investing time in explaining the treatment options to patients	50 (83.4)
15	Educating the patients regarding the disorder	38 (63.4)
16	Discussing the effect of illness on the patient's family	48 (80)
17	Educating patients to take care of themselves	52 (86.6)
18	Dealing with negative outcomes of treatments	36 (60)
19	Explaining to the patient in simple understandable language	40 (66.7)
20	Involving patients in decision-making for treatment options	44 (73.3)
21	Discussing the cost of the treatment and tests prescribed	42 (70)
22	Taking specific steps to ensure comfort and responsiveness in patient	48 (80)
23	Implementing values of communication skills	58 (96.7)
24	Incorporating evaluation to enhance communication skills during internship training	46 (76.6)
25	Including communication skills as a part of the practical requirement for undergraduate training	50 (83.4)
26	Increase awareness about ethics by implementing real-life scenarios	54 (90)

Note: CSAS scale.

Table 2. Association Between Socio-demographic Factors and Observed Opinions of Doctors in Improving Effective Communication Skills.

			Communication Skills				
Sl. No.	Factor	Categories	Positive	Neutral	Negative	χ^2	*P* Value
1	Age	<25	2 (50)	2 (50)	0 (0)	22.47	.004
		26–30	10 (55.6)	8 (44.4)	0 (0)		
		31–35	10 (83.3)	0 (0)	2 (16.7)		
		36–40	14 (87.5)	2 (12.5)	0 (0)		
		>40	10 (100)	0 (0)	0 (0)		
2	Years of practice	<5	12 (60)	8 (40)	0 (0)	14.261	.075
		6–10	14 (70)	4 (20)	2 (10)		
		11–15	8 (100)	0 (0)	0 (0)		
		16–20	2 (100)	0 (0)	0 (0)		
		>20	10 (100)	0 (0)	0 (0)		
3	Gender	Male	26 (76.5)	6 (17.6)	2 (5.9)	1.747	.417
		Female	20 (76.9)	6 (23.1)	0 (0)		

with the study done by Suh et al. from his research. There was also a strong link between doctors' friendliness and patient satisfaction.[14]

This is understandable since everyone enjoys being treated with respect. According to the findings of research done by Korsch et al., there is a substantial link between patient

satisfaction and doctors' courteous behavior.[15] Effective communication is a necessary skill for providing high-quality patient care and developing compassionate and mutually respectful patient-doctor partnerships.

According to studies, student's communication abilities deteriorate as they become older. Medical students are more interested in medical situations and information, even though this may accidentally lead to a lack of communication skills.[16] Other studies, on the other hand, have shown no change in students' attitudes about developing communication skills over time.[17] it is a good idea to start teaching communication skills early in the undergraduate medical curriculum. Because attitude is a learned response that can be changed, intervening early is more likely to result in quicker positive adjustments. In fact, the early years may be crucial in developing skilled and successful future doctors.[18,19]

Conclusions

Physician communication skills are critical in gaining patients' happiness and confidence in their doctors. Initiatives and training to generate a trained workforce might strengthen doctor-patient relationships, reducing future healthcare system disagreements and institutional mistakes. Because of this, favorable attitude toward developing communication skills, progressive integration of communication skills curriculum into undergraduate medical education may help to strengthen doctor-patient relationships and reduce institutional violence. Faculty development initiatives and training to generate a trained workforce in the nation might also strengthen doctor-patient relationships.

Acknowledgment

We acknowledge all the participating doctors of urban area of Raichur.

Data Analysis

Data were analyzed using SPSS version 21. Cronbach's alpha was used to measure the consistency of items within the scale. Chi-squared test was done to find the association between different demographic variables and study questions with the Communication Skills Attitude Scale. The numerical values were expressed as mean ± SD and categorical variables as percentages.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee—Navodaya Medical College (IEC/NMC/2020/12-10).

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Informed Consent

Informed consent from the participants were taken.

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Original Article

The Ethical Considerations and Impact of Children Taking Part in Dance Competitions

Journal of Indian Academy
of Forensic Medicine
46(3) 401–406, 2024

DOI: 10.1177/09710973251316355
journals.sagepub.com/home/iaf
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Abstract

Introduction: The rise of professional dance competitions has introduced children to a highly structured and competitive environment. While these events provide opportunities for skill development, they often expose minors to physical and psychological risks. Parents' aspirations for fame and financial gain, combined with the allure of immediate rewards, drive many children into competitive dance. However, this environment poses ethical concerns and challenges, particularly regarding child labor, physical injuries, and the psychological impact on young participants.

Background: Dance competitions have evolved into a complex industry involving various stakeholders, including organizers, parents, and educators. The culture encourages early and intense participation, sometimes at the expense of children's formative experiences and leisure activities. Modern competition formats prioritize rewards over traditional placements, raising concerns about the impact of such systems on young dancers' well-being and social development.

Ethical Considerations: The participation of children in dance competitions highlights ethical dilemmas. These include the physical demands placed on immature bodies, the psychological strain of high expectations, and the questionable motivations of parents and organizers. The pressure to achieve early success often compromises children's autonomy, rest, and holistic development. This scenario frequently aligns with definitions of child labor and abuse, as outlined by international frameworks like the United Nations Convention on the Rights of the Child.

Impact on Health: Children engaged in competitive dance face a heightened risk of injuries, such as musculoskeletal disorders and overuse syndromes. Psychologically, the competitive atmosphere can induce stress, behavioral changes, and depressive episodes, particularly following losses. The transition from informal dance to professional competition often disrupts their social and academic lives, leading to long-term repercussions on their overall well-being.

Case Analysis: The unexplained demise of a young dancer during a competition underscores the grave risks associated with this activity. Stakeholders often evade responsibility for such incidents, leaving critical ethical and legal questions unanswered.

Conclusion: In conclusion, while dance competitions provide opportunities for skill development and social bonding, they also pose significant risks to children's social development, well-being, and rights. The emphasis on winning over learning can negatively impact young dancers' lives, limiting their exploration of other interests and causing physical, behavioral, and psychological harm. Participation in such events often aligns with definitions of child abuse or mild child labor, as children face compromised rights, ethical dilemmas, and undue pressure from parents and organizers. A balanced, child-centered approach is essential to ensure their holistic development and safeguard their well-being.

Keywords
Child labor, parents, child health, child rights

Received 23 August 2024; **accepted** 01 November 2024

Introduction

In contemporary discourse, there has been an increasing trend within the entertainment sector towards the facilitation of professional dance competitions. In numerous instances, children may find themselves subjected to exploitation by either the organizers or the parental figures who encourage their participation for the purposes of notoriety and financial

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gain. These dance competitions are conducted at varying tiers, ranging from local events to national and even international competitions. The youth often exert considerable effort in preparation for these contests, primarily driven by the aspirations of their parents and, at times, the allure of fame and monetary rewards. It is noteworthy that participants may often be minors of a tender age. The younger the participant, the greater the associated fame and glamour. Children who engage in these competitions frequently exert themselves to the detriment of their social and psychological well-being. It is imperative for them to possess physical resilience in order to meet the rigorous demands of the industry. Investigations into early childhood adversity and its ramifications have been notably scarce in India, characterized by a dearth of both cross-sectional and longitudinal research.[1]

In this manuscript, we commence by presenting an essential examination of the ethical considerations and implications concerning the involvement of children in dance competitions. It scrutinizes the intricate culture surrounding dance competitions, which encompasses a diverse range of stakeholders including participants, parents, judges, event organizers, dance studio proprietors, and instructors.

Ultimately, it is posited that the engagement of minor children in dance competitions constitutes a form of child abuse or child labor. The repercussions of these dance competitions may inflict harm upon the children involved. Behavioral and psychosocial alterations may ensue in the lives of these children as a consequence of their participation in such events. There exist significant ethical dilemmas that necessitate attention in this context. The rights of children are frequently undermined. The involvement of children in dance competitions can be interpreted as a manifestation of "Child Labor," wherein parents and other stakeholders may inadvertently participate, either directly or indirectly.

In contemporary society, there has been an increasing prevalence within the entertainment sector regarding the systematic organization of professional dance competitions. In numerous instances, children may find themselves exploited either by the organizers or by their parents, who may urge their participation driven by aspirations for fame and financial gain. These dance competitions are conducted at multiple tiers, ranging from localized events to national or even international contests. The youth typically exert considerable effort in preparation for these competitions, often motivated by desires to fulfill parental expectations and, at times, by the allure of fame and financial rewards. On occasion, the participants are minors at tender ages, with younger contestants often attracting greater fame and glamour. The children engaged in these competitions dedicate themselves to rigorous training and make significant sacrifices regarding various facets of their formative years. It is imperative for these children to possess physical resilience in order to meet the strenuous demands of the industry. From the author's perspective, the phenomenon of child professionalism in this context can readily be classified as "Child Labor" or a variant of Child Abuse.

In addition to the risk of fatalities, children also face the potential for injuries while engaging in dance competitions. Sekulic et al. (2020) documented that 53% of dancers reported experiencing musculoskeletal issues or injuries, with the average dancer suffering approximately 0.72 injuries throughout the study duration (95% CI: 0.28–1.41), which translates to an annual injury incidence rate of 280%. The incidence of injury was not significantly correlated with either gender or dance styles. A heightened risk for injury was noted among older and more experienced dancers.[2]

Bellerose (2020) identified various injuries commonly sustained in dance, including but not limited to ankle sprains, Achilles tendonitis, shin splints or tibial stress syndrome, muscle strains and tears, trigger toe, anterior/posterior ankle impingement, snapping hip syndrome, hip impingement, patellofemoral pain syndrome, and osteoarthritis.[3]

Beyond physical injuries, children may experience enduring musculoskeletal alterations as a consequence of intensified physical activity. The premature development of musculature and skeletal structure may instigate psychological transformations, potentially influencing behavioral patterns in children.

The child may exhibit behaviors characteristic of a responsible adult; however, this abrupt transition from innocent childhood to adult-like behavior may engender a psychological conflict within the child, rendering them uncertain about how to appropriately navigate the dichotomy of being a child versus an adult responsible for familial obligations.

In addition to this behavioral conflict, children may also experience depressive episodes following competition losses. Although children possess a limited capacity for comprehensive understanding, they are acutely aware of their parents' expectations. This awareness may ultimately culminate in self-sacrifice for the benefit of their parents, who may remain oblivious to these underlying emotions, mistakenly equating success with fame and glamour.

The discourse explores the progression from informal dancing to a more formalized structure as children engage in competitive dancing, underscoring its potential ramifications on their social development and raising concerns regarding the extensive time commitments, diminished leisure opportunities, and elevated performance expectations imposed on young competitors.

It delves into the transition from informal dancing to a more structured approach when children participate in competitive dancing, emphasizing its potential impact on their social development and concerns regarding the time commitment, reduced leisure time, and heightened performance standards that competitive dance imposes on young participants.[4]

The Federal Child Abuse Prevention and Treatment Act (CAPTA) (42 U.S.C.A. § 5106g), as amended by the CAPTA Reauthorization Act of 2010, defines child abuse and neglect as, at minimum: "Any recent act or failure to act on the part

of a parent or caretaker, which results in death, serious physical or emotional harm, sexual abuse or exploitation"; or "An act or failure to act which presents an imminent risk of serious harm."[5]

Background of Children's Participation in Dance Competitions

Children's participation in dance competitions has a rich historical background that has evolved over time. Dance competition culture involves various stakeholders, including competitors, guardians, judges, organizers, studio owners, and teachers.[4,6] It is common for parents to enroll their young children in dance classes to enhance their motor skills, and dance studios typically welcome students of all age levels and experiences. However, when children transition to competitive dance, a more serious and demanding approach is required. Competitive dance involves extensive training, rehearsals, and traveling, which can significantly impact a child's social life and free time. Moreover, the shift in focus from learning to winning in competitive dance raises concerns about the potential negative effects on young individuals' social development.

Furthermore, the competitive dance industry has seen changes in competition formats, with some competitions now awarding prizes based on hitting specific point categories rather than traditional first-place winners.[6] This shift has drawn in young dancers and their parents by offering instant gratification through awards. However, it has also sparked criticism, with concerns raised about the impact on young dancers who dedicate extensive hours to training and rehearsing, only to be scored in a matter of seconds. Judges play a crucial role in offering constructive criticism and inspiring dancers, with the responsibility to understand their influence on the future generation of dancers. Overall, understanding the historical context and the evolving nature of children's participation in dance competitions is crucial in comprehensively addressing the ethical and societal implications of this practice.

Child Labor Laws and Regulations

Child labor laws and regulations play a critical role in governing children's participation in dance competitions, ensuring their well-being and protection. In the context of dance competitions, these laws often dictate the maximum number of hours a child can rehearse and perform, as well as the working conditions and supervision requirements.

Definition of Child Labor

Child labor is defined as any work that deprives children of their childhood, potential, and dignity, and that is harmful to their physical and mental development.[7] The International Labor Organization (ILO) sets the minimum age for work at 15 years, with an exception for light work starting at 13, and hazardous work at 18. In the context of children's participation in dance competitions, it is crucial to consider whether the nature and intensity of their involvement align with these parameters, as well as with the overarching goal of safeguarding their well-being and development.

Furthermore, the definition of child labor encompasses not only the hours worked but also the type of work performed. It is essential to assess whether participation in dance competitions aligns with the principles of protection and education, ensuring that it contributes positively to the child's physical, emotional, and social development. Balancing the competitive nature of dance competitions with the ethical considerations related to child labor remains a key challenge in the industry.[6]

Ethical Considerations

Ethical considerations surrounding children's participation in dance competitions are multifaceted and require careful examination. DeMaria[4] highlights that while dance competitions can foster skill development and discipline, they can also pose risks to the social and psychological well-being of young participants. The decision for a child to engage in competitive dance often involves various stakeholders, including parents, teachers, and competition organizers, each with their own motivations and responsibilities. Mack[6] emphasizes the evolving nature of dance competitions, with a shift toward recognizing multiple top scorers rather than a singular first-place winner. This alteration aims to provide constructive feedback and encouragement to all participants, but it also underscores the intense pressure and dedication demanded from young dancers.

The ethical discourse on children's involvement in highly competitive activities necessitates a balanced consideration of the benefits and potential drawbacks, particularly in relation to the physical and psychological maturity of the participants. It is crucial for parents, guardians, and dance professionals to conduct thorough research and make informed decisions that prioritize the holistic well-being of the child, rather than solely focusing on competitive success.

Impact on Physical and Mental Health

Intense participation in dance competitions can have significant implications for the physical and mental health of children. Competitive dance involves extensive training, rehearsals, and travel, leaving little time for other activities and interests, as highlighted by DeMaria.[4] This intense focus on competition can lead to physical strain, fatigue, and increased risk of injury, especially in young dancers whose bodies are still developing. Moreover, the shift from learning and enjoyment to a relentless pursuit of victory can create

psychological stress and impact social development, particularly when young individuals are not fully mature enough to handle such pressures. The high standards and expectations set for competitive dancers may exacerbate these challenges, raising concerns about the well-being of young participants. Therefore, while competitive dance can offer opportunities for skill development, it is crucial to consider the potential risks and ensure that the physical and mental health of children remains a priority in this context.

Case Discussion

Anisha Sharma, A 12-year-old girl suddenly collapsed mid-dance and died unexplainedly at a competition in Kandivali West on Tuesday evening in an incident that has baffled and shocked eye-witnesses. Doctors have reserved their opinion on the cause of her death. According to a forensic expert at Bhagwati Hospital, where the girl's body was sent for postmortem, she suffered no physical injury and had no known medical history of illness.[8]

If we look into the case of Anisha Sharma, the question arises about the cause of death in this case and the responsible entity, who put this 12-year-old child in this fatal situation. Legally, at this age, the child is regarded as a minor and is unable to understand the potential threat she has, as a result of his involvement in this competition.

If we try to fix the accountability for the death of Anisha Sharma, all the stakeholders have their own version to defend themselves. All of them positively claimed to be innocent and not guilty. So, the question remains an unsolved mystery "Who is responsible for the Death of Anisha Sharma."

It is debatable now that since the death and injuries are beyond hypothetical level and are correlated with this activity, can we say that participation in dance competitions can be considered as "An act which may results in death, serious physical harm."

Winning or loosing in these competitions may also impact the social image of the child and his family as well. With every win the child may face social recognition or may face boycott after losing, in both ways, the tide of emotional outbursts may devastate the childhood. The impact of this social trauma may impact the school performance, the child may loose interest in going to school as he is already achieving success with every win in his life.

Factor promoting this "Child Labor" or "Child Abuse"

1. Parent Factors: The parent on many occasions sees the dance competition as an opportunity for the child to become a successful dancer of the future having financial benefits. The glamorous life of the cities also motivated the parents to encourage their children to participate in these events. The parent may sometimes be motivated to have a shortcut to the child's success.
2. Organizer Factor: The organizers of these competitions advertised these events purely on a marketing basis but labeling them as "Talent Shows." The usual purpose of these shows is rather financial.
3. Child Factors: The child usually participates as a result of a motivational drive from parents and the organizers. The children in this age group are usually incapable of understanding the gravity of the situation. They usually believe that, as parents are motivating, it is a good act.
4. Ethical Factors: Ethically and socially, the children are in the custody of their parents or guardians, and on many occasions, the parents or guardian use their kids as objects, knowingly or unknowingly, without or having very limited concerns about the child's decision or non-compliance.

Legally the Children enjoy rights. The United Nations Convention on the Rights of the Child is an important agreement by countries that have promised to protect children's rights. The convention explains who children are, all their rights, and the responsibilities of governments. All the rights are connected, they are all equally important and they cannot be taken away from children.[9–11]

The rights of the child violated in this particular situation are:

1. Best interests of the child: When adults make decisions, they should think about how their decisions will affect children. In this case, parents have limited understanding or awareness about the impact of these acts on the life of a child.
2. Respect for children's views: Children have the right to give their opinions freely on issues that affect them. Adults should listen and take children seriously. The pressure of achieving early success may sometimes compromise with the children's views of non-participation.
3. Freedom of thought: Children can choose their own thoughts and opinions. In this case, it is compromised as the child may sometimes be forced to participate.
4. Protection of privacy: Every child has the right to privacy. Privacy is compromised with each competition more and more people are aware of the private life of the child.
5. Children with disabilities: Every child with a disability should enjoy the best possible life in society. Participation by disabled children is more than welcome by organizers who do not want to miss the popularity gained by exposing a disabled child to the public. The emotional gain guided the financial benefits of the organizers.
6. Rest, play, culture, arts: Every child has the right to rest, relax, play and to take part in cultural and creative activities. The child may have found limited time after the daily training activities.
7. Protection from harmful work: Children have the right to be protected from doing work that is dangerous

or bad for their education, health or development. If children work, they have the right to be safe and paid fairly. This right is violated as we consider this work as hazardous work. hazardous work means the work which, by its nature or the circumstances in which it is carried out, is likely to cause harm to the health, safety or morals of children and adolescents.

8. Protection from sexual abuse: it is not uncommon condition in which the child face sexual harassment at dance school and competitions.

Conclusion

In conclusion, the ethical and practical implications of children's participation in dance competitions are multifaceted. While dance competitions offer opportunities for skill development, performance experience, and forming strong bonds with peers, it is crucial to consider the potential negative impact on young individuals' social development and well-being. The shift in focus from learning to winning awards in competitive dance raised concerns about the toll on young dancers' social lives and limited opportunities to explore other interests. Additionally, the importance of understanding the perspectives of various stakeholders, including parents, dance studio owners, competition directors, and convention teachers, in redefining the competitive dance industry to ensure a balanced and positive experience for young participants. These insights underscore the need for a comprehensive approach that prioritizes the well-being and holistic development of children involved in dance competitions.

It is also concluded that participation in dance competitions by small kids is considered a form of child abuse or child labor. The children may suffer harm as a result of the impact of these dance competitions. The child may suffer from behavioral and psychosocial changes as a result of these events in his life. There are ethical issues to be addressed in this situation. The child's rights are often compromised. Participation of children in dance competitions may be considered as a mild form of "Child Labor" in which the parents and stakeholders or unknowingly involved.

Recommendations

Alternatives to Competitive Dance

Competitive dance has been a prevalent avenue for young dancers, but there are alternative pathways that offer a broader perspective on the variety of opportunities available for children's engagement in dance. Recreational dance programs, for instance, provide a non-competitive environment where children can explore and enjoy dance without the pressures of winning or losing. These programs focus on skill development, creativity, and fun, promoting a more relaxed and inclusive approach to dance education.[1] Additionally, community-based dance classes and workshops offer a supportive and collaborative setting for young dancers to learn and grow, emphasizing personal growth and expression over competition.[6]

It is important to recognize that while competitive dance can enhance talent and work ethic, it should not overshadow the fundamental aspects of dance education, such as technique and passion. By considering these alternative pathways, parents, educators, and young dancers can make informed decisions about the most suitable approach to dance education, taking into account the physical, psychological, and social well-being of the children involved.

Recreational Dance Programs

Unlike competitive dance, recreational programs prioritize learning and personal improvement over winning, allowing young participants to enjoy dance without the intense time commitments and pressure associated with competitions. It is suggested that while competitive dance can enhance a student's drive and work ethic, it should not be the sole approach to dance education, highlighting the need to balance competition with a focus on education and personal development.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Statement

Ethical permission was not applicable for this article, as this is a review article drafted from various research articles and not from patients directly.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

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Victimology of Child Survivors of Sexual Assault with Special Emphasis on Judicial Outcome: A 10-year Retrospective Study

Journal of Indian Academy
of Forensic Medicine
46(3) 407–412, 2024

DOI: 10.1177/09710973251316362
journals.sagepub.com/home/iaf
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Abstract

Introduction: Sexual abuse of children has become a subject of great community concern and the focus of many legislative and professional initiatives. Despite the existence of a strong legal framework, there has been a substantial increase in the number of crimes against children. This study aims to study the demography of the child survivors, analysing the victim-perpetrator relationship and circumstances at the time of the crime.

Methodology: The study's objective is to find out why the final judicial outcome of the cases has been decided. This is a retrospective study of records of victims of sexual assault who were brought for examination between January 2010 and December 2019. The study includes sexual assault victims who were under the age of 18.

Results: Thirty of the 231 cases under analysis resulted in a conviction, while 60 ended in acquittal. In court, 143 cases are still open.

Conclusion: The burden of proof typically rests with the defence party in matters involving sexual violence since they are commonly easy to report but difficult to prove. The current study contributes to our understanding of the system's flaws and how people have taken advantage of them to their advantageous ends.

Keywords

Child sexual abuse, POCSO, judicial outcome, consensual sexual intercourse

Received 07 January 2024; **accepted** 29 April 2024

Introduction

Child abuse refers to the emotional, physical, economic and sexual mistreatment of individuals below the age of 18. This issue is widespread worldwide. Like India and other countries, there is limited awareness regarding the scope, scale and patterns of child abuse. The increasing complexities of life, coupled with significant socio-economic transitions in India, have significantly heightened the likelihood of children being subjected to different forms of mistreatment.

The Protection of Children from Sexual Offences (POCSO) Act, 2012 is a landmark law that resulted from years of civil society struggles and the Government of India's acknowledgement of the problem. It protects children not only from penetrative sexual assault but also from other forms of child abuse.

This study aims to understand the reasons for the registration of cases, and the victim demography, and the main objective was to identify the reasons based on which judicial outcome was decided.

Materials and Methods

Study Design

Retrospective longitudinal study.

Duration of Study

From September 2021 to January 2023.

Study Material and Methods

As it is a retrospective study, data for the study was collected from the department's records section, after approval of the

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Institutional Ethics Committee (ECARP/2021/133). Data of all the victims of sexual assault was segregated as per the inclusion criteria and information from the examination papers required like the age of the victim, sex of the victim, characteristics of the assault and relationship between victim and perpetrator were noted. As for the outcome of the court case, at the time of examination, the accompanying police brought a requisition letter for examination, which had an FIR number. With the help of the FIR number, its outcome was traced online on the E-courts services website of the District Courts of India.

Statistical Analysis

The data was entered in Microsoft Excel and analysed. The qualitative data like age groups of the victims, gender difference of sexually assaulted victims, laboratory reports, number of incidents, places of sexual assaults, type of alleged incident, type of injuries, consequences of sexual assault, time gap between incidents and examination, relation of accused to victim state, etc., and quantitative data like age, number of assailants, marital status, and so on, will be presented in appropriate formats.

Results

Table 1 shows that the most affected sex was females and those were mainly from 13 to 18 years of age group.

1. Disposal without trial: Such disposal was given by the judiciary body for cases where the accused died during the course of court proceedings. There were only two cases with such disposal.
2. Uncontested: Such disposal was given by the judiciary body for cases where the accused was unknown and could not be traced by law enforcement.

Discussion

Victim-perpetrator Relationship (Table 2)

Out of 231 cases studied, the accused in 76 cases were the boyfriends of a victim (32.9%) and 38 were related to the victim as a brother, biological father, step-father, step-brother or maternal uncle (16.5%). The findings in the study were consistent with the following studies—Bhowmik and Chaliha,[1] Tamuli et al.,[2] Adogu et al.,[3] Sabale et al.,[4] Jemal[5] and Surender et al.[6]

Rate of Disposal of Cases Registered Under the POCSO Act

In 231 cases taken in our study, judgement orders of 94 cases were available on the portal (40.7%) (Table 3). These were disposed off by the court either as acquittal (Table 4), or conviction (Table 5), or disposed without trial (accused died), or uncontested (accused could not be traced) as their final judgement. Only 7.4% cases were disposed of in less than a year. The majority of cases, that is, 37.2%, were disposed of in one to three years of time duration followed by 33% of the cases being disposed in three to five years of time duration.

Table 1. Age-wise Distribution of Study Subjects (*n* = 231).

Age group	Male	Female	Total	%
1–6 years	3	19	22	9.5
7–12 years	13	40	53	22.9
13–18 years	6	150	156	67.5
Total	22	209	231	100.0

Source: Medicolegal data from the department's record section.

Table 2. Relation with Perpetrator (*n* = 231).

Relation with perpetrator	No.	%
Boyfriend	76	32.9
Neighbours	51	22.1
Relatives	38	16.5
Stranger	32	13.9
Work colleague	16	6.9
Friends	13	5.6
Boyfriend and his acquaintance	2	0.9
NA	2	0.9
Servant	1	0.4

Table 3. Final Judgement (*n* = 94).

Results	No.	%
Acquitted	60	63.8
Convicted	30	31.9
Disposal without trial	2	2.1
Uncontested	2	2.1

Table 4. Reasons for Acquittal (*n* = 60).

Reason	No.	%
Love affair	27	45.0
Victim tutored	23	38.3
Medical examination	9	15.0
Hostile victim	6	10.0
Failure to prove age	2	3.3
Victim absconded during trial	1	1.7
Final order pending	1	1.7

Table 5. Reasons for Conviction (*n* = 30).

Reason	No.	%
Medical examination and FSL reports	9	30
Medical examination	9	30
Victim's statement	7	23.3
Eye witness	5	16.6
Accused accepted guilt	1	3.3

Table 6. Reasons for Police Complaint (Other than Penetrative Sexual Assault) (*n* = 68).

Reason	No.	%
Missing complaint	12	17.6
Pressured by family	7	10.3
Fondling with private parts	36	52.9
Luring	11	16.2
No history of any assault	2	2.9

This was consistent with a study named 'A decade of POCSO: Developments, challenges and insights from judicial data' by Vidhi Centre for Legal Policy, which observed the scenario of child sexual offence cases in the judicial system since the enactment of the POCSO Act till 2021 and found that, in Maharashtra, the percentage of disposed cases was at 39.77%.[7]

Reasons for Police Complaint (Other than Penetrative Sexual Assault) and Judicial Outcome in the Concerned Cases (Table 6)

In 12 cases, the primary complaint was for missing reports. It was found that, in four out of 12 cases, the acquittal was the judicial outcome while others were pending. In all four of those cases, the victim and accused were in a romantic relationship and eloped from their respective homes as their parents were against the relationship and they had decided to get married. In three of those cases, the victim was above 16 years of age while one was 11 years of age. In eight cases, the trial is still ongoing.

In seven cases, the complainant was under family pressure. In three out of seven cases, acquittal was the final judgement. In all three cases, the victim was tutored by family members because of a feud over property or personal loss. In one case the accused died during proceedings and three are pending in court.

In 36 cases, there was a history of fondling with private parts of the victim. Seven out of 36 cases ended in conviction, in four of those, the victim's testimony was the key to conviction while in the other three cases, it was eye witnesses' testimony. Ten out of 36 ended in acquittal of the accused, in eight of those, the victim was tutored by the family to report for fondling with private parts to the police.

In 11 cases where the registered complaint was of luring (offering food, employment, giving a smartphone to play with, or promise of marriage). In these cases, four cases ended in conviction, based on FSL report findings of pornographic content in smartphones. In four cases, there was acquittal, as the victim turned hostile. In all of these 8 cases, the victims were in the late adolescent age group and working in prostitution. In the rest of the three cases, the trials are ongoing in court.

Victim-perpetrator Relationship and its Influence in Judicial Outcome

In 25 cases with the final judgement, it was found that the victim and perpetrator were in a romantic relationship, and all ended in the acquittal of the accused. The court identified those who had failed in the relationship at the time of filing the complaint and ruled its judgement as acquittal. However, in one case of conviction, although the victim stated that it was a LOVE AFFAIR and that her family was not against this. The accused stated that he wanted to marry her and had consensual sexual intercourse under the impression that she was a major and left her studies. The DNA of the FETUS matched that of the accused FSL REPORT). Still, the court ruled its judgement based on the fact that, if the person commits penetrative sexual assault on a child, then, the offence is made out and there is no need to prove that the accused did not know the juvenility of the victim.

In 84 cases out of the 231 cases studied, the victims were in the age group 16–18 years. 20 cases out of the 84 cases were of consensual sexual intercourse. Among these 20 cases, 17 were love affair cases. Among these 17, there were three cases where the accused and victim were married as per Muslim Marriage law. In those three cases, the age of the accused was 19, 22 and 23 years, respectively. This brings conflict between the POCSO Act, which defines sexual intercourse with a child <18 years of age as a criminal offence, and Muslim Marriage law, where the age for consent for marriage is 16 years or attainment of menarche.

In 38 cases, where the accused were related to the victim as brother, biological father, step-father, step-brother or maternal uncle, eight cases ended with conviction as final judgement. In three cases, the victim's testimony was helpful. In three cases, medical examination helped in conviction. In one case, as per the FSL report, the pornographic content on mobile, concluded the judgement as conviction while in another case, the accused accepted his guilt. In 16 out of 38 cases, Acquittal was the final judgement. In 13 of those, the victim was tutored and it was due to a feud among family members or neighbour enmity for petty reasons.

These findings were consistent with the study of Hudaverdi Kucuker, where he found that 85 (38.6%) victims accepted to marry the so-called assailants during the trial, leading to the adjournment of the sentencing.[9]

In the judgement for the case of Vijayalakshmi v State, 2021, the Madras High Court gave its views on consensual teenage relationships. They interpreted such relationships as integral to biosocial dynamics, cautioning against unfairly stigmatising them as criminal activities, as such a characterisation would be counterproductive. Furthermore, they emphasised that the primary goal of the POCSO Act is not to treat an adolescent boy entering into a relationship with a minor girl as an offender. Consequently, the court decided to quash proceedings under Section 482 of the CrPC, 1973, Section 366 of the IPC, 1860, and Section 6 of the POCSO Act, 2012, in line with their understanding of the nuanced nature of such relationships.[10–12]

In the case of Pradhuman v State, B.A. No. 2380 of 2021 (Del H.C.), the Delhi High Court labelled it as an 'unfortunate practice' when addressing the situation. This was due to the involvement of adolescents in a 'consensual' relationship, leading the police to file the case under the POCSO Act following the objections raised by the girl's family against the relationship.[13]

Findings on Medical Examination and its Role in Judicial Outcome

In our study, 25 cases had recent hymenal injuries on medical examination. The key and important point to note is, that all these cases were examined within 48 hours of the incident of penetrative sexual assault. The judicial outcome in seven out of those 25 cases was the conviction of the accused.

In two out of those 25 cases, a court acquitted the accused. In one case, the complainant (victim's mother) denied that she lodged the complaint as she was told by an informant (eye witness) about the incident and he dictated the complaint to police and that no sexual violence was told to her by her daughter. The victim also denied any wrongdoing by the accused. The informant (neighbour) had previous enmity with the accused.

In the other case, the victim delivered a full-term neonate, inside the bathroom of the public toilet near their house. The accused was 19 years old, cousin brother to the victim. As mentioned in judgement order,

> The victim nowhere testified that the accused committed non-consensual intercourse to her. Also, during the course of her pregnancy, neither her mother nor sister observed the changes in her body. Also, if there was a question of assault, she would have mentioned it to someone but she did not. This proved that the sexual intercourse was consensual and due to fear of scolding she didn't tell her mom.

There were 24 cases out of 231, where a history of digit penetration was given by victims. In 10 cases, hymenal injuries (5 recent and five old) were reported. In 14 cases, no evidence of any injury was found. Four cases ended in conviction, six in acquittal, one accused died during the course of court proceedings while 13 are still pending in court of which four cases could not be traced.

In cases where a conviction was the final judgement, medical examination, victim's statement, eye witness and FSL report of accused's mobile phone were the respective reasons. In the case where medical examination findings were conclusive, recent hymenal tears were found.

In cases where the acquittal was the final judgement, victim tutoring was the main reason for the decision in five out of six cases and the reasons were feud among family members and neighbour enmity. One case was of a love affair.

In two cases, where a trial is still going on in court, local examination findings were conclusive of forceful penetration of vagina. In one case of a 9-year-old female child, congestion and tenderness were noted around the labia minora while, in other cases of a 3.5-year-old female child, congestion was present over labia majora and fresh hymenal tear was present at 6 o'clock position. The trial in both cases has been ongoing for the last five years.

Although there are not any references, describing injuries to the hymen due to digit penetration, our study showed that, if the perpetrator had forcefully penetrated his/her fingers into the vagina, findings will be conclusive of penetrative assault.

These Findings are Consistent with Findings of the Following Authors

In the study conducted by Hudaverdi Kucuker, noteworthy findings emerged in 221 cases (82.4%), predominantly in the perineal and anal regions. These findings encompassed various indications such as hymenal rupture, erythema of labia minora, perineal bruising-abrasion and anal bruising-abrasion or mucosal tears. Among these instances, 163 (74%) involved female subjects with exclusive vaginal injuries, while 12 (5.4%) displayed solely anal injuries and 15 (6.8%) exhibited both vaginal and anal injuries. Remarkably, anal injuries were identified in 31 cases (77.5%) involving male victims. Furthermore, 32 (11.9%) females had spermatozoa detected in their vaginal smears, prompting the application of DNA fingerprinting. Among all examined cases, legal proceedings resulted in the conviction of the accused in 156 instances (58.2%). Concerning assaults on female victims, sentences were imposed in 114 cases (51.8%). Postponement of sentencing (acquittal) occurred in 85 cases (38.6%) due to subsequent marriage between the victim and accused. Additionally, 21 cases (9.6%) saw no penalties imposed due to insufficient evidence. As for assaults on male victims, sentences were handed down to 42 accused individuals (87.5%), while in six cases (12.5%), no penalties were imposed due to insufficient evidence.[9]

In the study conducted by Palusci VJ, Cox EO et al., involving 497 children, only 17% exhibited positive physical findings. Notably, 35.8% of cases leading to successful

criminal prosecution showed positive examination findings, contrasting with 12.7% in cases with no prosecution or a verdict of 'not guilty'. Children revealing child sexual abuse were four times more likely to present positive findings for abuse during examination. Instances with positive examinations were 2.5 times more likely to conclude with a guilty verdict for the perpetrator; nonetheless, mere disclosure alone did not serve as a reliable predictor of guilt.[14]

In the study conducted by P. Saint-Martin et al., which involved 756 cases, it was found that genital injuries were present in 6.8% of girls and 6% of boys in the under-15 age group. Convictions were secured against 36.3% of the assailants. The examination conducted at the request of law enforcement authorities and the prior acquaintance of the assailant by the victim were significantly linked to convictions. However, the presence of general body and/or genital trauma was not found to be associated with convictions.[15]

In the study conducted by Peterson J et al., which examined 81 charged cases, it was discovered that convictions were obtained in 82.7% of these cases. Notably, when physical evidence was collected, the conviction rate significantly increased to 87.3%, compared to a 66.7% conviction rate in cases where no physical evidence was gathered. This underscores the importance of physical evidence in strengthening the legal outcomes of charged cases.[16]

Positive Pregnancy Status and its Influence on Judicial Outcome

In our study, 12 cases out of 231, had positive pregnancy status on USG and UPT. However, only one case among those ended in conviction of the accused. In that case, the victim testified that it was a love affair and that her family was not against this. The accused stated that he wanted to marry her and had consensual sexual intercourse *under the impression that she was a major* and left her studies. The DNA of the foetus matched the accused's (FSL REPORT). However as per the court's understanding and inference of Section 3 of the POCSO Act, which defines, 'Penetrative sexual assault on a child', Accused was convicted. The court made its judgement stating that, if a person commits penetrative sexual assault on a child, then the offence is made out and *there is no need to prove that, the accused had no knowledge of the juvenility of the victim.*

In two cases, the acquittal was the final judgement. In one of the cases, victim was in a romantic relationship with the accused. They had a baby out of wedlock and later married as per Muslim Marriage law. But since the victim and her mother turned hostile, the court ruled its judgement as acquittal. This brings conflict between the POCSO Act, which defines sexual intercourse with a child <18 years of age as a criminal offence, and Muslim Marriage law, where the age for consent for marriage is 16 years.

In nine cases, the trial is pending in court in five cases while, in four cases, the record was not available due to unavailability of FIR no. In all the five pending cases, the victim and accused were in a romantic relationship and the cases have been ongoing for more than five years.

Importance of Testimony of Child and its Impact on Judicial Outcome

In our study, out of all the 30 cases ending in conviction, in seven cases court relied solely on the testimony of the child. Two cases had positive findings on local examination but in one case, the medical examination was rejected by the court because it was done 1.5 months after the alleged assault and in other cases, it was corroboratory to the testimony of the child. In five cases, there was only a history of fondling with chest and private parts of the child. The age of children in these cases was between 10 and 15 years, respectively.

These Findings were Consistent with the Following Studies

In the study by Sugue-Castillo M., 68.7% of the 115 cases solely relied on the victim's testimony. She also noted that the most frequently cited cause of acquittal was dismissal because of the victim's desistance. In 66.7% cases where medical findings were normal, resulted in conviction based on doctor's testimony.[17]

In the study by Eg MB et al., 226 girls reported a history of one incident of vaginal penetration. Among these cases, 22% exhibited hymenal clefts, with 34% of them having complete hymenal clefts. Notably, in instances with complete hymenal clefts, 63% led to prosecution, and 50% resulted in convictions. Age emerged as a significant factor in relation to conviction in this study. This observation was highlighted by the fact that cases resulting in conviction had a mean child age of 11.49 years. It was noted that children of this age demonstrated better recollection of the incident, enabling them to provide clear evidence during court proceedings.[18]

In the research conducted by Hansen LA et al., it was determined that abnormal anogenital findings were observed in 38% of girls and 20% of boys. However, there was no discernible connection between these findings and the legal outcomes, which were categorised as 'appearing in court' and 'being convicted'. Notably, the child's age emerged as the crucial factor influencing legal outcomes rather than the physical findings. Out of the 190 cases analysed, 165 resulted in the accused being charged as 'guilty'. Within different age groups, 28 cases in the 0–6 years range, 55 cases in the 7–10 years range and 82 cases in the 11–15 years range ended in convictions. This trend was attributed to the older children's ability to provide clearer testimony in court.[19]

A study conducted by Adams JA et al. involved a review of case files and colposcopy photographs from 236 children whose perpetrators were convicted of sexual abuse as per court judgements. The findings revealed that 28% of cases had no positive findings on genital examination, 49% had

nonspecific findings, 9% were deemed suspicious and 14% showed abnormal findings. Through discriminant analysis, it was established that two significant factors correlated with abnormal genital findings in girls: the time elapsed since the last incident and a reported history of blood during the sexual assault. The study emphasised that abnormal genital findings are rare in sexually abused girls, according to standard classification systems. Consequently, the researchers concluded that particular attention should be given to documenting the child's description of the sexual assault.[20]

Conclusion

Sexual violence against children has been a matter of concern for the judicial system for the last two decades, not just in our country but also around the world. Various studies have shown how much of a grave concern it is for communities. It not only violates a child physically but also scars them for life. In our study, we observed that innocent adolescents are dragged into court because of rejection of their romantic relationships by their parents or guardians. We also observed, that due to conflict between Muslim Marriage laws and POCSO Act, over-age for consent, cases are registered. Since the POCSO Act has a provision, stating the importance of the testimony of the child and there are judgements, where the court decided conviction as its final verdict, it is of utmost importance for medical professionals to note the history narrated by the child at the time of examination.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

Ethical approval for this retrospective study was obtained from the Ethics Committee for Academic and Research Projects of Topiwala National Medical College, Mumbai (Approval No.: ECARP/2021/133).

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Consent

The requirement for informed consent was waived due to the retrospective nature of the study.

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Estimation of Time Since Death from Entomological Evidence: A Case Series

Journal of Indian Academy
of Forensic Medicine
46(3) 413–418, 2024

DOI: 10.1177/09710973251321991
journals.sagepub.com/home/iaf
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Abstract

Precise estimation of time since a death has great importance while investigating suspicious foul play in deaths. Findings help to estimate time since death gradually diminishes along with the progression of time. In the case of decomposed bodies, entomological evidence plays a great role in finding out the probable time since death. In this case series, we observed and analysed the life cycle of flies and gave opinions about the time since death. For this purpose, we developed an artificially ventilated environment and did not change the feeding substance. We observed that when the body is in an advanced stage of decomposition; entomological evidence acts as an important tool to estimate the time since death.

Keywords

Time since death, forensic entomology, decomposition changes

Received 30 November 2023; **accepted** 05 February 2024

Introduction

Entomological evidence plays a crucial role in forensic investigations, especially in estimating the time since death. Forensic entomologists analyse the insects found on a corpse, considering their developmental stage to determine the postmortem interval. This analysis provides crucial information for investigators to reconstruct events leading to death and serves as valuable support that can confirm or challenge other evidence in a case.[1,2] In addition to estimating the time since death, entomological evidence can also be used to determine the location of death and aid in toxicological evaluations when traditional biological samples are not available. This information can be crucial in criminal investigations and provide valuable insights into the circumstances surrounding a suspicious death.[1,3]

The accurate estimation of the time since death is crucial in forensic investigations. It not only helps establish a timeline of events but also assists in determining the cause of death, identifying potential suspects and providing valuable evidence in the court of law.[4] Forensic entomology, specifically the analysis of insect evidence, has emerged as a reliable method for estimating the time since death in forensic investigations.[5] By studying the life cycle and behaviour of necrophagous insects, forensic entomologists can estimate the minimum time since death based on the developmental stage and species composition of the insects found on the body. This information, combined with other postmortem findings, can provide important insights into circumstances surrounding death.[1]

Case Series

In the past six months, our department has handled three cases involving bodies in an advanced stage of decomposition and entomological evidence. In one instance (Case 1), the decomposed body of an unidentified female was found in bushes and transferred to our mortuary for examination. During the examination, we observed marbling and blackish discoloration on the skin, loose teeth inside the oral cavity,

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easily pluckable hair, loosened nails, absence of rigour mortis and postmortem staining. Internally, liquefaction of the brain and spleen was noted along with softening of abdominal tissues. Additionally, multiple live maggots were found in various orifices; these were carefully collected alongside muscle bits for further study in a controlled environment to complete their life cycle. Few live maggots were collected separately for gross and microscopic examination.

In Case 2, The body of an unknown middle-aged man was discovered in a forested area, showing early signs of decomposition. Upon examination, there was bluish discoloration on the abdomen and well-developed rigour mortis in the large and small joints. Postmortem staining was also visible on the back. Additionally, a stab wound was found on the left side of the chest. The soft tissues were missing from the left forearm at elbow level with a crescent-shaped margin suggesting postmortem animal scavenging. The body was carefully examined for entomological evidence, and a pale-yellow colour cluster of eggs was noted over the left elbow area & left side of the chest. These eggs were meticulously gathered alongside muscle fragments and relocated to a controlled environment with artificial ventilation to undergo their life cycle.

In Case 3, The body of a young adult male was found in a paddy field. Upon external examination, weak rigour mortis was present over the large joints of the lower limbs. Postmortem staining was not noticeable, and patchy discoloration ranging from blackish to greenish was observed on the abdomen, neck and upper chest.

Evidence of insect activity was apparent, with multiple live maggots discovered around body openings and surrounding areas. These maggots were carefully collected along with muscle bits and transferred to an artificially ventilated environment for their life cycle to complete.

We set up an artificially ventilated environment using a rectangular glass specimen jar. We placed around 500 grams of dry soil and several dry leaves inside, then added entomological samples and muscle bits for observation. To ensure proper ventilation, we covered the top of the jar with a white paper sheet perforated with multiple small holes. Finally, we positioned the entire setup in a shaded area.[6]

The collected maggots and eggs were observed closely under controlled conditions, monitoring their growth and development. During the observation period, we documented the sequence of developmental phases of eggs & maggots and their developmental rates.[7] In all three cases, we noted the range of temperature during the observation period, which ranged from 26°C to 32°C.[1]

To determine the developmental stages, a small number of live maggots from controlled environments were gathered. These maggots were preserved in rectified spirit for wet mounting to facilitate microscopic examination and assess their developmental stage. To achieve this, cross-sectioning of the posterior end was conducted and secured with DPx mounting solution for identification of posterior spiracles.

Discussion

Case 1

At the time of postmortem, collected maggots were examined grossly and their size was up to 12 mm with a hairy appearance. On microscopic examination, a segmented posterior spherical with incomplete three lobes & tubercles were noted. After 24 hours maggots were kept in the artificially ventilated environment, and a significant increase in maggot size was observed & gross their size was up to 15 mm. On microscopic examination, a cross-sectional view of the posterior segment shows distinct three lobes (Figure 1). In the next 24 hours, maggots migrate away from these remains, indicating their continued development and movement. Initially, they turn into reddish-brown colour soft shell-like structures and gradually turn into dark black colour hard shell-like structures, suggestive of the pre-pupae and pupae stage (Figure 2).

These findings suggest that the maggots collected from the decomposed body were undergoing successive developmental stages, progressing from larvae to pre-pupae and pupae. It remained in the same condition for two to three days & turned into a green metallic colour adult fly, identified as a green bottle fly (Figure 3). The complete life cycle of the maggots collected from the decomposed body was successfully observed and documented, with the maggots progressing through various developmental stages from third instar larvae, pre-pupae, pupae, and finally emerging as adults. The total observation period was approximately five to six days. The maggots present at the time of postmortem belong to the third instar phase which finally developed into green bottle flies.

The findings from the observation of the collected maggots and their developmental stages suggest that the time since the death of the decomposed body in Case 1 was approximately three to five days. But, if we consider the decomposition features to estimate the time since death, it will be between 5 and 10 days.[8]

In Case 2, collected eggs hatched on the very next day after being placed in the artificially ventilated environment & larvae appeared. Grossly their size was up to 5 mm and microscopically unsegmented posterior spherical noted (Figure 4), suggestive of the first instar phase.[9] Within the following 24 hours, the larvae experienced growth, reaching a size of about 10 mm. Under microscopic examination, they exhibited a segmented posterior sphere with two lobes, indicating the 2nd instar phase (Figure 5).[9] In the next 24 hours, maggot size increased to approximately 15 mm with a hairy appearance, and a distinct three-lobed cross-sectional view of the posterior segment (microscopic view), indicating the progression to the third instar phase.[9] This stage lasts for two days. By the 6th day, some maggots moved away from the feeding site to selectively pupate. Subsequently, a reddish-brown soft shell-like structure was observed, gradually transforming into a blackish, hard shell-like structure identified as

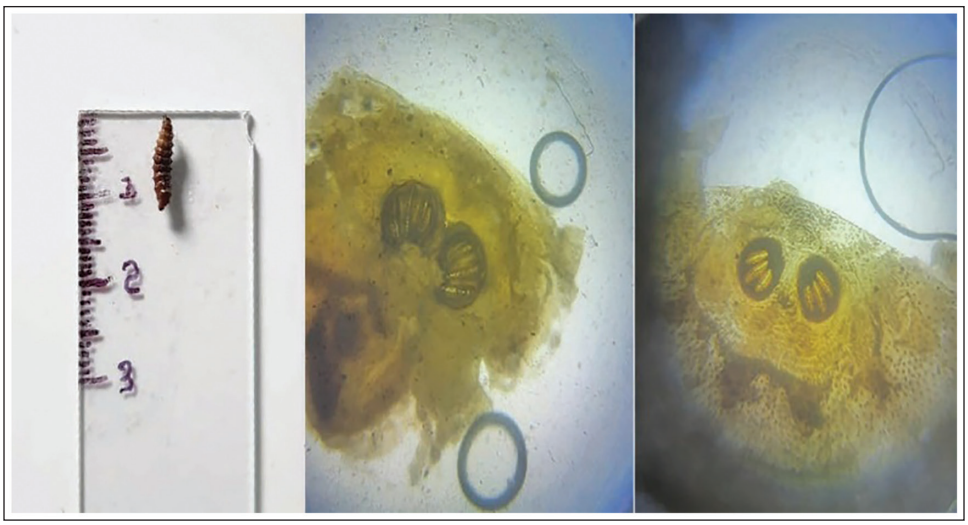

Figure 1. Larvae Length 12 mm with Hairy Appearance; on Microscopically Posterior Spiracle with Incomplete Three Lobe Followed by Distinct Segmented Posterior Spherical Three Lobe.

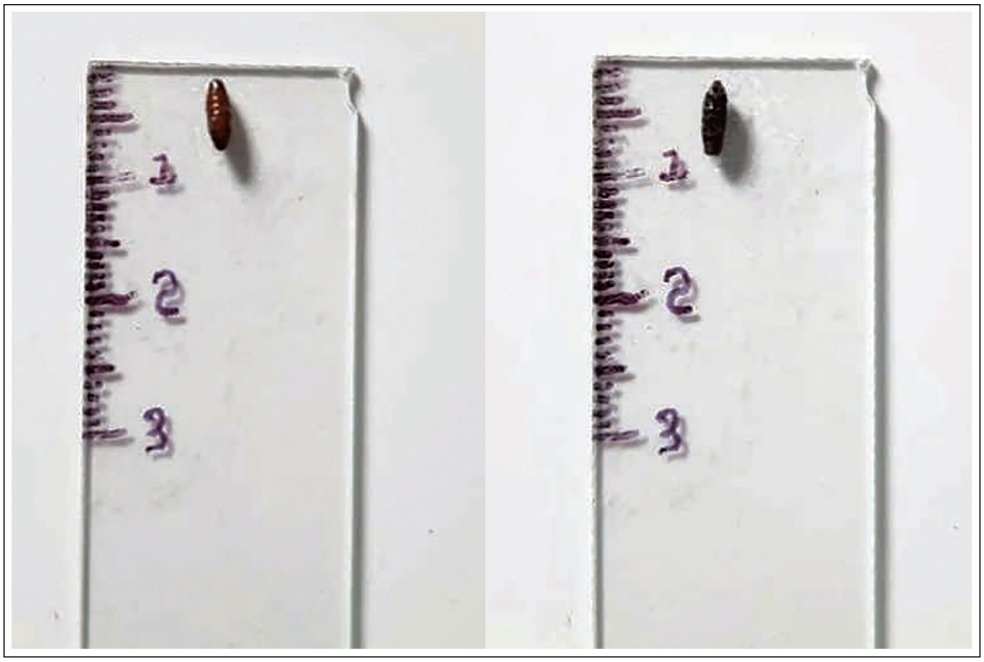

Figure 2. Reddish Colour Soft Shell-like Structure—Pre-pupae, Blackish Colour Hard Shell-Like Structure—Pupae.

pupae. This pupal stage lasts for two to three days before finally developing into green bottle flies. Considering the postmortem features, the estimated time since death was 12–24 hours. However, when considering entomological evidence, the time frame was approximately within 24 hours, which lacks specificity.

In Case 3, during the initial examination of the maggots, their size was noted to be up to 5 mm. Microscopically, an unsegmented posterior sphere was observed, indicating the first instar phase. Subsequently, within the next 24 hours, these maggots reached a size of around 10 mm, displaying a segmented posterior sphere with two lobes, signifying progression to the second instar phase. In the subsequent 24 hours, their size increased to approximately 15 mm, and they developed a hairy appearance. Additionally, a distinct three-lobed cross-sectional view of the posterior segment was observed, indicating the third instar phase lasts for up to 48 hours.

In this stage, the maggots showed active feeding behaviour. Starting from the 6th day, the maggots moved away from their feeding site for selective pupation. They underwent a gradual transformation, first adopting a reddish-brown

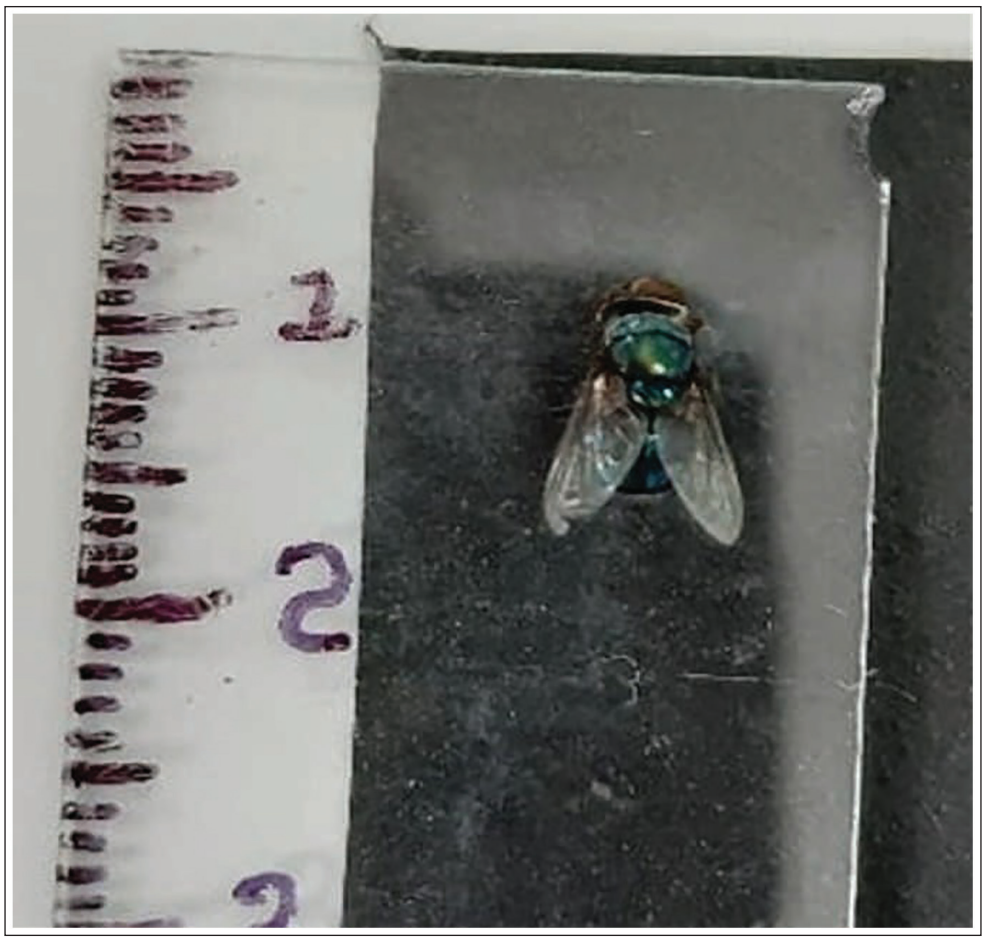

Figure 3. Green Metallic Colour Fly—Green Bottle Fly.

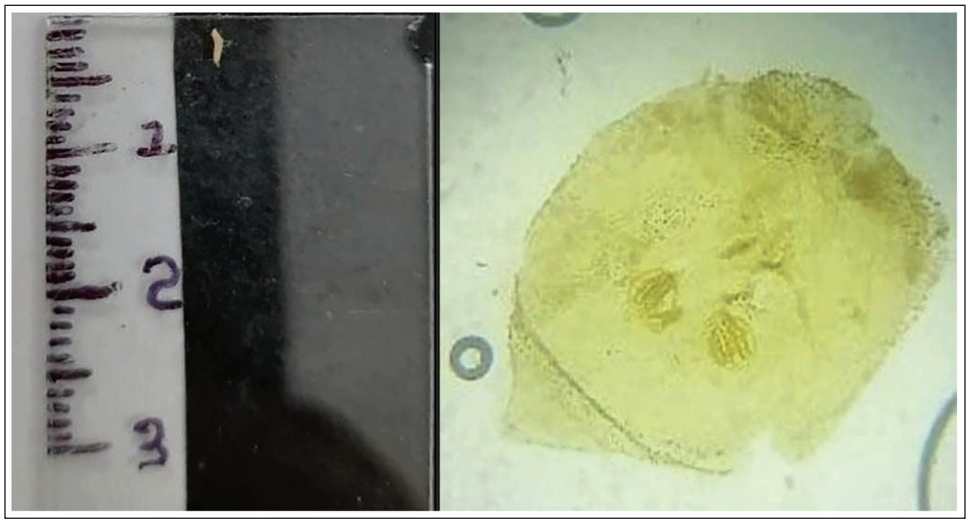

Figure 4. Larvae Length 5 mm. On Microscopically Unsegmented Posterior Spiracle Noted—1st Instar Stage.

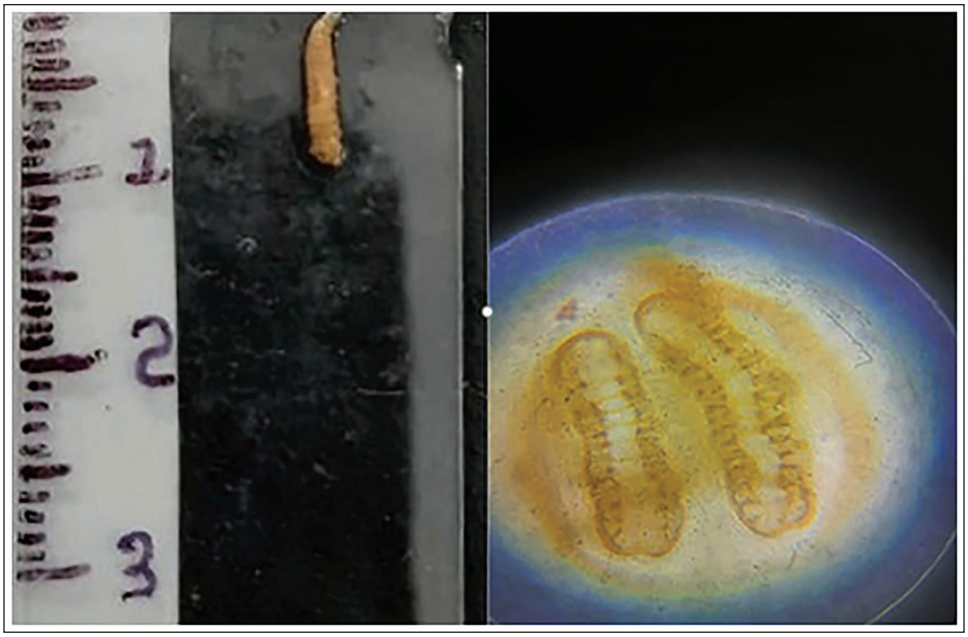

Figure 5. Larvae Length 10 mm. On Microscopically Segmented Posterior Spiracle With Two Lobes Noted—2nd Instar Stage.

soft cell-like structure and later developing into a dark black hard cell-like structure, indicative of the pre-pupae and pupae stage. The pupal stage lasted for two to three days before the emergence of green bottle flies. For Case 3, the estimated time since death derived from entomological evidence was approximately 24–48 hours. However, considering postmortem changes, the time since death is more accurately narrowed down to within 24–36 hours, rendering it more precise than the entomological evidence.

Green bottle flies deposit eggs in relatively fresh corpses within the first 24 hours of death. These eggs hatch within a day, giving rise to first instar larvae that commence feeding on decomposing tissues. As the larvae progress through their instar stages, they enter the 2nd instar phase typically within the subsequent 24 hours, followed by the development of the 3rd instar phase within an additional 24 hours. During the 2nd and 3rd instar phases, maggot sizes reach up to 10 mm and 15 mm, respectively. Microscopically, the posterior segments exhibit a segmented appearance with two lobes during the 2nd instar phase and three lobes during the 3rd instar phase.[2,10]

Conclusion

The study of green bottle fly maggots and their life cycle is crucial in forensic entomology for estimating the time since death in decomposed bodies. Careful observation of the different instar phases, from egg hatching to adult fly emergence, provides vital evidence and helps narrow down the time since death.[11] The combination of entomological evidence and postmortem changes is crucial for accurate estimations, as demonstrated in observed cases. It is important to note that identifying fly species based on adult characteristics alone can be challenging. Examining eggs and maggots at different stages of development, along with observing postmortem changes, provides a more comprehensive and reliable estimate of the time since death in decomposed bodies. This case series emphasises the importance of using species-specific developmental data sets and considering environmental conditions when estimating the time since death in decomposed bodies using entomological evidence.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Ethical Approval and Informed Consent

Ethical approval taken from Institutional Ethics Committee and informed consent taken from legal guardian.

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Determination of Gestational Age and Live Birth in Decomposing Infant Corpse

Journal of Indian Academy
of Forensic Medicine
46(3) 419–421, 2024

DOI: 10.1177/09710973251322015
journals.sagepub.com/home/iaf
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Abstract

The number of unwanted pregnancies globally remains high. This is one of the contributing factors to the frequent discovery of decomposing newborn bodies, which can make forensic examinations challenging for pathologists. In April 2022, the body of an unidentified baby, wrapped in a plastic bag, was found in the bushes. An autopsy was conducted following a visum et repertum request. The examination revealed a decomposed infant with a fully formed earlobe, fingernails extending beyond the fingertips, female genitalia with the labia majora covering the labia minora, and ossification nuclei present in the distal femur, proximal tibia, and cuboid bone. Wreden's test also indicated the presence of air inside the middle ear cavity. Based on these findings, it was concluded that the baby was born alive, with a gestational age of 9–10 months.

Keywords

Autopsy, decomposed body, gestational age, live birth

Received 23 September 2023; **accepted** 06 March 2025

Introduction

An unwanted pregnancy is a pregnancy that occurs in a woman who does not plan to have children or an untimely pregnancy. Globally, in 2015–2019, there were an average of 121 million unwanted pregnancies each year in women aged 15–49, with 61% ending in abortion. The desired pregnancy rate tends to be higher in middle-income countries than in high-income countries.[1] In Indonesia, the incidence of abortion reaches 2.3 million per year with the largest contributors to the incidence of abortion related to unwanted pregnancy are school-age adolescents and unmarried.[2] Unwanted pregnancies can be caused by sexual violence, promiscuity, parenting, low socio-economic levels of the family, low level of education and others. This can cause the still rampant cases of finding newborns in the trash, even if some are found dead or decomposed, which can be challenging for forensic experts to conduct examinations, primarily to determine gestational age and whether the baby was born alive or dead.

Discussion

Age estimation is an important point that must be sought in an autopsy to determine the exact age of an unknown person or body, especially in the process of investigation or trial of a criminal act.[3,4] In forensic examination of infant corpses, the age determined is the gestational age calculated from the first day of the mother's last menstruation until the baby is born.[5] When the baby is found in a decomposed condition, the determination of gestational age can be done by looking at developmental features unaffected by decay. Fully formed earlobes, nail growth that had exceeded the fingertips, and female genitals with labium major conditions covering the labium minor suggest that the estimated gestational age of the baby is about 9–10 months. In addition, gestational age can also be determined by looking at the ossification centre of the epiphyses, commonly referred to as secondary ossification[6] (Figure 1).

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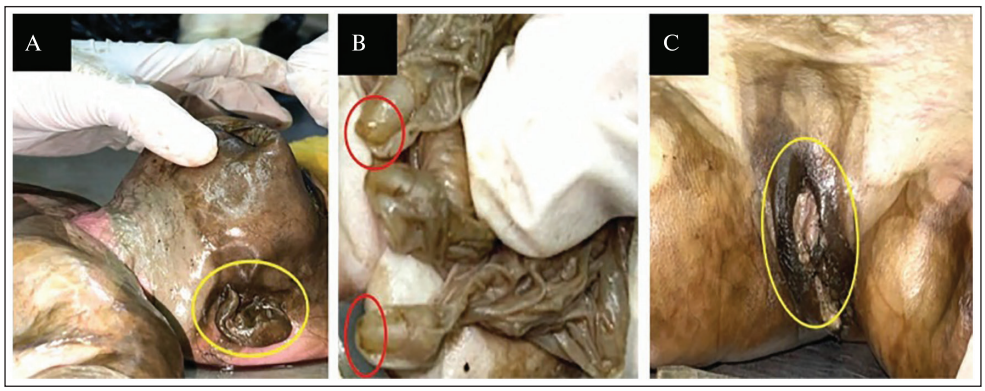

Figure 1. Developmental Characteristic Visible on External Examination: (A) Auricles Tense With Perfect Deep Creases (Yellow Circle); (B) Growth of Nails That Have Exceeded the Fingers (Red Circle); (C) Female Genitalia With the Labium Minor Covered by the Labium Major (Yellow Circle).

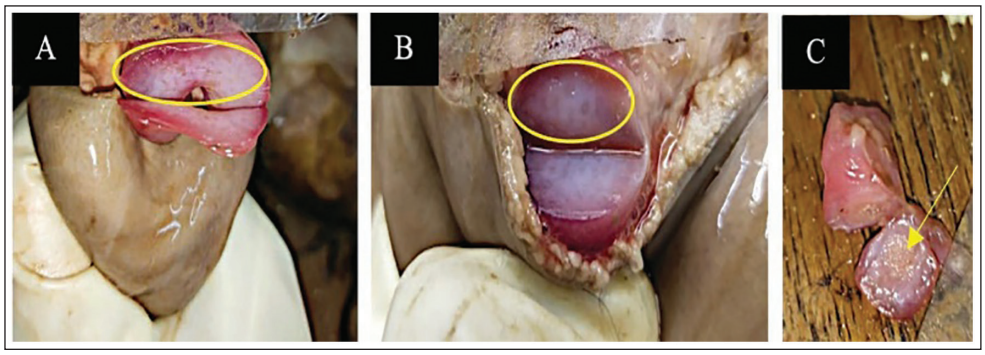

Figure 2. Ossification Centre in the (A) Distal Femur (Yellow Circle); (B) Proximal Tibia (Yellow Circle); (C) Cuboid (Yellow Arrow).

Case Report

In April 2022, the body of an unidentified newborn wrapped in a plastic bag was found in the bushes and taken to the hospital for an autopsy under the visum request letter. The autopsy showed the corpse of a baby with an umbilical cord still attached without a placenta, accompanied by signs of further decomposition in the form of a brownish-green body, epidermal peeling throughout the body, all decayed internal organs, fully formed earlobes, nail growth that exceeds the fingertips, and female genitalia with labium major covering labium minor. Secondary ossification centres appear in the distal femur, proximal tibia and Cuboid. Positive Wreden's test indicates the presence of air inside the middle ear.

Human bones develop from primary and secondary ossification centres. Bone growth of both centres will continue until the bone is fully formed.[7] Ossification of the limb begins at the end of the embryonic period. The primary ossification centre is present in all long bones at 12 weeks gestation. From the primary ossification found in the diaphysis, ossification will develop at the ends of the bones by forming epiphyseal plates, which are cartilage.[8] The secondary ossification centre in the epiphyses mainly consists of blood vessels, which can be seen directly in the autopsy process by flexing the leg on the knee joint and making a longitudinal incision over the patella. After that, the bone is pushed forward and makes a transverse incision in the cartilage (epiphysis) at the distal end of the femur. If the reddish blood vessel points on the epiphysis are visible, the transverse incision is continued in the proximal direction until it reaches the diaphysis's core. The same step is also performed to look at the proximal tibia. The ossification centre can also be seen in cuboids by making an incision between the third and fourth toes parallel to the axis of the long bone and then deepening towards the ankle until it finds a cube-shaped bone.[9] In this case, the secondary ossification centres can be seen in both the distal femur and proximal tibia and in the cuboids that appear pale red in the middle, which indicates that the gestational age of the baby is between 9 and 10 months. An important test to determine whether the baby was born alive or dead is the middle ear test (Wreden's test) because the air in the middle ear cannot be affected by decomposition. A baby who has breathed at birth will make swallowing movements, and because the Eustachian auditive tube is open, air can enter the middle ear cavity. This test is done by making sculptures or small holes in the tympanic tegmen below the water's surface. If a bubble comes out of the hole, as in this case, it can be said that the baby was breathing and born alive[6] (Figure 2).

In the case of the discovery of infant corpses in Indonesia, several possible criminal acts must be considered, namely child homicide, criminal provocateuse abortion, child neglect, intrauterine foetal death and infanticide.[6] Child homicide can be categorised as an intrafamilial or extrafamilial homicide. Intrafamilial murder is committed by biological or step-parents, guardians or caregivers equivalent to the parents, while extrafamilial murder is committed by perpetrators who are outside the intrafamilial.[10] Forensic medicine defines abortion as the removal of conception results at any stage of its development before complete gestation is reached. It can be classified into spontaneous abortion and abortus provocatus. Abortus provocatus is divided into medicinal abortion and criminal abortus provocatus, which is performed without medical consideration. Infanticide, in the perspective of Indonesian law, is defined as the murder of a child committed by a mother against her biological child at birth or shortly after birth for fear of being caught giving birth.[6,11] Determination of criminal acts is the task of the investigator by considering the results of the autopsy by the forensic pathologist.

Conclusion

In the condition of decomposing infant corpses, gestational age is determined based on visible developmental characteristics and ossification centres, while the determination of live birth is done through Wreden's test. Autopsy results can be evidence and provide clues for investigators in determining the criminal act that occurred.

Acknowledgements

The authors are thankful to our teachers and friends in the Department of Forensic Medicine and Medicolegal, Faculty of Medicine, Universitas Airlangga for the permission and motivation given to us to compile this research.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

The study was approved by the relevant ethics committee. The autopsy was conducted under a visum request letter issued by the police for an unidentified corpse.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

Informed consent was not required as the autopsy was performed on an unidentified corpse, and no personal identifying information was involved.

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Labio-cervical Vertical Groove (LCVG): An Enamel Organ Insult as a Morphological Anomaly of Tooth

Journal of Indian Academy
of Forensic Medicine
46(3) 422–424, 2024

DOI: 10.1177/09710973251316108
journals.sagepub.com/home/iaf
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Abstract

Among the frequent congenital anomalies of teeth, the labio-cervical vertical groove (LCVG) is a rare congenital morphological anomaly of teeth. The science of forensic dentistry has valuable contributions to assist in personal identification, syndromic correlation of congenital diseases, victim search after a mass disaster by ensuring faster and scientific information from recorded secure past data to compare it with the present one. Infolding of an enamel organ and Hertwig's epithelial root sheath can create a vertical groove on the labial surface of permanent maxillary incisors extending from crown to root. A 47-year-old male patient, came to a private clinic with a complaint of bleeding from gums. On clinical examination, generalized mild gingival inflammation and vertical groove along with mild gingival irregularity were found on the labial surface of 21. The present case shows mamelon remnants extension with LCVG in 21 in the patient and his mother.

Keywords

Congenital anomalies, labio-cervical vertical groove (LCVG), forensic dentistry, enamel organ, mamelon remnants

Received 16 February 2024; **accepted** 13 June 2024

Introduction

The labio-cervical vertical groove (LCVG) is a unilateral or bilateral structural malformation in which infolding of the enamel organ and Hertwig's epithelial root sheath create a groove on the permanent maxillary incisors.[1–6] LCVG is a type of cementoenamel defect like palato-radicular groove and cervical enamel projection.[7] Different studies in past had described LCVG as a notch.[1–4] It appears as a shallow vertical enamel depression to deep groove,[1,8,9] which can be mild, moderate or severe type based on its extent and depth.[5] Etiology includes trauma to the developing tooth bud via primary teeth injury,[1,3,8,10] vertical extension of the mamelon groove,[4,5,11] environmental, nutritional, infection or genetic.[2,5,12] This article reports, a unilateral labio-gingival groove on tooth 21 in a 42-year-old male and his mother, to consider defect occurrence was due to vertical extension of the mamelon grooves.[5,12]

Case Report

A 47-year-old male patient came with a complaint of gingival bleeding. On clinical examination, generalized mild gingival inflammation was present. Abnormal gingival contour and vertical groove were present in relation to the labial surface of 21 (Figure 1). Careful intraoral examination revealed a deep vertical groove on the labial surface of 21 of patients with mamelons remnant on incisal age and mild change in gingival contour. An intraoral periapical radiograph (IOPA) of patient revealed mild linear abrupt radiolucency up to cervical one-third of radicular part of 21 (Figure 2) Same defect of mild form was also observed in patient's mother, aged 72 years (Figure 3). There was no past history of trauma to the primary teeth and non-contributory medical history. Scaling along with deep curettage of localized areas the treatment of choice, was done. An explanation of care to be taken for a particular deformity was discussed till patient's satisfaction. Regular periodic follow-up and cleaning were suggested as a preventive measure.

Discussion

LCVG is a congenital morphological anomaly of an enamel,[1] in which an infolding of the inner enamel epithelium and

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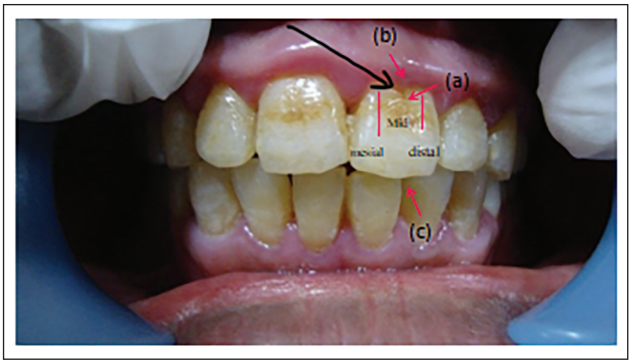

Figure 1. Labio-cervical Vertical Groove: Male Patient with a Permanent Maxillary Left Central Incisor (Tooth #21 According to the FDI Tooth Numbering System). (a) A Deep Vertical Groove (Severe Form) in the Mid-cervical Region of the Tooth Crown, Abruptly Merging with the Tooth Convexity. (B) Abnormal Gingival Contour with Reddish Gingival Margins. (c) Mamelon Remnants.

Figure 2. Intraoral Periapical Radiograph (IOPA): Abrupt and Notched Pulp Canal, Correlates with the Clinical Defect as a Labio-Cervical Vertical Groove.

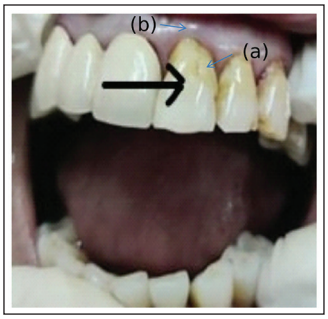

Figure 3. Labio-Cervical Vertical Groove: Female Patient, in Permanent Maxillary Left Central Incisor Tooth 21. (a) A Shallow Vertical Groove (Mild Form) in the Mid-part of the Cervical Region Of The Tooth Crown. (b) Mild Inflamed Gingival Margin and Calculus.

Hertwig's epithelial root sheath create a groove, extending to varying depth in the root.[1–6] found at the labio-cervical surface of the permanent maxillary central incisors.[1–7] It is a 3rd type of cementoenamel defect similar to palato-radicular groove on permanent maxillary lateral incisors and cervical enamel projection as enamel pearls in the furcation areas of maxillary and mandibular molars.[2,7] Gingival contour is normal in shallow enamel depression, whereas it is irregular[1,8,9] and shows a breach in gingival attachment as a deep groove.[2] Radicular extension of LCVG can be mild, moderate or deep based on its extent and depth.[1,5] Brin and Ben-Bassat (1989, 2001)[10] have observed that LCVG is associated with single or multiple incisor teeth involvement. According to past studies, deep grooves were observed predominantly in males and involving the left central incisors. Mass et al.[5] have categorized groove into three stages, that is, (a) a mild subgingival shallow groove below the marginal gingiva that can be felt only by probing. (b) A moderate groove that can be detected with the eyes extends subgingivally as in (a), and additionally supragingivally on the labial crown surface, not more than 2 mm from the marginal gingiva in the incisal direction and (c) a severe defect which extends supragingivally more than 2 mm from the marginal gingiva on the labial crown surface and further subgingivally. According to the severity ranked by Mass et al., in our case, it is a moderate type with mild gingival contour deformity in the patient and only gingival recession in his mother's case. Different studies in the past have described it as a notch.[2–4,11] The etiology is thought to be trauma to developing tooth bud,[2] vertical extensions of mamelon groove,[2,6] genetics, environmental and nutritional factors. Damage to the ameloblasts, enamel organ and Hertwig's epithelial root sheath with impaired function causing gingival, periodontal, aesthetic and prosthetic concern.[12–15] Teams of specialists from different fields such as Law enforcement departments, Pathologists, Odontologists and Anthropologists, Knowledge and evidence from dental specialists are unique to guide for positive outcome of individual identification.[16] The present case noticed a vertical groove on 21, which are remnants of mamelon groove extension in the patient and his mother. Suggestive treatment includes the elimination of grooves by gingival curettage, saucerization and restorative fillings, whereas, in hopeless teeth, extraction is recommended.[2] In the present case, we performed deep curettage only to resolve a complaint and advised to keep follow-up at regular intervals of time.

Conclusion

Abnormal tooth morphology may be a systemic indicator of developmental problems. Accurate diagnosis, elimination of inflammation and periodic follow-up are key factors to achieving favourable results. Early detection and prompt treatment of defects minimize plaque accumulation, caries, gingival inflammation and periodontal problems. Further

studies can include screening of more family members to understand the underlying genetic correlation.

Acknowledgment

I acknowledge my deep sense of gratitude to my guide Mr Rami Kamlesh B. for encouraging guidance and kind supervision. I am also thankful to Dr Kunal Thakkar for his support in providing data along with good photographs of both patients and my nephew Harshil Mehta for support in editing and writing. Their deep thoughts, knowledge and immense support have created an opportunity for me to present this case at its best.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval

Not applicable.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

Informed Consent

Informed written consent were obtained from the patients.

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Forensic Importance of Footwear Impression Evidence: A Review

Journal of Indian Academy
of Forensic Medicine
46(3) 425–430, 2024

DOI: 10.1177/09710973251322020
journals.sagepub.com/home/iaf
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Abstract

Footwear impressions are the marks which the outsole of a protective covering of feet, such as a shoe, sandal, slipper or boot leaves on a surface against which it presses. These marks are distinctive patterns which are endowed with both class and individual characteristics. As a result, they are considered valuable forensic evidence. In many crime cases, such marks can be traced back to specific footwear to the exclusion of all other varieties. Therefore, these have the potential not only to place the suspect at the crime scene, but also to track his/her movement within the crime scene.

Keywords

Footwear, impression evidence, Schallamach patterns, shoeprint, wear patterns

Received 26 December 2023; **accepted** 29 April 2024

Introduction

Like fingerprints and tool marks, footwear prints are classified as impression evidence.[1] Following the Locard principle, this type of evidence comes into being as a result of an exchange of matter between the outsole of the footwear and floor, carpet, furniture or any other artifact with a flat surface at the crime scene.[2] The footwear impression reveals an array of information about the suspect. Its dimensions divulge the size of the wearer's feet; its depth gives an idea about the wearer's weight; its shape may tell about the person's occupation; its brand may provide an idea about the person's economic status. If numerous footwear marks are present at a crime scene, these may throw light on the gait of the person and also on his trail.[3]

Like other impression evidence, footwear patterns incorporate a host of class and individual characteristics. Class characteristics are present when a person purchases a pair of footwear.[4] These include size, design and outsole texture. Individual characteristics arise after the person has worn the footwear for as short a time as a few hours. These manifest themselves as defacement, scratches, nicks and cuts in the outsole.[5]

Although footwear prints are not as unique as fingerprints, the information provided by a combination of class and individual characteristics can possibly reveal the identity of the suspect. In fact, criminals often wear gloves to neutralize fingerprints, but they just cannot avoid impinging their footwear prints while traversing the crime scene. If the protocols of crime scene management are properly followed, it is possible to retrieve 30% of footwear impressions from the scene of crime.[6] Moreover, if a suspect resorts to multiple unscrupulous acts in a short duration, it is unlikely that he/she will change the footwear between different crime sites.[7] Therefore, footwear evidence proves to be a promising asset in forensic investigations.[8,9] The forensic significance of footwear impression evidence is reviewed in this communication.

Footwear impressions as forensic evidence: The screening of footwear impression evidence involves examination, and subsequent comparison, of class and individual characteristics conflated therein. Class characteristics are a fallout of the

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manufacturing process. These include the physical size and design of the footwear. The textured pattern on the outsole is also a class characteristic. If the logo of the company is imprinted on the outsole, it too constitutes a class characteristic.[10,11] These characteristics are shown in Figure 1.

The individual characteristics are the wear marks which appear randomly and accidentally on the outsole once the footwear is put to use. These markings are unpredictable since their intensity and frequency depend on the type of surface on which the wearer walks, as well as on the way he/she walks.[12] If a person walks repeatedly on a rough surface like a concrete pavement or a metaled road, the wear marks initially appear as abrasions and scratches and later as cuts and grooves on the outsole. If objects like rock particulates, glass pieces or tapes become attached to the outsole and leave their pattern in the developed footwear print, then these too constitute individual characteristics.[11]

As far as the personal walking habits of the wearer are concerned, wear patterns appear as ridges mainly on the toe and heel of the outsole. These ridges are called Schallamach patterns.[13] The ridges are separated by 0.05–0.5 mm and are distinct for each footwear.[14] The Schallamach patterns change after 48–50 hours and can be used as a comparative aid only if the known footwear is recovered within that span of time. However, other wear patterns, which appear as abrasion marks on the outsole either due to the roughness of the walking surface or due to the walking habit of the wearer, do not change or fade out.[15] The more footwear is worn, the greater the manifestation of wear patterns.[16] Such patterns appear more rapidly on harder leather soles, than on softer rubber soles.[17]

When the questioned footwear impression, left at the scene of crime, is to be matched with a suspected footwear, the class characteristics are compared first of all. If the design or the size of the two do not match, then their association is ruled out. However, if their design and size matches, then there is a possibility that the impression was made by the suspected footwear and therefore the focus should shift to individual characteristics.

It needs to be emphasized that no other forensic evidence can narrow down a questioned sample to a control sample to such a large extent on the basis of class characteristics alone, as does the footwear impression. It is estimated that the possibility of a particular shoe design in a specific size to be

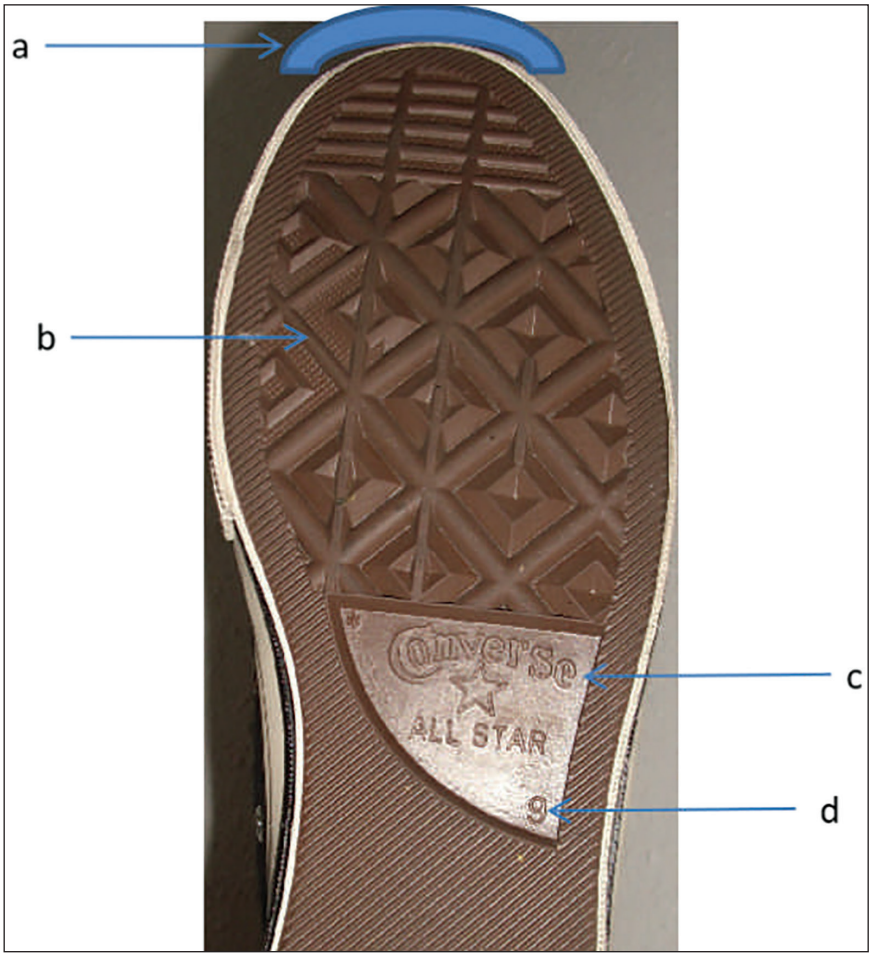

Figure 1. Class Characteristics of Footwear: (a) Design, (b) Outsole Texture, (c) Logo and (d) Size.

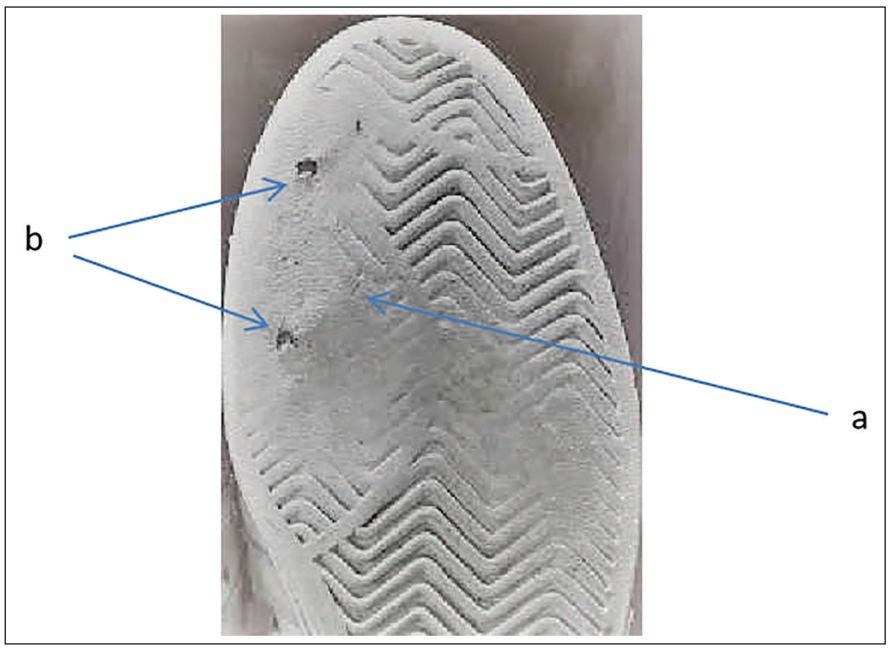

Figure 2. Wear Patterns: (a) Which are not Individual Characteristics and (b) Which are Individual Characteristics.

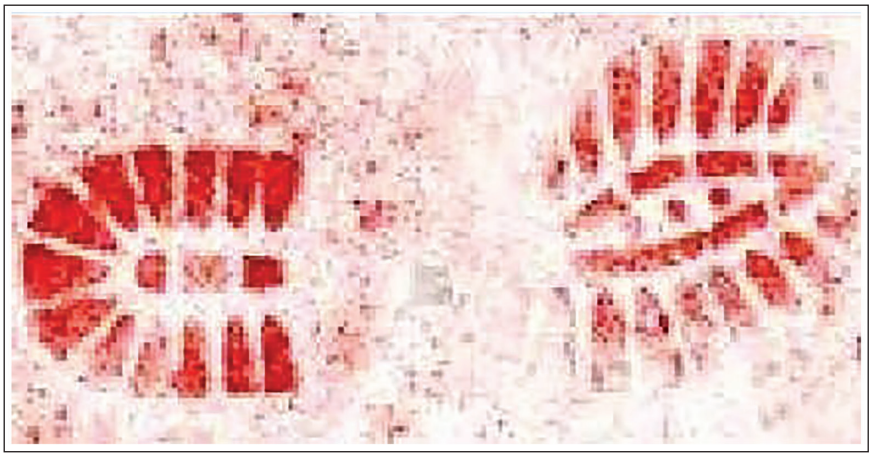

Figure 3. A Visible Footwear Impression.

repeated in another pair is of the order of 1% of the total shoe population. If the outsole design and the logo too are discernible in the impression, the probability of non-association further declines.[18] Nevertheless, for investigative purposes, no decision can be taken on the basis of class characteristics alone and, therefore, a comparison of individual characteristics too has to be taken into consideration.

Strictly speaking, wear patterns which originate due to erosion of the outer sole should serve as useful individual characteristics. However, the erosion of the outsole depends on too many factors, such as the type of surface on which the wearer walks, the way the person walks, the weight of the person, the duration for which the footwear is worn and the activity in which the wearer is engaged in. As a result, the wear patterns become so disordered that these cannot be classified as individual characteristics.[19] Moreover, two persons wearing the shoes of same size and design and engaging in similar activities will have near identical wear patterns on their footwear. On the other hand, the footwear impressions of a person who uses different pairs of shoes for different activities will show non-identical wear patterns.

Nevertheless, when the footwear is worn for a relatively long time or the wearer is engaged in an aggressive activity, such as jogging, some of the wear patterns get eroded to such an extent that these get transformed from mere scratches to cuts, tears, holes, stone holds and/or irregular-edged distortions. These types of abrasions have the potential to serve as individual characteristics (Figure 2). Such damage appears prominently in the developed footwear impression and offers a better clarity for comparison than the chaotic line or ridge patterns.[20,21]

This brings to the fore the significance of quantification of individual characteristics. The unique features found in the developed footwear impression as well as in the suspect footwear may be quantified on the basis of four parameters: Size, shape, position and orientation (or angle).[11] As a result of this quantification, a meaningful comparison can be made even if there are too few identifiable individual characteristics.[17,22] When a particular piece of footwear shows a set of unique individual characteristics which are also identifiable in its impression lifted from the crime scene, then it can be associated with the suspect to the exclusion of all other footwear of the same class.

Classification of footwear impressions: Footwear impressions are classified into three types: Visible, latent and plastic.

A visible impression results when footwear first comes into contact with a foreign substance like blood, grease, oil or water and then steps onto a clean surface.[23] The substance which becomes coated on the outsole leaves a contrasting, visible print on the walking surface. One such print is shown in Figure 3.

A visible impression is a 2-dimensional print since only its length and width are identifiable. A latent impression too is a 2-dimensional print, but it is not visible to the naked eye. It is formed through the exchange of static charges between the soil particles adhering to the outsole and a smooth, hard surface. Examples include shoe prints on tiles, wooden floors or metal coverings. Ideally, these prints do create a coating of dry soil impression on the walking surface, but the dust layer is so thin that it is invisible.[24] A plastic impression occurs when the footwear steps into a soft surface like clay, wet sand or snow.[25] One variety is shown in Figure 4.

Such an impression is a 3-dimensional print since its length, width and depth are discernible.

Development of footwear impressions: There are three broad methods which are commonly used to develop footwear impressions at crime scenes: Chemical enhancement, electrostatic lifting and casting. While the first two may be used for visualizing both visible and latent impressions, the third is exclusively meant for plastic prints.

Chemical enhancement: A latent footwear impression may be faintly visualized by illuminating with white light, the source of which is held in an oblique position. The surroundings should be made as dark as possible. Once located, it may be rendered visible by treatment with a suitable reagent like 2, 2'-dipyridyl,[26] bromophenol blue,[27] potassium thiocyanate[28] or cobalt chloride hexahydrate.[29]

Formulations used for detecting latent fingerprints may also be used for visualizing invisible or faintly visible footwear impressions. For example, Adair[24] used black powder and Hammell et al.[28] used magnetic powder to enhance footwear impressions. Ashe et al.[30] used cyanoacrylate fuming, in

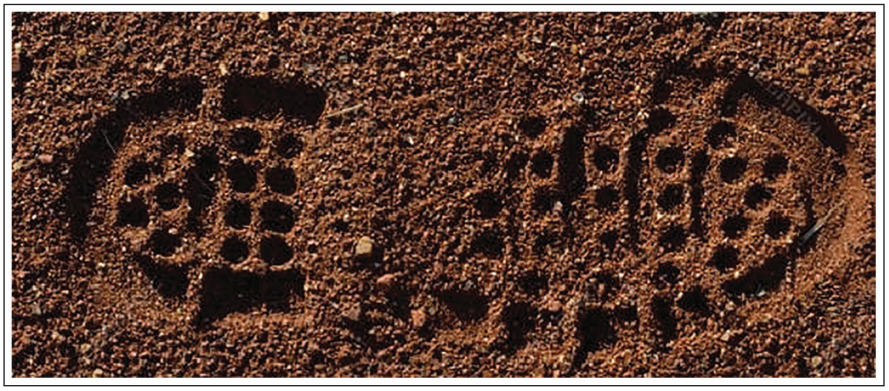

Figure 4. A Plastic Footwear Impression.

Figure 5. A Footwear Impression Cast.

concert with basic yellow 40, to lift footwear marks present as grease or oil residues on plastic bags.

Fingerprint reagents may also be used to enhance bloody footwear impressions. Bodziak[31] recommended leuco crystal violet for this purpose. The same reagent proved useful for developing blood footwear prints on substrates like white cotton, newspapers and trash bags that had remained buried for different periods of time.[32] There are a host of other chemicals which enhance blood footwear prints on fabrics. These include protein stains,[33] luminol[34] and amino acid stains.[35] Once the latent or visible footwear impressions have been enhanced, these may be preserved for record by adhesive tape lifting[36] or gelatin lifting.[37]

Electrostatic lifting: The most suitable method for recovering both the visible and the invisible footwear impressions is by a device called electrostatic dust apparatus or ESDA.[38] A lifting film is placed on the footwear print and a high voltage is applied. The film acquires a negative charge, while the outsole coating acquires a positive charge. The coating is attracted toward the film and gets deposited thereon as a precise mirror image of the original. The print appearing on the film is photographed for the record.

While the gelatin method is suitable for lifting both dry and damp footwear impressions, the electrostatic technique gives satisfactory results only if the imprint is dry.[39]

Casting: A 3-dimensional plastic footwear impression is preserved as evidence in the form of a cast. The casting material is shaken in water to create a slurry which, in turn, is poured along the sides of the impression and then allowed to spread, slowly and evenly, over the entire print. It is advisable to apply a thin film of hair spray before pouring the casting material so as to prevent the cast from collapsing.[40] After about 30 minutes, the cast is lifted up with the aid of a knife. It is cleaned with a solution of potassium sulfate and air-dried for 24–48 hours. A cast gives an actual-size molding of the original impression. As shown in Figure 5, it captures even minor details of the impression.

Examples of casting materials include plaster-of-Paris, Traxtone, crime-cast and dental stone.[41,42] The latter has emerged as a material of choice. It hardens quickly, and hardening is more durable than other analogs.

If the plastic impression is in water, then any debris material floating on the surface is first removed. A thicker slurry is poured and the hardening time is stretched to 60 minutes. If the plastic impression is in snow, either talcum powder or snow print wax is sprinkled onto it.[40] After about 10 minutes, the dental stone slurry, prepared in ice-cold water, is poured evenly over the impression and allowed to harden for 60 minutes.[43]

Preservation of footwear impression evidence: Footwear impression evidence, when collected and documented by proper scientific protocols, can lead to the positive identification of suspects. While securing the crime scene, the barrier tapes should engulf a large enough area so as to obviate the possibility of entry and exit points being left out. Since these impressions are easily despoiled by weather and vehicles, priority should be given to documentation of outdoor prints. Indoor impressions are likely to be smudged by overstepping and therefore only one investigator should initially enter the scene to tag evidence markers onto these. Till the time the outdoor or indoor impressions are developed, it is better to cover these with boxes or cones.[2]

The photography of the evidence should begin by showing its location with respect to other artifacts. Hence a few overview shots must be taken in the beginning, followed by mid-range shots. The evidence marker must be included in both types of photographs. To capture the details of the footwear evidence, a close-up photograph should then be taken by mounting the camera on a tripod. In order to minimize distortion, the plane of the film should be parallel to the plane of impression. A scale should be placed on the same level as the impression and about one inch away from it. However, the focus should be on the imprint and not on scale or evidence marker. Better details can be visualized if each impression is photographed using a light source positioned at different angles.[44]

Conclusion

Footwear impressions are present at every crime scene. However, most often these are either overlooked or despoiled by overstepping. Nevertheless, when such markings are developed by sound scientific procedures and the class and individual characteristics embedded therein are recorded meticulously, these provide a definite link between the suspect and the crime scene. Therefore, the analysis of footwear patterns can go a long way to solving crime cases.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

Not applicable.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Informed Consent

Informed consent on this research has been mutually agreed upon by both the authors.

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Review Article

MLIIR in Crime Investigation and Administration of Justice

Journal of Indian Academy
of Forensic Medicine
46(3) 431–435, 2024

DOI: 10.1177/09710973251316357
journals.sagepub.com/home/iaf
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Abstract

The importance of a well-structured history and interview and its correlation with physical examination and laboratory investigation is established in both diagnoses of disease and crime investigation. But in India, medico-legal experts are rarely involved in history and interviews with suspects and witnesses. During the psychological autopsy, various information was obtained which were very useful for the investigation of the case but did not fall under the purview of the psychological autopsy. This new terminology was coined namely Medico-legal Interview for Information Retrieval (MLIIR).

Keywords

History, medico-legal experts, psychological autopsy, medico-legal interview, information retrieval

Received 23 November 2023; **accepted** 19 February 2024

Introduction

Coordinated approaches among the different experts are key to success in any field including crime investigation. Crime investigation is a purely scientific field which involves the expertise of various disciplines but the most important role of that person comes who is capable of coordinating all experts, available information and evidence. Therefore, such a person should be well qualified in scientific subjects related to crime investigation and should have access to all types of information with the capability to understand the nature and importance of different scientific evidence and should be able to correlate them to draw reasoned inferences.

Being medical professionals we compare the crime investigation analogous to a diagnosis of disease which involves history, physical examination and investigations. In India the basic difference between disease diagnosis and crime investigation is, in the case of disease diagnosis history and physical examination are done by the same individual and also the decision of lab investigation and its correlation is done by the same who is the specialist of that subject. Whereas in crime investigation the functions analogous to history taking, physical examination (autopsy or injury examination) and lab investigation are done by three different agencies like police/magistrate (or other similar agencies), Medico-legal expert (doctor specialized in Forensic Medicine) and forensic science experts, respectively.

Among all these steps in clinical diagnosis the researchers, experienced teachers and medical professionals emphasized the most important role of history. In one research it has been established that history, physical examination and investigations contribute about 76%, 12%, and 11%, respectively.[1] Other researchers also established the role of good history taking most important.[2,3]

However, in India, these agencies are working independently of each other with minimum coordination among them.[4] Even these three agencies are not able to understand the basic terminologies of scientific works related to the other two fields. Besides these the most important scientific responsibility of history, crime scene investigation and correlating all scientific evidence with available history has been given to medically and scientifically unqualified and

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inexperienced magistrates and police. In many places, even no column of information obtained by history and crime scene investigation has been provided in the format of medico-legal reports.

In many developed countries a person qualified in Forensic Medicine/Pathology and trained in law known as a medical examiner has been given responsibility at most of the stages of investigations including crime scene investigation, post-mortem examination, evidence collection witness and suspect interview etc.[5,6]

Due to these reasons, medical examiner of inquest in the Federal Court of USA, conviction rate extends to 99.8%, whereas in India it is 50.4%.[7,8]

Besides these due to the non-involvement of forensic medicine experts in history, crime scene investigation, and collaboration of scientific evidence added with insufficient information provided by police in the inquest report, number of negative autopsies becomes falsely high thus doctors are failing in their honors duty to find out the exact cause of death and to reduce the number of negative autopsies as far as possible.[9–11]

The author during psychological autopsy accidentally received various information which were very useful in crime investigation but did not fall under the scope of psychological autopsy therefore coined the new terminology "Medico-legal Interview for Information Retrieval (MLIIR)."

Current System of Crime Investigation in India

In India mainly three types of agencies are involved in crime investigations against the human body:

1. Police/Magistrate or other similar agencies
   a. They are non-scientific persons neither qualified in science nor necessarily in law
   b. They are responsible for the following works in crime investigations:
      i. Crime scene investigation.
      ii. Deciding scientific laboratory investigations.
      iii. Interview/interrogation of suspects and witnesses.
      iv. Collection of materials for scientific investigations.
      v. Interpretation of scientific reports.
      vi. Correlation of scientific reports.
2. Forensic Medicine experts
   a. They are qualified in medical science and basic criminal laws.
   b. They are entrusted with the following works:
      i. Examination of living or dead bodies and preparation of medico-legal reports.
      ii. Collection of biological materials from the human body for laboratory analysis.
3. Forensic Science experts
   a. They are qualified in any one of the subjects of science.
   b. They are responsible for the analysis of samples in a laboratory.

Lacunae in Current Crime Investigation in India

1. Scientific and non-scientific agencies are working independently with no discussion among them. Even they are not able to understand the basic terminologies used in the other two disciplines.
2. Forensic Medicine experts are not aware of the report of crime scene investigation, history and information obtained from interviews of witnesses and suspects.
3. Crime scene investigation is rarely done by scientific/forensic medicine experts.
4. Interpretation and correlation of scientific reports are done by non-scientific people.

Current Role of Scientific Experts in Interviewing Suspects and Witnesses

In the present system scientific experts are playing a limited role in some of the investigations which are as follows:

1. Polygraph
2. Narco-analysis
3. Brain mapping
4. Eye detection system
5. Psychological autopsy.

1. Polygraph

In this skin conductivity, respiratory rate, heart rate and blood pressure, and are continuously recorded expecting a change in their pattern upon lying due to stimulation of the sympathetic nervous system.[12,13] Questions are designed after studying available information preferably by forensic experts.[14–16] The accuracy of this test has been found to the tune of 45%–60%.[15] Although it is the oldest and most basic method of deception detection it is not used for the purpose of correlating the medico-legal reports. Also, it can be used in very selective suspects and witnesses with limitations of easy coning and confession is not possible.

2. Narco-analysis

In this, a person at an appropriate level of semi-consciousness which is brought about by hypnotic drugs cannot invent falsehood on questioning that can conceal his guilt.[17] According to different guidelines and practices, different experts are included in the team comprising of anesthesiologist, psychiatrists, psychologists, forensic medicine experts, and nursing staff. Videographers etc. Although in

this procedure success rate is very high and confession is possible as it is an invasive procedure and law requires consent of the subject therefore it is not frequently used.[18,19] Besides these required depth of trance stage is difficult to maintain however author introduced a new technique namely BIS (Bispectral Index) electrode to objectify the monitoring.

3. Brain mapping

In this technique the electrical brain wave response namely MERMER (memory encoding related multifaceted electroencephalographic responses) is measured which is generated by exposing words, phrases, pictures, videos, etc. on a computer screen.[20,21]
It is 100% accurate but requires expensive setup and higher expertise.22 It can only suggest whether individual had seen crime scene or not.

4. Eye detection system

It is a type of Ocular-motor Deception Test (ODT) based on an infrared system which records different types of eye movements (like fixation, blinking and pupil dilation), response rate, cognitive workload, reading behavior, error rate, involuntary deception cues etc. With increasing lie cognitive load increases which affects eye behavior.[23–25] It is a newer method which on careful interpretation yields better results. It is expensive requires higher expertise and is not intended to correlate entire history and medico-legal reports.

5. Psychological autopsy

Psychological autopsy is the procedure conducted in a case suicide to unearth intention and state of mind of the deceased prior to death through structured interviews of the people knowing the deceased closely and also by perusal of relevant records.[26–29] It is handy even when a physical autopsy cannot be done. However, it is of limited use as it is used in only suicidal cases and is also difficult to rule out biases.

Medico-legal Interview for Information Retrieval

In the Indian system of crime investigation, there is no opportunity for medico-legal experts to be involved in interview of suspects or witnesses and also crime scene visits by medico-legal experts are very rare. But being an institute of national importance, some cases were referred for both medico-legal opinion and psychological autopsy to AIIMS, Patna, in which even the manner of deaths was in question. Therefore, a combined team of forensic medicine experts, psychiatrists, and psychologists was formed. During the psychological autopsy and examination of documents by the combined team it was felt that much such information was elicited which was useful in the investigation and had not been elicited by investing agencies yet but not falling in the purview of psychological autopsy. As in the opinion of psychiatrists and psychologists, psychological autopsy can only be used in known cases of suicide to know the circumstances leading to suicide and is not meant to differentiate suicide, homicide or accident. Thus, the need to coin new terminology was felt and it was decided to coin the term "Medico-legal Interview for Information Retrieval (MLIIR)". Methods of MLIIR suggested as follows:

1. It should be done by a team of Forensic Medicine experts. Psychiatrist and/or psychologist may be included in the team when required.
2. Team should visit crime scene, collect evidence, interview suspects & witnesses, analyse medico-legal and scientific reports, correlate entire information & evidences, plan further investigation and suggest law enforcement agencies.
3. Team should take help of experts in other fields of science, art, law, undercover informer etc.
4. Team should issue final report/opinion on cause, manner and circumstance of death after analyzing all facet of investigation.

Advantages

1. The scope of this procedure is broader than psychological autopsy as psychological autopsy is limited to suicidal cases only.
2. As it shall be done by a team of multidisciplinary experts, therefore, questionnaire and responses shall be more exhaustive and relevant.
3. As it shall be done by scientific experts therefore correlation of information and evidence shall be more relevant.

Disadvantage

1. Direct confession is not possible which is possible in narco-analysis.
2. By only interview, only circumstantial information can be retrieved, however as the team shall analyse all medico-legal and scientific evidence therefore final opinion shall be given with more certainty.

Discussion

Various types of inquests/inquiries are prevalent in different parts of the world and are conducted by medical examiner, coroner, magistrate, police, juries etc. In India presently two systems are in place, that is, police and magistrate systems. In this system role of medico-legal experts is limited to issuing autopsy reports, injury reports and other medico-legal reports. Their interpretation and correlation are done by non-scientific people.

A wide range of involvement of medico-legal experts has been felt by the different authors, researchers and agencies all over the world especially in the history, interview and interpretation & collaboration of evidence. Reddy KSN suggests medical officers find out the apparent cause of death before autopsy by careful examination of documents and other available details as lack of information may result in loss of evidence.[11] Kumar B et al. found significant improvement in the opinion regarding cause, manner and time of death when medico-legal experts perform crime scene visits and interviews with witnesses.[4]

Such functions of medico-legal experts are optimally utilized by medical examiners practicing in the USA, in most jurisdictions. Indian coroner system was similar to medical examiner system which was abolished completely from India in 1999.[30] When the Forensic Medicine department was established in India, Dr. Urquhart who was a private practitioner who was also posted as city corner was given charge of Professor in Forensic Medicine at Medical College of Madras in 1857.[31]

The medical examiner can be differentiated from other types of inquest by the fact that a medical man (forensic medicine/forensic pathology specialist) with the necessary training in law and death investigation, conducts or oversees most portions of scientific crime investigations whereas in others it is confined to preparation of medico-legal reports.[32,33]

To further discuss the topic, in 2003 the authorities of Washington DC formed a committee for deliberation on a system of medico-legal death investigation. After conducting the workshop pertinent recommendations and observations were published in a workshop summary under[33]:

1. The process of certifying a death should only be carried out by a well-qualified medical man who possesses the basic competencies of evaluating recent and past medical histories, speaking with witnesses, performing physical examinations, and coordinating autopsy results with crime scene and laboratory results.
2. The public health system, pathology departments, forensic science labs, and other subspecialty facilities should all be housed in medical schools, which should oversee the ideal medical examiner system.
3. To promote excellent professionalism in crime investigation, it was ultimately determined in the workshop to nationally approve the replacement of coroner investigation by medical examiner.

Consequently, in the year 2007, coroner investigation system was completely replaced by the medical examiner investigation system and Chief Medical Examiner was given the position of coroner.[33]

Conclusion

Crime investigation is a multidisciplinary work involving expertise of various specialties in which interview/interrogation should be done in the background of results of scientific investigations and also vice versa, that is, scientific investigations should be planned in accordance with information available from the scientific interview. Thereafter all information should correlate to reach up to conclusion. Presently all these works are done by different independent agencies with no interaction among them in the name of secrecy resulting in low conviction rate. Therefore, crime investigation by combined team of investigating agencies, forensic medicine experts, forensic psychiatrists/psychologists, forensic science experts etc is need of hour. This dream may come true by establishing medico-legal institute where all facilities may be established under one roof.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval and Informed Consent

Not applicable.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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Short Communication

Balancing Innovation and Responsibility: Training Medical Students in Ethical Issues in Precision Medicine

Journal of Indian Academy of Forensic Medicine
46(3) 436–438, 2024

DOI: 10.1177/0971097325131638l
journals.sagepub.com/home/iaf
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Abstract

The emergence of precision medicine has transformed the manner in which healthcare is delivered to the general population. Regardless of these merits, we must acknowledge that a number of ethical issues are linked to precision medicine, and they must be carefully dealt with to avoid harm to patients. As there are many ethical concerns, we must prepare our medical students during their undergraduate training period to respond to them effectively and efficiently. In conclusion, there is an immense need to train medical students using a combination of teaching-learning methods, and that too throughout the duration of training so that future generations of healthcare professionals can maintain dignity and be respectful to all patients.

Keywords

Precision medicine, ethics, healthcare, medical education

Received 23 June 2023; **accepted** 27 November 2023

Introduction

The emergence of precision medicine has transformed the manner in which healthcare is delivered to the general population.[1] As medical students of today's generation will be the future members of the health team, it is extremely essential that they should be trained in precision medicine, as such initiatives will expose them to the field of genomics and biomarkers, and also empower them to deliver patient-centered care.[2,3] The adoption of precision medicine has been linked with a wide range of benefits to medical students, healthcare professionals, patients, the community, the healthcare delivery system, and the nation as a whole.[1,4] Regardless of these merits, we must acknowledge that a number of ethical issues are linked with precision medicine, and they must be carefully dealt with to avoid harm to patients.[5] In other words, we must maintain a balance between advancement in scientific knowledge and the safety and welfare of patients.[5]

Ethical Issues in Precision Medicine Education

As precision medicine essentially involves genetic testing of patients to enable customized delivery of treatment, there is an indispensable need to obtain written informed consent from the patients prior to testing.[6] As healthcare professionals are obtaining informed consent, they must ascertain the validity and reliability of genetic tests that will be performed on the patient and must educate patients about the potential limitations of these tests as well.[6,7] The issues become even more prominent when we are performing genetic testing among minor and other vulnerable groups of patients.[8] There is an indispensable need that obtained genetic reports to be kept confidential, as we cannot rule out the possibility of discriminating against patients based on their genetic information with regard to their medical insurance, job opportunities, and other social contexts.[9,10] Further, we must also explicitly state who will be the accountable person when genomic data will be shared to

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other stakeholders or institutions for research purposes, and how patient confidentiality will be maintained.[6,7] In addition, we must maintain transparency while doing research or sharing data and strictly adhere to standard ethical norms.[11,12]

We also should consider ethical issues about the allocation of resources in different aspects of precision medicine, and make efforts to distribute them equitably.[13] As precision medicine is gradually increasing in popularity, we must ensure that access to precision medicine-related technologies or treatment is accessible to everyone, and should not augment the prevailing disparities in the health sector.[14] Though the healthcare professional is the one who is running these genetic and biomarker-related tests, we must educate and empower patients regarding their condition, including the genetic information, so that they can make autonomous decisions regarding their clinical treatment (patient-centered care).[1–3] Further, there is a definite need to recognize and be respectful toward the varied cultural perspectives on genetics so that we can understand and accordingly communicate to patients keeping in mind the potential cultural biases.[15] We must also be wary of the long-term follow-up and monitoring of patients who underwent genetic testing and thus might develop psychological and social consequences.[16]

Potential Solutions

As there are many ethical concerns, we must prepare our medical students during their undergraduate training period to respond to them effectively and efficiently.[7] Medical students should be trained in ethics across different professional phases in relation to precision medicine, starting right from the first professional phase, and this will ensure that they are pretty much aware of ethical principles.[17] Teachers can conduct different case-based learning sessions with different ethical challenges in relation to precision medicine, and this exposure will provide them with an opportunity to discuss real-world situations.[18] Further, an institutional ethics committee can be involved in all complex ethical issues related to precision medicine, and give students hands-on exposure to navigate through these scenarios.[19] During clinical rotations, teachers can encourage patient-centered discussions, with emphasis on basic ethics principles, informed consent, maintaining privacy, and being respectful of patients' autonomy in the context of genetic details.[3,20]

In order to ensure holistic understanding among medical students, experts from other professions (viz. legal experts, social scientists, etc.) can be invited to share their perspectives and this will benefit students to correlate any issue from different angles.[21] Another approach could be via exposing medical students to simulation exercises, wherein students can once again learn about ethical decision-making in controlled settings.[22] As a part of the mentorship programs, whenever students are stuck in any ethical issue surrounding precision medicine, they can approach their mentors for appropriate guidance. Students can also be trained in patient advocacy, wherein medical students learn to advocate for the rights and privacy of patients. In addition, students can also be trained in cultural competence, which will empower them to be more aware and respectful of the ethical perspectives of patients belonging to different regions.[15]

Further, medical students can be encouraged to attend other training programs or sensitization sessions conducted in the field of precision medicine, and not only improve their understanding but even realize the presence of various ethical concerns that can emerge.[23] Another strategy to respond to the ethical challenges is encouraging students to perform reflection on ethical grounds and then discuss the same openly to get better insights.[3] It is also a welcome move to train students in the domain of research ethics, as this will enable responsible conduct in genomic research and ensure that students are aware of all ethical issues in research areas.[12]

Conclusion

In conclusion, there is an immense need to expose medical students to the ethical dimensions of precision medicine as it will significantly improve their approach to healthcare delivery in the future. This calls for the need to train medical students using a combination of teaching-learning methods, and that too throughout the duration of training so that future generations of healthcare professionals can maintain dignity and be respectful to all patients.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Ethical Approval and Informed Consent

Not applicable.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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