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From Editor's Desk

Dear All,

I thank you all for showing your confidence and faith, by electing me for the prestigious position as the Editor of this esteemed journal. I do not have the words to express my gratitude. I fully understand the responsibilities that you all have bestowed upon me. I hope that with your continuous support, we all will have a wonderful academic time and all grievances will be quickly resolved.

Me and **Dr. Siddhartha Das** as Joint Editor will work for the upliftment and maintenance of the quality publications of the JIAFM. We solicit your cooperation, understanding, and guidance wherever required in the journey.

I am really thankful to **Dr. Tanuj Kanchan** and all our previous editors and joint editors, who have brought laurels to this journal by putting in their continuous efforts and hard work as a result of which JIAFM has achieved greater heights with each passing year.

In our team, we have from now onwards **Dr. Mandar Sane** and **Dr. Narendra Patel** as Associate editors; **Dr. Vivek Chouksey** as Assistant editor; **Dr. Richa Nigam** as Research and Statistical Editor; and **Mr. Chain Singh Lodhi** as technical editor. We have also included a few very dynamic international and national faculty advisors having excellent expertise in various sub-specialties, who would be helping us improve by positive criticism.

Further, we are planning to enhance the sections for publication by adding case series, research brief, short communication, book reviews and letter to the Editor. Together with your support, we sincerely look forward to the academic upliftment of our fraternity through quality publications.

Sincerely

Prof. Dr. Manish Nigam
(M.D. LL.M.)

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Editorial

Is there a need to celebrate Forensic Medicine Day in India?

Prof. (Dr.) Mukesh Yadav

The Indian Academy of Forensic Medicine (IAFM) was established in Goa, under the society registration act of Goa, 1860 on 12th May 1972, and we have recently organized the 43rd annual national conference in its golden jubilee year at SGPGIMS, Lucknow, U.P. from 29th April to 1st May 2022.

IAFM is the largest and oldest association of Forensic Medicine experts in India, with more than 1500 Life members (1584 as approved in GBM dated: 30.04.2022), who are teaching the subject in MBBS curriculum, along with lots of medicolegal and research work to solve legal and social issues in India.

Not only the cases of medical negligence, both civil and criminal increasing in India due to increased stress on the quality of health care and increasing vigilance on deficiency in service under consumer courts but also cases of violence against doctors increasing in all parts of India. Recently, suicide was committed by a bright, young gynaecologist from Kota, Rajasthan, after FIR was lodged against her for the alleged death of a patient, due to criminal negligence under section 302 IPC, who was suffering from PPH. This act of suicide by doctors was due to ignorance of the law and the medicolegal aspect of patient care on the part of various stakeholders, along with the doctor herself.

The prosecution in case of death or a person due to alleged medical negligence by a doctor comes under section 304-A of the Indian Penal Code. The hon'ble supreme court in its judgment dated 05.08.2005 in the matter of Jacob Mathew vs. state of Punjab has taken note that the investigation officers and the private complaint cannot always be supposed to have knowledge of medical sciences so as to determine whether it was lawful under section 304-A of IPC. The criminal process once initiated, forces the medical professional to serious embarrassment and sometimes harassment.

To protect doctors from frivolous or unjust prosecution against medical negligence, hon'ble supreme court in the said judgment observed that rules or executive instructions incorporating certain guidelines need to be framed and issued by the government of India and/or the state government in consultation with the medical council of India. The hon'ble court had also held that doctor accused of rashness or negligence, may not be arrested in a routine manner (simply because a charge has been leveled against him) unless the alleged negligence is of gross nature and arrest is necessary for furthering the investigation or for collecting evidence or unless the investigation officer is satisfied that the doctor would not make himself available to face the prosecution unless arrested, the arrest may be withheld.

Further, the hon'ble supreme court in the matter of Lalita Kumari vs. State of U.P & Ors., vide Judgment dated 12.11.2013 (and partially modified on 05.03.2014) held that the preliminary inquiry in medical negligence cases should be made time-bound and, in any case, it should not exceed fifteen days generally and in exceptional cases of it must be reflected in the general diary entry.

The ethics and medical registration board (EMRB), of the national medical commission (NMC), vide letter no. NMC/MCI/EMRB/C-12015/0023/2021/ETHICS/022426, dated: 29.09.2021, written to the secretary, ministry of health & family welfare, govt. of India, recommends framing the guidelines for protecting doctors for criminal rashness or unjust prosecution against medical negligence.

I am hoping that the ministry of health and family welfare, govt. of India along with state governments and UTs should take cognizance and constitute such medical negligence boards in the larger public interest.

Similarly, EMRB of NMC, recently vide public notice F.No.12013/01/2022/ETHICS, dated: 23.05.2022, draft regulation is placed in the public domain through NMC website on 23.05.2022 in accordance with section 27, 30, 31 & 57 of the National Medical Commission Act, 2019 inviting comments from of the national medical experts/stakeholders/organizations for the following proposed regulations: "National Medical Commission, Registered Medical Practitioner (Professional Conduct) Regulations, 2022".

Another historical document after 2002, regulations (the Indian Medical Council (Professional Conduct, Etiquettes and Ethics) Regulations, 2002, which is part and parcel of the syllabus for teaching to MBBS Students by Forensic Medicine faculty.

With the above context, it is pertinent and need of the hour to celebrate Forensic Medicine Day (IAFM Foundation Day) in India on the occasion of completion of the 50th golden jubilee day, on 12th May each year in India to not only commemorate IAFM foundation day but also to create awareness among all stakeholders about role and importance of Forensic Medicine in improving quality of healthcare and quality of medicolegal work in India.

On the call to celebrate First Forensic Medicine Day (IAFM Foundation Day) in India on 12th May 2022, by all life members of IAFM and the forensic fraternity of the department of Forensic Medicine of all medical colleges/Institutions including all AIIMS, an overwhelming response of celebration highlighted need to celebrate every year in future. It will also help in generating self-confidence among the Forensic fraternity who are feeling ignorance of the Forensic speciality by all concerned authorities.

In spite of increase in number of specialists in Forensic Medicine all over the country, the number still is meagre as compared to other broad specialities. The requirement of teachers in the department as per student intake given by NMC is still undermined looking to the medicolegal workload apart from teaching. Celebrating the day by showing importance of the subject in civilized society, will automatically let people know our job profile, and soon time will come where we need not have

to describe or define Forensic Medicine amongst our UG students. This will also show the administrators and rule makers the usefulness of increasing the requirement of specialists in the department.

Through this program we also need to communicate the society, administrators and judiciary that there is difference in qualification and working between Forensic Science and Forensic Medicine. Awareness in knowledge and application of Forensic Medicine by all concerned like judiciary, police,

clinicians, etc. helps in improving the quality of healthcare and medicolegal work in India, hence decreasing medical negligence cases.

Good PG aspirants will feel motivated to join MD in Forensic Medicine as their career, which will further improve the quality of medical education in India along with improvement in quality of medicolegal work, and post-mortem work, hence improving the criminal justice system of India.

Prof. (Dr.) Mukesh Yadav

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Glimpses of National Forensic Medicine Day Celebration 12th May



ORIGINAL ARTICLE

Estimation of Stature from Foot Print: A Study on Medical Students of Bihar

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Abstract :

Height and sex from different parts of the body help in solving crime mysteries related to human identity. Similarly, foot or shoe prints if present at the scene of the crime may provide a clue regarding the height and the sex of the person that helps in establishing the partial identity of the suspect. Aims & Objectives is to investigate the relationship between footprint length with sex and to derive a regression equation from footprint length. Footprints of 200 subjects (100 males and 100 females), from among asymptomatic, apparently healthy, young adults studying in All India Institute of Medical Sciences (AIIMS), Patna, Bihar, India were taken as a subject for the study. Maximum footprint length and the height of each subject were measured. Predictive equations using linear regression were then derived separately for males, and females and for the combined data with the purpose of estimating the height when only the subject's footprint length is known. It was found that males were taller and have longer feet than females. A correlation coefficient (r) of 0.739 in males and 0.6958 in females was obtained between the height and footprint length of the subjects. The standard error of the estimate was 4.6815 in males and 5.081 in females. The study revealed a highly significant degree of correlation between the measurements of footprint lengths and stature.

Keywords : Anthropology; Stature; Sex; Foot length; regression formulae.

Introduction :

Personal identification literally means the determination of the individuality of a person. It can be complete (absolute) or incomplete (partial). Complete identification means the absolute fixation on the individuality of a person. Partial identification implies ascertainment of only some facts about the identity of the person while others still remain unknown. Age, sex, and stature are the primary characteristics of identification.¹

Forensic anthropology is the application of the study of humans to situations of modern legal or public concern. This typically takes the form of collecting and analyzing human skeletal remains to help identify victims and reconstruct the events surrounding their deaths.² However, the scope of forensic anthropologists nowadays has evolved as they do not only examine dead remains but also the living. Anthropometric standards are commonly accepted as vary among different populations and have to be constantly renewed to cope with temporal change.³

Many authors have studied the relationship between various parts of the body with the stature and sex. Determination of stature from incomplete skeletal and decomposing human remains is predominantly important in personal identification. Stature

estimation from dismembered body parts can be done on the ratio of the body part concerned, in relation to the entire body. The relationship between humerus, radius, ulna, femur, tibia, fibula, and clavicle with the stature has been a topic of research interest for decades.⁴

Morphology of human feet is greatly influenced by the combined effects of heredity, region, and living style of man that determines the size and shape of the feet or footprint and thereby makes them unique data to establish human identity.⁵

Identification by foot print has much increased because of the increase in the numbers of the catastrophic events causing mass death or mass disaster, which requires the identification of the victim from dismembered human remains. Personal identification of the foot and its segments becomes more important in cases of mass disasters, where there is always a likelihood of recovering feet (often enclosed) in shoes separated from the body.¹

Footprints are of immense value in establishing the personal identity of criminals in forensic examinations. Examination of barefoot impression is important, especially in developing countries like India where the majority of the rural population like to walk barefooted because of socio-economic and climatic reasons. Analysis of footprints helps in the estimation of an individual's stature because of one's stature and foot size; the footprints are also considered indicators of the skeletal and body stature of a person.⁶

Foot or shoe prints, if present at the scene of the crime, may provide a clue regarding the stature and sex of the person, which may help in establishing the partial identity of the suspect. Moreover, in an aircraft accident, it is the feet, which are

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recovered more intact than other parts of the body, as they are often shoe clad. Hence, feet can be an excellent clue regarding personal identity.⁵

Foot and shoe prints' relationship to the stature has been previously studied in the previous literature⁷ as it provides an invaluable tool in forensic investigation. It can be used as an aid in the criminal investigation in order to develop a biological profile to find suspects or to associate with the witness statement.

Ossification and maturation in the foot occur earlier than in the long bones and therefore, during adolescence age, height could be more accurately predicted from foot measurement as compared to that from long bones.⁸

There is no universally accepted formula to express the relationship between stature and body parts of an individual. Estimation of the stature of an individual in India by using formulae given by western workers involves an error of 5-8%.⁹

Devesh V et al (2006) conducted a study for estimation of stature and sex from footprint length using regression formulae and standard footprint length formula respectively over 100 male and 100 female college-going students of age group 18-26 years at Mangalore, Karnataka.¹⁰

Jitendra Kumar Jakhar et al (2010) carried out a study in the department of forensic medicine and toxicology in Haryana state. A total number of 103 medical students were included which showed a good correlation of height with footlength and it was statistically highly significant.¹¹

In another study done by Rameswarup Suman Babu et al (2013) over 104 healthy individuals of the population residing in Secunderabad, aged between 21-35 years found that there exists a linear relationship between the height and the foot length.¹²

Krishan and Sharma (2007) examined the relationship between stature and dimensions of hands and feet among Rajputs of Himachal Pradesh in a group of 246 subjects (123 males and 123 females) 17 to 20 years old. In their study also the highest correlation coefficient existed between stature and foot length. The lowest standard error of estimate indicated that the foot length provides the highest reliability and accuracy in estimating stature.¹³

Kanchan et al., (2008) examined the relationship between stature and foot dimensions among 200 (100 males and 100 females) Gujjars (North Indian community). They devised linear and multiple regression equations for estimating stature using foot dimensions.¹⁴

According to the study done by Bhavna et al., (2005) on male Shia Muslims in Delhi, the regression equation was found to be;

$$\text{Height} = 119.74 + 1.92 \times \text{Foot length} \pm 4.77$$

Also, they found the multiplication factor to calculate stature from foot length to be 6.76.¹⁵

Various studies in past have been undertaken to study the relationship between height and sex of a person with various body parts in different regions of the country, but not in the Bihar

region. Therefore, the purpose of the present study is to study the anthropometric relationship by deriving a linear regression equation, thus providing additional evidence of identification between footprint and body height in normal young adults and its sexual dimorphism.

Aims and Objectives :

1. To investigate the relationship between footprint length with sex.
2. To derive a regression equation from footprint length.
3. To find out the correlation of body height with foot length.

Types of Study :

Hospital-based descriptive research study.

Materials and Methods :

Place of Study :

The present study was conducted in the Department of Forensic Medicine and Toxicology, at All India Institute of Medical Sciences (AIIMS), Patna, Bihar

Sample size :

Two hundred medical students (100 males and 100 females) of asymptomatic, apparently healthy, young adults studying in All India Institute of Medical Sciences (AIIMS), Patna, Bihar, India were taken as subjects for the study. The subjects were within the age limit of 21-32 years as stature attains its maximum limits at around 21 years of age and senility-related changes of stature start appearing after 32 years.⁸ Their nutritional and socioeconomic status were not assessed. The information of each subject was recorded on a proforma that included serial number, sex, age, address, date of birth, height, and right & left foot length.

Inclusion Criteria :

1. Subjects with an age limit of 21-32 years, who were studying in AIIMS, Patna.
2. Subjects of all districts of Bihar origin, irrespective of caste and religion.
3. Individuals whose exact age and origin was known and verified (duly verified from the birth certificates /matriculation certificate/aadhaar card/elector's identity card/driving license etc.).

Exclusion Criteria :

1. Subjects of age less than 21 years and more than 32 years.
2. Subjects of non-Bihar origin.
3. Subjects with skeletal anomalies especially of the spine, long bones, and feet.
4. Subjects of dwarfism where skeletal growth is abnormally stunted.
5. Subjects of gigantism where skeletal growth is abnormally enhanced.

Ethical clearance was obtained from IEC (Institute Ethics Committee) before starting the study. Informed and written

consent of participants was taken and socio-demographic indices like sex, age, address, date of birth, height, and right and left foot length were noted. Each student was studied for the measurements of stature and footprint length.

Methodology :

Anthropometric measurements of foot length were taken independently on the left and right sides of each individual. Besides the above measurements, the stature of each subject was also recorded. All the measurements were taken in a well-lighted room. The measurements were taken in centimeters to the nearest millimeter in the following manner:

Anthropometric Measurements :

Stature - It is the vertical distance between the point vertex and the heel touching the floor (ground surface).

The stature of the individual was measured in a standing erect anatomical position with a standing height measuring instrument in centimeters through a stadiometer. The measurements were taken at a fixed time between 9:00 A.M to 02:00 P.M to eliminate diurnal variation and by one person to avoid personal error in methodology.

Foot length: It is the distance from the most prominent part of the heel backward to the most distal part of the longest toe (2nd or 1st).

Kores duplicating ink was uniformly spread on glass using a roller and the subject was first asked to place his/her feet on the slab and then on the plain white sheet of paper. The footprints thus obtained were numbered and filed. After taking the footprints, the sole of the feet was cleaned with cotton wool soaked in acetone. The subject was advised to wash it again with soap and water. The footprints obtained from the right and left foot of the subject were selected for the study. Maximum footprint length was measured as the straight distance between the highest points on the first or the second toe (whichever will be higher) and the lowest point on the margin of the heel.

The data collected were then analyzed using the computer software SPSS version 22.0 and linear regression equations were derived to determine the stature from maximum footprint length. The results obtained were compared with the actual stature of the subjects.

Observation and results :

The present study focused on the estimation of stature from the dimensions of feet. Sexual differences in the studied parameters were assessed with the help of the "t" test. In order to predict the stature of an individual from the anthropometric measurements, simple linear regression was derived.

Table 1 shows that the mean \pm S.D. of stature is (168.803 \pm 6.938) in males, (158.227 \pm 7.025) in females, and (163.515 \pm 8.781) (table 2) in both genders together with males being taller than females in the studied sample.

Table 1 also shows a statistical analysis of anthropometric measurements of feet in both sexes. The values of all the measurements of parameters in the case of males are higher than

in females and these sex differences are statistically highly significant ($p < 0.001$).

Table 2 illustrates the correlation coefficients between stature and dimensions of feet on the left and right sides in both the sexes. All the measurements exhibit a statistically significant correlation with stature ($p < 0.01$). Correlation coefficients of the foot length measurements are higher in males bilaterally. The highest correlation is exhibited by the right foot ($r = 0.7430$).

Table 1: Sexual differences in foot length

	Mean \pm S.D		t-test	P-value
	Male	Female		
Stature	168.803 \pm 6.938	158.227 \pm 7.025	10.7115	<0.0001
Foot length right	25.828 \pm 1.279	23.891 \pm 1.273	10.7340	<0.0001
Foot length Left	25.944 \pm 1.286	24.084 \pm 1.329	10.0577	<0.0001

Tables 2 also list the regression coefficients for estimation of stature from measurements of feet of both sexes separately and together. The best correlation with stature is demonstrated by right foot length in males as well as in females.

Earlier the multiplication factor method was used for estimation of stature from anthropometric measurements of the body but nowadays the most widely used method for estimation of stature from anthropometric measurements of the body is the regression formulae. Worldwide, the regression formulae are accepted as of utmost importance in the determination of stature from various

Table 2 : Height, foot length, correlation coefficient @, regression coefficient (b) and value of constant (a)

	Male	Female	Both the Gender
Total number	100	100	200
Height range (cm)	154 - 180	145 - 173	145 - 180
Mean Height (cm)	168.803	158.227	163.515
S.D of Height	6.938	7.025	8.781
Left foot length range (cm)	23 - 30.5	21.2 - 26.8	21.2 - 30.5
Mean left foot length (cm)	25.944	24.084	25.014
S.D of left foot length	1.286	1.329	1.609
Correlation coefficient (r) (foot left length and height)	0.7366**	0.6725**	0.8071**
Regression coefficient (b)	3.97369	3.5551	4.40494
Value of constant (a)	65.72822	72.60594	53.32862
Right foot length range (cm)	23 - 30.1	21.2 - 26	21.2 - 30.1
Mean Right foot length (cm)	25.828	23.891	24.86
S.D of Right foot length	1.279	1.273	1.606
Correlation coefficient (r) (foot right length and height)	0.7430**	0.7244**	0.8308**
Regression coefficient (b)	4.02824	3.9972	4.5415
Value of constant (a)	64.76171	62.72981	50.61546

** Correlation is significant at the 0.01 level (p value < 0.00001)

anthropometric dimensions.^{16,17} No such type of study was carried out in Bihar.

In the present study, the formula derived is as under.

Regression equation:

Stature= value of constant (a) + regression coefficient (b) x foot length.

(A) Male:

- i. Height (in cm) (Y) = 65.72822 + 3.97369 x (Left foot Length)
- ii. Height (in cm) (Y) = 64.76171 + 4.02824 x (Right foot Length)

(B) Female:

- i. Height (in cm) (Y) = 72.60594 + 3.5551 x (Left foot Length)
- ii. Height (in cm) (Y) = 62.72981 + 3.9972 x (Right foot Length)

(C) Both gender (male & Female) together

- i. Height (in cm) (Y) = 53.32862 + 4.40494 x (Left foot Length)
- ii. Height (in cm) (Y) = 50.61546 + 4.5415 x (Right foot Length)

It was observed that there was no significant bilateral difference in foot length. So, the data for the two sides were pooled for statistical analysis of the foot length of both genders (Table 3). In the present study, the value of correlation between foot length and stature in males was 0.739 and in females was 0.6958 respectively. It means there is a strong bond between height and foot length and if either of the measurement (foot length or total height) is known, the other can be calculated and this would be useful for Anthropologists and Forensic Medicine experts.

Table 3 exhibits standard error of estimate (SEE) along with linear regression equations for foot length in male and female subjects. It ranges from 4.6815 for males, to 5.081 for females. Estimation of height from foot length of male subjects exhibits lower values of the standard error of estimate than from foot length of female subjects. It means the reliability of estimation of stature from foot length of male subjects is more than female subjects.

Table 3 : Estimation of Stature

S.No.	Sex	Regression equation	S.E.E	Value of r
1.	Male	65.4498 + 3.9925 (foot length)	4.6815	0.739
2.	Female	68.3680 + 3.7460 (foot length)	5.081	0.6958

Discussion:

Various studies have been conducted on the estimation of stature from the human skeleton. There are various methods to estimate stature from the bones but the easiest and the most reliable method is regression analysis.^{18,19}

Earlier, studies using hands and feet measurements for stature estimation are scarce. These studies indicate that the bilateral variation was insignificant for all the measurements in both sexes. Robbins also did not find significant bilateral asymmetry in various measurements of the feet of a U.S. sample.

Similar views are expressed by Philip that either of the feet can be used for the estimation of stature as no significant asymmetry was observed by him while working on the footprints of a South Indian population.²⁰ The present study similarly did not find any bilateral asymmetry in measurements of foot length in an individual.

The foot has been used to estimate stature in several studies,²¹⁻²⁷ in different endogamous groups, where nomograms have been derived to reconstruct stature from foot dimensions. These types of studies in different communities become essential, as several factors which include genetic and environmental, are known to affect stature and foot morphology as well as dimensions.

Table 4 shows the mean stature of males and females of different study groups including the study group of the present study. The mean stature in all studies was found to be significantly greater in males compared to females. Table 4 also shows variation in mean stature between same-sex groups of different study groups. Stature is determined by several factors which include genetic and environmental factors. This is the reason for variation in mean stature amongst individuals of the same sex belonging to different endogamous groups. Table 4 also shows the mean foot length of males and females of different study groups including the study group of the present study. The findings of the present study also showed that the males had longer feet than females on both sides. This is because the growth of feet stops about two years earlier in females than in males.

Table 4 also shows variation in mean foot length between same-sex groups of different study groups. The foot length is determined by several factors which include genetic and

Table 4 : The observation made by the various workers and the results obtained have been presented below

S. No		Stature in males (cms)	Stature in females (cms)	Foot length in males (cms)	Foot length in females (cms)
1.	Giles et al. (1980) ²¹	174 ± 6.61	162.95 ± 6.52	26.77 ± 1.30	24.31 ± 1.25
2.	Agnihotri et al. (2007) ²²	173 ± 6.13	159.56 ± 6.25	26.12 ± 1.09	23.33 ± 1.08
3.	Sen et al. (2008) ²³	162.23 ± 5.69	149.53 ± 5.37	24.01 ± 1.09	22.27 ± 1.00
4.	Krishan et al. (2008) ²⁴	167.4 ± 5.9	159.5 ± 5.1	26.3 ± 1.5	23.28 ± 1.1
5.	Mansur DI et al. (2012) ²⁵	165.66 ± 8.34	156.70 ± 6.16	23.89 ± 2.09	22.64 ± 1.36
6.	Upadhyay MC et al. (2015) ²⁶	167.2 ± 4.58	154.45 ± 4.7	23.61 ± 1.02	21.37 ± 0.95
7.	Present study	168.80 ± 6.93	158.22 ± 7.02	25.82 ± 1.27	23.89 ± 1.27

environmental factors. This is the reason for variation in mean foot length amongst individuals of the same sex belonging to different endogamous groups.²⁷

As per table 5, the correlation coefficient (r) for correlation

between foot length and stature in males of different study groups ranged from 0.623 to 0.925 and in females from 0.587 to 0.741 which indicates a large to nearly perfect correlation. Patel et al.²⁸ attained nearly perfect correlation for male ($r = 0.925$) in their study. In the present study correlation between foot length and stature is 0.739 and 0.659 in males and females respectively, which suggests a significant correlation. This means stature can be better predicted with good accuracy using foot length (Table 5).

The regression equation to estimate stature from foot length of males of various study groups has also been presented in table 5, using which the stature or foot length can be estimated by substituting the value of the other parameter in the equation.

The regression equation has a constant and multiplication factor. The foot length is multiplied by the multiplication factor and added to the constant to get the stature. In the equation for the right

measurements of feet were found to be positive and statistically significant and the right foot length in subjects of both the genders together exhibits the overall highest value of correlation ($r = 0.8308$) with stature followed by the length of the right foot in females. The correlation coefficients between stature and foot dimensions were found to be highly significant. However, the results were contrary as observed by Kanchan et al in North Indian endogamous group.³⁰

Conclusion :

The study has revealed a highly significant degree of correlation between the measurements of footprint lengths and stature from footprints of 200 subjects of both sexes between the ages of 21-32 years.

Regression formulae have been developed to predict stature separately for males, and females, and the combined data along with the standard error of the estimate. The results obtained are found to show less error in predicting stature as compared to other conventional methods used earlier.

- The present study has established a definite correlation between stature and foot length and also regression equations have been established in the sample studied.

- While calculating the regression equation, it is found that there exists a linear relationship between the height and foot length which is collaborating with previous workers. It will help in medico-legal cases in establishing the identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions, accidents, etc.

- It will also help in establishing identity in certain civil as well as criminal cases.

- The right foot length gives a better prediction of stature than the left foot length. Stature prediction is more accurate and reliable in the case of male medical students than in female medical students of Bihar.

Thus, it is concluded that the foot length in males and females shows highest correlation with stature. So, the foot length provides the highest reliability and accuracy in estimating stature.

Conflict of Interest : Nil

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Table 5 : Correlation coefficient (r), Regression equation to estimate stature from foot length in different study groups

S.No.	Study	Male		Female	
		R	Regression equation	R	Regression equation
1	Giles et al. (1980) ²¹		82.20 ± 3.447 FL		82.20 ± 3.447 FL
2	Agnihotri et al. (2007) ²²	0.72	68.58 ± 4.036 FL	0.608	77.059 ± 3.56 FL
3	Sen et al. (2008) ²³	0.623	84.07 ± 3.255 FL	0.682	68.663 ± 3.632 FL
4	Krishan et al. (2008) ²⁴	0.764	90.27 ± 2.93 FL	0.502	105.20 ± 2.287 FL
5	Mansur DI et al. (2012) ²⁵	0.688	100.18 ± 2.73 FL	0.587	96.4 ± 2.66 FL
6	Upadhyay MC et al. (2015) ²⁶	0.752	86.96 ± 3.40 RFL	0.731	77.35 ± 3.61 RFL
7	Patel JP et al 2012 ²⁸	0.925	77.89 ± 3.55 FL	0.741	38 ± 5.192 FL
8	Present study	0.739	65.4498 ± 3.9925 FL	0.695	68.3680 ± 3.7460 FL
FL = Foot length					

foot in males, the constant is 65.4498, and the multiplication factor is 3.992. So, it means that for every 1 cm increase in right foot length the stature increases by 3.992 cm in males. In our study, for both right and left feet, the correlation coefficient (r) is slightly greater in males.

The present study shows sex differences to be highly significant for all the measurements ($p < 0.001$) which are in line with studies of Sharma et al.²⁹ In the present study, the significant differences in stature and foot measurements between males and females can be attributed to the fact that fusion of epiphysis of bones occurs earlier in girls in comparison to boys. In other words, boys have about two more years of bony growth than girls, which were expressed in males surpass of the somatometric measurements of the adult.³⁰

The correlation coefficients between stature and all the

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ORIGINAL ARTICLE

Estimation of Stature from External Ear Morphometry: A Preliminary Study

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Abstract :

External ear is a defining feature of the face that gives a decent and definite look to a human face with an aesthetically fine appearance. Along with hearing, they are one of the most important body parts helping in human identification. The cross-sectional study was undertaken on a total of 149 dead bodies brought for postmortem examination from May 2019 to December 2019 of which 93 were males of age between 18 to 82 years and 56 were females of age between 19 years to 92 years. Total four parameters of the right and left ear that is length (EL), Ear breadth (EB), Ear lobule length (ELL), and Ear lobule breadth (ELB) of the adult population were studied with a digital vernier caliper capable of measuring nearest 0.01 mm and was correlated statistically with body length. In the right ear, the correlation coefficient (r-value) was higher in males for ear length, ear lobule length and lower in right ear lobule breadth, however in the left ear it was higher in females for ear length and ear lobule breadth, but it was higher in males in case of left ear lobule breadth. In the right ear the determination coefficient (r² value) was higher in males for ear length, and ear lobule length, and it was higher in females for ear breadth and ear lobule breadth, however in the left ear it was higher in females for ear length, ear breadth but it was higher in male for ear lobule length and ear lobule breadth.

Keywords : Identification; Anthropometry; Stature; Ear; Morphometry.

Introduction :

Identification is the determination of the individuality of a person based on certain physical characteristics. It may be complete or incomplete. Complete identification means the absolute fixation on the individuality of a person, however partial or incomplete identification is the ascertainment of only certain facts about the identity.¹ Medical personnel is mainly concerned with the identification of a dead body required in cases of mass disasters like fire accidents, explosions, road traffic accidents, aviation accidents, etc. Complete identification is necessary when the investigating officer finds unknown, unclaimed dead bodies or fragmentary remains.^{2,3}

From intrauterine life, stature increases up to 20 to 21 years of age of a person. According to Roche, generally, stature at 18 years is accepted as adults; although there is a small increment occurs in stature after this age. The sex difference in reaching adult height is considerable; the median age for attaining an adult height in males is 21.2 years and in females 17.3 years with growth continuing in 10 percent of males until 23.5 years and in 10 percent of females until 21.1 years.⁴

Anthropometry deals with the measurements of various parts of the human body which is also called the Bertillon system or Bertillonage. It comprises measurements of characteristics of the individual under descriptive data, body marks, and body measurements.¹ Human anthropometry refers to the measurement

of human body dimensions for the purpose of understanding human physical variations, as it plays important role in Forensic investigations.⁵

The external ear consists of auricle (pinna) having curved outer rim called as helix, the inner curved rim called the antihelix which opens into the ear canal. The tragus protrudes and partially obscures the ear canal facing antitragus. The hollow region in front of the ear canal is called the concha.⁶ (Fig.1) The anthropometric measurements given in the western literature are less likely to be of use in the Indian population^{7,8} and very few studies have been carried out on anthropometric data of the Indian human ear to correlate with the stature.^{9,10}

Often the mutilated dead bodies were brought for postmortem examination by forensic experts. In such a situation examination of the ear may offer valuable information to estimate the stature to fix the partial identity of the deceased. The present study was carried out on the cases brought for postmortem examination to tertiary care institute with an aim to correlate the ear dimensions of adult males and females with stature in the western Maharashtra population.

Material and Methods :

The present cross-sectional study was undertaken on a total of 149 dead bodies brought for postmortem examination to government medical college and hospital from may 2019 to December 2019. The sample size was calculated with the online sample size calculator "Qualtrics.com" with a 90% confidence interval and 5% margin of error and 325 cases autopsied in that duration. The measurements were taken as, 1) ear length (EL), 2) ear breadth (EB), 3) ear lobule length (ELL), and 4) ear lobule breadth (ELB) for each right and left ear of the subject (Fig. 2). The head was in a horizontal plane lying on the autopsy table. Ear length was measured as the distance between the most superior point of the

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helix and the most inferior point of the ear lobule. Similarly, the ear breadth was measured as the distance between the most anterior and the most posterior points of the auricle. The ear lobule length was taken as the distance between the most inferior points of the lobule to the base of the tragal notch. The ear lobule breadth was measured as the horizontal width of the lobule at the midpoint. All the body measurement was taken in millimeters and two times an arithmetic mean of the two values is taken to ensure the precision and accuracy with a standard digital vernier caliper (in size make) capable of measuring to the nearest of 0.01 mm. The measurements were recorded in predesigned proforma in an excel sheet (windows-10) for statistical analysis.

The obtained results were statistically analyzed. The correlation coefficient, linear regression analysis, R-square values were estimated. The relationship between the parameters studied was established using Pearson correlation to establish the strength of the relationship between ear length (EL), ear breadth (EB), ear lobule length (ELL), and ear lobule breadth (ELB) for each right and left ears with stature. Linear regression equations were derived for stature estimation from ear length (EL), ear breadth (EB), ear lobule length (ELL), and ear lobule breadth (ELB) for each right and left ear in males and females with stature. Adult cases more than 18 years were included in the present study. The subjects having a craniofacial injury, craniofacial deformity, evidence of ear infections, tumors, and surgical interventions in the ear were excluded from the study. As per the law of land for conducting postmortem examination inquest Panchnama and requisition letter received from police. No identities of individuals were revealed so permission from the institutional committee was not taken.

Result :

In the male, the means for ear length, ear breadth, ear lobule length, and ear lobule breadth in the right ear were 63.72 mm, 31.54 mm, 19.77 mm, and 19.44 mm respectively and the standard deviation was 2.62, 1.80, 2.05, and 1.95 respectively. The correlation coefficient was 0.51, 0.40, 0.48, and 0.40 in ear length, ear breadth, ear lobule length, and ear lobule breadth respectively. In the female, the mean for ear length, ear breadth, ear lobule length, and ear lobule breadth in the right ear were 58.56 mm, 27.36 mm, 16.04 mm, and 14.43 mm respectively and the standard deviation was 3.52, 1.66, 1.95, 1.37 respectively. The correlation coefficient was 0.50, 0.40, 0.40, and 0.41 in ear length, ear breadth, ear lobule length, and ear lobule breadth respectively (Table 1)(Graph 1).

In male means for ear length, ear breadth, ear lobule length, and ear lobule breadth in the left ear were 63.26 mm, 30.41 mm, 18.82 mm, and 17.83 mm respectively and the standard deviation was 2.82, 1.64, 2.10, 2.52 respectively. The correlation coefficient was 0.50, 0.43, 0.44, and 0.41 in ear length, ear breadth, ear lobule length, and ear lobule breadth respectively. In females means for ear length, ear breadth ear lobule length and ear lobule breadth in the left ear were 58.23 mm, 28.12 mm, 15.78 mm, and 14.28 mm respectively and the standard deviation was 3.20, 1.65, 1.46, 1.44 respectively. The correlation coefficient was 0.51, 0.43, 0.41, and

0.40 in ear length, ear breadth, ear lobule length, and ear lobule breadth respectively (Table 2).

The determination coefficient (r^2 value) was 0.2644, 0.0016, 0.2394, 0.166 for male right ear length, ear breadth, ear lobule length and ear lobule breadth respectively and for female right ear they were 0.2543, 0.1614, 0.1674, and 0.1741 respectively. The determination coefficient (r^2 value) was 0.2528, 0.1868, 0.1950 and 0.1722 for male left ear length, ear breadth, ear lobule length and ear lobule breadth respectively and for female left ear they were 0.2627, 0.1911, 0.1695, and 0.1641 respectively (Table 3).

Discussion :

Stature refers to the body height or body length of a person. It is one of the most important parameters to determine the physical

Table 1: Distribution of cases as per dimensions of the right ear in males and females.

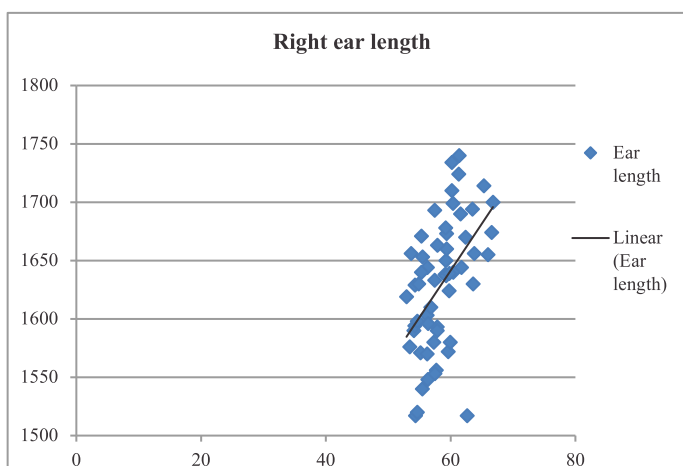
Dimensions (mm)	Male	Female
Min EL	53.79	52.92
Max EL	69.11	66.78
Mean + SD	63.72 + 2.62	58.56+3.52
R value	0.51	0.50
Min EB	26.19	23.69
Max EB	33.51	31.47
Mean + EB	31.54 + 1.8	27.36+1.66
R value	0.40	0.40
Min ELL	13.76	13.03
Max ELL	23.17	20.93
Mean + SD	19.77 + 2.05	16.04+1.95
R value	0.48	0.40
Min ELB	14.45	11.12
Max ELB	24.25	18.34
Mean +SD	19.44 + 1.95	14.43+1.37
R value	0.40	0.41

EL- Ear length, EB- Ear breadth, ELL- Ear lobule length, ELB- Ear lobule breadth. R-Correlation coefficient, SD- Standard deviation.

Table 2: Distribution of cases as per dimensions of the left ear in males and females.

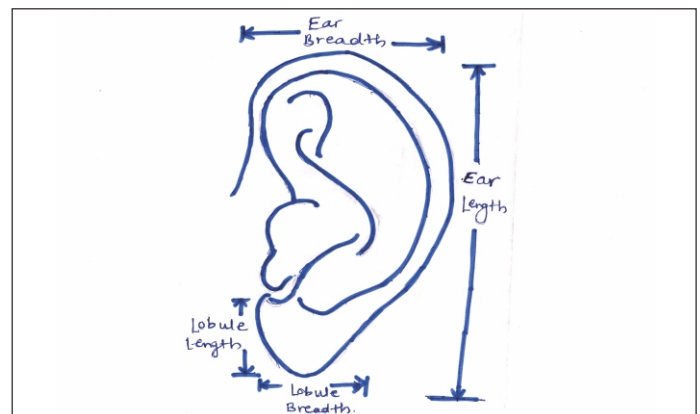
Dimensions (mm)	Male	Female
Min EL	51.38	51.15
Max EL	68.48	65.51
Mean + SD	63.26 + 2.82	58.23 + 3.20
R value	0.50	0.51
Min EB	26.05	23.16
Max EB	34.56	31.36
Mean + EB	30.41 + 1.64	28.12+ 1.65
R value	0.43	0.43
Min ELL	14.17	13.37
Max ELL	23.72	19.27
Mean + SD	18.82 + 2.10	15.78+ 1.46
R value	0.44	0.41
Min ELB	10.71	10.12
Max ELB	22.77	19.09
Mean +SD	17.83 + 2.52	14.28+1.44
R value	0.41	0.40

EL- Ear length, EB- Ear breadth, ELL- Ear lobule length,ELB- Ear lobule breadth. R- Correlation coefficient, SD- Standard deviation

**Graph 1: Showing Relationship between right ear length (mm) and stature (mm) of female****Table 3: Showing linear regression equation and R- square values for males and females with respect to ear dimensions and stature.**

Dimensions	Male	R-square	Female	R-square
Right EL	$y = 9.7428x + 1077.7$	0.2644	$y = 8.0222x + 1160.1$	0.2543
Right EB	$y = 0.0729x + 1695.1$	0.0016	$y = 13.548x + 1253$	0.1614
Right ELL	$y = 11.82x + 1464.9$	0.2394	$y = 11.72x + 1441.9$	0.1674
Right ELB	$y = 10.365x + 1497.1$	0.166	$y = 16.994x + 1384.7$	0.1741
Left EL	$y = 8.856x + 1138.3$	0.2528	$y = 8.9707x + 1107.6$	0.2627
Left EB	$y = 13.055x + 1301.5$	0.1868	$y = 14.775x + 1214.4$	0.1911
Left ELL	$y = 10.454x + 1501.7$	0.195	$y = 15.777x + 1380.9$	0.1695
Left ELB	$y = 8.1734x + 1552.8$	0.1722	$y = 15.724x + 1405.4$	0.1641

EL- Ear length, EB- Ear breadth, ELL- Ear lobule length, ELB- Ear lobule breadth.

**Fig 1: Diagrammatic representation of ear****Fig 2: A. Showing measurement of ear length with digital vernier caliper. B. Showing measurement of ear width with digital vernier caliper.**

identity of an individual. There is a definite biological relationship of stature with all the body parts such as the head, trunk, extremities, hand, foot, and vertebral column.¹¹ Estimation of stature from long bones is preferable to practice because of the higher correlation coefficient and small error of the estimate. However, practical difficulty arises in a situation where only dismembered body part or part of the body is available for medical examination. Therefore, in search of new parameters, Forensic investigators are exploring different body parts to estimate stature.¹² Due to the establishment of the DNA profiling technique as a reliable tool in identification, the utility of such traditional methods is now questioned. However, the usefulness of such methods cannot be discarded especially in circumstances where sophisticated techniques are not available or where such techniques have limitations. Few studies even have demonstrated the utility of fingers in estimating stature.¹²

There are two basic approaches to the estimation of stature; the anatomical method and the mathematical method. The anatomical method may be applied in situations where a complete skeleton is available for forensic examination; this can be achieved by using some correction factors. On the other hand, incomplete skeletons and dismembered dead bodies can be used for estimation of stature using mathematical techniques, such as regression analysis and the multiplication factor method.¹³

In the present study, an attempt was made to explore different dimensions of the external ear to estimate stature. The correlation coefficient (r-value) in right ear length, right ear breadth, right ear lobule length and right ear lobule breadth was 0.51, 0.40, 0.48, and 0.40 respectively in males, and it was 0.50, 0.40, 0.40, and 0.41 respectively in females. So, the correlation was higher in males for ear length, and ear lobule length and lower in ear lobule breadth but the same in the case of ear lobule length.

The correlation coefficient (r-value) in left ear length, left ear breadth, left ear lobule length and left ear lobule breadth was 0.50, 0.43, 0.44, and 0.41 respectively in male and it was 0.51, 0.43, 0.41 and 0.40 respectively in females. So, the correlation was higher in females for ear length and ear lobule breadth, but the correlation was higher in males in the case of ear lobule breadth, but the same in the case of ear breadth.

The determination coefficient (r² value) in right ear length, right ear breadth, right ear lobule length and right ear lobule breadth was 0.2644, 0.0016, 0.2394, 0.166 respectively for male, and it was 0.2543, 0.1614, 0.1674, and 0.1741 respectively for females. So, it was higher in males for ear length, and ear lobule length, and it was higher in females for ear breadth and ear lobule breadth.

The determination coefficient (r² value) in left ear length, left ear breadth, left ear lobule length and left ear lobule breadth was 0.2528, 0.1868, 0.1950 and 0.1722 respectively for male and it was 0.2627, 0.1911, 0.1695, and 0.1641 respectively for females. So, it was higher in females for ear length, and ear breadth however they were higher in males for ear lobule length and ear lobule breadth.

Obaje SG et al. stated that the human ear gives a clue to estimating

stature at the time of criminal investigations and legal discussions.¹⁴ As per Taura et al. among the six variables considered in the study right ear width is the best predictor of height.⁹ Study conducted by Durugwale et al observed that there was a statistically significant correlation between ear length and ear width of both ears and stature.¹⁰ Trube-Becker stated that no two ears are absolutely identical, even two ears of the same individual are not completely identical. This is also true in identical twins.¹⁵ Murgod et al. measured the various parameters of the external ear and found prominent bilateral asymmetry and moderate sex difference. He also found that shapes of the ear, lobule, tragus, upper helix, and anti-helical border around the concha are most variable even bilaterally in the same individual.¹⁷ The identity of Veerappan, the sandalwood smuggler in India who was killed by the Special Task Force was at first established through the morphology of the ear by comparing the anatomical structure of Veerappan's external ear in antemortem and postmortem photographs on the basis of the combination of a large and square-shaped lobule with a flat tragus which is contiguous with the curved portion of the helix made Veerappan's ear 'unique', thus helping in his identification.¹⁶

Conclusion :

From the above study, it can be concluded that in the right ear the correlation is higher in males for ear length, ear lobule length, and lower in ear lobule breadth. On the left side, the correlation is higher in females in ear length and ear lobule breadth, but it was higher in males in the case of ear lobule breadth. On the right side, the determination coefficient (r²-value) is higher in males for ear length, and ear lobule length and it is higher in females for ear breadth and ear lobule breadth. On the left side it is higher in females for ear length, and ear breadth and higher in males for ear lobule length and ear lobule breadth. So, dimensions of the ear can be correlated positively as an additional tool for estimation of stature using regression analysis equations for medicolegal and anthropological purposes. However, it would be interesting and fruitful to have similar studies in other geographical areas and with different populations so as to evaluate whether population and geographical difference exists or not?

Conflict of Interest : Nil

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ORIGINAL ARTICLE

Estimation of Stature from Length of Sternum in Adult Females of North East Madhya Pradesh - An Autopsy Based Study

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Abstract :

Determination of stature is an important step to complete the biological profile of an individual to establish identity particularly in partially skeletonized, dismembered, mutilated, and highly decomposed bodies. The present descriptive observational study was conducted on 50 female cadavers of age more than 25 years brought for medicolegal autopsy in this tertiary care center located in north east Madhya Pradesh. The aim of the present study was to find out a correlation between the lengths of different parts of fresh sternums and stature and derive a simple linear regression equation for stature estimation from the length of the sternum. Simple linear regression formulae were derived by correlating stature with the length of manubrium, length of mesosternum, and the combined length of manubrium and mesosternum. We observed a moderately positive correlation between stature and length of manubrium ($R=0.167$) and the combined length of manubrium and mesosternum ($R=0.207$). Amongst all parameters taken into consideration in the present study, stature can be most reliably predicted by the regression equation which is derived from the correlation between stature and the combined length of the manubrium and mesosternum [standard error of estimate (SEE) - 5.85]. Due to lesser values of correlation coefficient and higher SEE, lengths of different parts of the sternum are less reliable in predicting stature than lengths of long bones, hand length, and foot length. The findings of the present study will be useful for rapid estimation of stature in relatively fresh but mutilated bodies or badly decomposed bodies only when long bones are not available or are partially broken and fragmented.

Keywords : Forensic anthropology; Stature estimation; Sternum; Regression analysis.

Introduction :

Establishing the identity of a person is of paramount importance in forensic practice as law enforcement authorities need positive identification which provides the starting point of their investigations. Forensic experts often encounter cases where the body is partially skeletonized, deliberately dismembered, mutilated by human or animal activities, or highly decomposed due to which establishment of identity becomes difficult. They have to rely on many facets some of which include determination of age, sex, race, and stature to complete the biological profile of an individual. Determination of stature is one of the vital steps in the forensic examination of skeletal remains for narrowing down the number of potential candidates.¹ Stature can be estimated by anatomical method and mathematical method. The anatomical method involves direct estimation of stature by measuring lengths of adjacent skeletal elements from skull to foot, adding them together, and applying soft tissue correction factors as described by fully. The mathematical method utilizes regression formulae based on the correlation of length of the individual bone

to stature.² In this method, stature is the dependent variable, and length of bone is the independent variable.³ Regression equations derived from lengths of long bones most accurately predict stature than other parameters. However, intact long bones may not be available every time due to partial or complete destruction, fractures, dismemberment, or scavenging activity by animals more prominently seen at the ends of long bones. Hence, there is a need to develop methods of stature estimation using skeletal elements other than long bones.⁴ As the sternum is relatively protected in the body, it is found intact in many cases when other skeletal elements like long bones are dismembered or mutilated. Very few researchers have derived regression equations for estimating stature from lengths of the sternum in India and that too in other regions of country. They reported contrasting observations regarding the practical utility of the sternum for stature estimations.^{5,6} Also, as human proportions vary between different populations, regression equations derived for one population may not accurately predict stature in other populations.⁷ Contradictions in observations of previous studies and the need to derive population-specific regression equations encouraged authors to conduct the present study on estimation of stature from the length of sternum. Most earlier studies have focused on stature estimation from dry and macerated sternums. However, as maceration of the sternum is time-consuming, lengths of fresh sternums can be used for rapid stature estimation.⁵ Hence, the present study was conducted to find a correlation between the lengths of different parts of fresh sternums and stature and derive a simple linear regression equation for stature

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estimation from the length of the sternum in the adult female population of north east Madhya Pradesh.

Material and methods :

The present descriptive observational study was conducted in the department of Forensic Medicine of this tertiary care center located in north east Madhya Pradesh on 50 female cadavers of age more than 25 years brought for medicolegal autopsy. Necessary approval was taken from Institutional Ethics committee. All decomposed, charred, and mutilated bodies and bodies having congenital or acquired malformations or injuries to the sternum were excluded from the study.

Bodies were kept in a supine position on a flat, hard-surfaced autopsy table after breaking rigor mortis, if any, with the knee and hip joint extended, and the neck and feet in a neutral position. Cadaveric lengths were measured in the supine position between the vertex of the head and the heel with a steel measuring tape to the nearest 0.1 cm. The sternum was removed from the cadaver as a single piece as per the standard procedure described by Otto Saphir by making incisions at the sterno-clavicular joints and at the junctions of costal cartilages with ribs.⁸ After removal, the sternum was cleaned thoroughly by removing the soft tissues as much as possible and air-dried. No maceration was performed. Vernier caliper was used to take midline measurements of the sternum after taking the precaution that the ends of the caliper touch the bone directly without any intervening soft tissues. We did not take into consideration the length of the xiphoid process while taking measurements as it was highly variable in its size and shape. Due to ethical limitations, the sternum was replaced in the body after taking the necessary measurements.

Different Measurements of the sternum were defined as

Length of the manubrium (M) - This is a straight distance between the center of the suprasternal notch to the center of the manubrio-mesosternal junction i.e. angle of Louis on the anterior surface in the midsagittal plane.

Length of the mesosternum (B) - This is the straight distance between the center of the manubrio-mesosternal junction (angle of Louis) to the xiphisternal junction in the midsagittal plane. It is difficult to identify points representing xiphisternal junction in fresh sternums. To overcome this difficulty, the lower ends of the two lateral articular facets for the seventh costal cartilage were connected by a line, representing the junction of the mesosternum and xiphoid process, and the midpoint of the line on the anterior surface of the mesosternum was marked as a point to take measurements.

Combined Length of Manubrium and mesosternum (CL) - This is a straight distance between the center of the suprasternal notch to the center of the xiphisternal junction on the anterior surface in the midsagittal plane (Figure 1).

The data were analyzed using the statistical analysis package of SPSS version 17 to derive a linear regression equation for stature estimation from the length of the sternum. For regression analysis, the dependent variable was taken as stature while the



Fig.1 : Photograph showing method of measuring combined length of manubrium and mesosternum

independent variable was the sternal length. Standard error of estimate (SEE) for regression was computed.

Results :

A total of 50 female cadavers were studied for estimation of stature from sternal lengths. Maximum cases belonged to the age group 26 to 35 years. The stature ranged from 137 cm to 165.2 cm, with a mean (\pm SD) of 150.9 (\pm 5.92) cm. The mean length of manubrium (\pm SD) was 45.43 (\pm 6.65) mm, ranging from 33.4 mm to 61.5 mm. The length of the mesosternum varied from 63.8 mm to 102.4 mm, with a mean (\pm SD) of 84.15 (\pm 8.61) mm. The

Table1 : Descriptive statistical analysis of stature and lengths of different parts of sternum

Lengths of different parts of sternum	Range	Mean	SD
Stature (cm)	137-165.2	150.90	5.92
Manubrium(mm)	33.4-61.5	45.43	6.65
Mesosternum(mm)	63.8-102.4	84.15	8.61
Combined length of manubrium and mesosternum (mm)	107-145	129.58	9.24

combined length of the manubrium and mesosternum ranged from 107 mm to 145 mm having a mean (\pm SD) of 129.58 (\pm 9.24) mm (Table 1).

Simple linear regression formulae were derived by correlating stature with the length of manubrium, length of mesosternum, and the combined length of manubrium and mesosternum. When stature was regressed on the length of manubrium, the standard error of the estimate (SEE) was 5.90 and the correlation coefficient (R) was 0.167, indicating a positive correlation between these two variables. 2.8 % of the variation in the sample is explained by this regression model ($R^2 = 0.028$). When regressing stature on length of mesosternum, the standard error of the estimate (SEE) was 5.96 and the correlation coefficient (R) was 0.09 indicating a very weak correlation between these two variables. Only 0.8 % of the variation in the sample is explained by this regression model ($R^2 = 0.008$). However, when regressing stature on the combined length of manubrium and mesosternum, the standard error of the estimate (SEE) was lowest (5.85) and the

correlation coefficient (R) was 0.207 indicating a better correlation than those with lengths of manubrium or mesosternum. 4 % of the variation in the sample is explained by this regression model ($R^2 = 0.04$) (Table 2).

Table 2: Linear Regression models for stature estimation

Linear regression models	R	R ²	Standard error of estimate(cm)
Stature=144.1 + 0.149 x M	0.167	0.028	5.90
Stature=145.5 + 0.064 x B	0.093	0.008	5.96
Stature=133.6 + 0.133 x CL	0.207	0.043	5.85

Discussion :

Estimation of stature from long bones is a commonly adopted method by forensic experts and anthropologists to complete the biological profile of a person to establish identity in cases of mutilated, dismembered bodies and skeletal remains. Many researchers have published their studies taking into consideration the correlation between stature and lengths of femur,^{1,9,10} tibia,^{10,11} humerus,^{1,9,10} radius,¹² ulna,¹² hand length^{13,14} and foot length.^{13,14,15} However, there is limited literature on the estimation of stature from the sternum and the methodologies adopted by different researchers are also different. Menezes et al,⁶ Singh et al⁴ and Saraf et al¹⁶ conducted their studies on macerated and dried sternums of south Indian, north-west Indian, and South Indian populations respectively; whereas Marinho et al,¹⁷ Yonguc et al¹⁸ and Tumram et al⁵ conducted their studies on fresh sternums of Portuguese, Turkish and central Indian population, respectively. The present study was carried out on fresh sterna of 50 females belonging to north east Madhya Pradesh. The mean stature estimated in the present study is shorter than that estimated in

Table 3 : Comparison between various studies regarding sample size, population studied, methods adopted and mean stature observed

Study	Sample size	Population	Method	Mean stature±SD(CM)
Menezes et al(2009) ⁶	40 females	South Indian	Dry sterna	155.8±5.27
Singh et al(2011) ⁴	91 females	North West Indian	Dry sterna	156.3±6.96
Yonguc et al (2014) ¹⁸	30 females	Turkish	Fresh sterna	160.2±6.7
Chandrakanth H et al ¹⁹ (2015)	50 females	South Indian	Dry sterna	155.7±8.1
Saraf et al (2018) ¹⁶	50 females	South Indian	Dry sterna	164.4±3.50
Present study	50 females	North East Madhya Pradesh India	Fresh sterna	150.90±5.92

other studies conducted on different Indian populations and Western populations (Table 3).

Yonguc et al¹⁸ and Singh et al¹⁴ observed higher mean lengths of manubrium than the present study; whereas, Saraf et al¹⁶ and Chandrakanth H et al¹⁹ observed lower mean lengths of

manubrium than the present study. When the mean length of mesosternum is taken into consideration, Saraf et al,¹⁶ Singh et al,⁴ and Chandrakanth H et al¹⁹ reported shorter mean lengths of mesosternum, and Yonguc et al¹⁸ reported a higher mean length of mesosternum compared to the present study. The value of mean combined length of the manubrium and mesosternum observed in the present study was higher than that observed by Saraf et al,¹⁶ Singh et al,¹⁴ and Chandrakanth H et al.¹⁹ However, we observed a lower value of mean combined length of the manubrium and mesosternum than Yonguc et al.¹⁸

Correlation coefficient values (R) calculated while estimating the correlation between stature and length of manubrium by Singh et al,⁴ Chandrakanth H et al¹⁹ and Saraf et al¹⁶ are 0.191, 0.148, and 0.680, respectively. We observed a slightly weaker correlation ($R=0.167$) than Singh et al⁴ and Saraf et al¹⁶ but a stronger correlation than Chandrakanth H et al¹⁹. When the correlation between stature and length of mesosternum was considered, we observed a weaker correlation ($R=0.093$) than Singh et al,¹⁴ Chandrakanth H et al,¹⁹ and Saraf et al.¹⁶ While considering the correlation between stature and the combined length of manubrium and mesosternum, we observed similar value of correlation coefficient like that of Chandrakanth H et al.¹⁹ However, Singh et al¹⁴ and Saraf et al¹⁶ observed a stronger correlation than the present study between these two parameters.

These differences in correlation between stature and lengths of different parts of the sternum observed by various researchers might be due to different populations studied and different methodologies adopted. Thus, when stature is correlated with the length of manubrium, length of mesosternum, and the combined length of manubrium and mesosternum, the strongest correlation was observed between stature and the combined length of manubrium and mesosternum by all researchers which is consistent with the present study.

When the correlation between stature and length of manubrium is studied, the standard error of estimate (SEE) observed by various researchers ranged between 0.173 as observed by Yonguc et al¹⁸ to 6.82 as observed by Singh et al.¹⁴ SEE observed in the present study is 5.90 which is slightly lower than that of Singh et al,¹⁴ but much higher than Yonguc et al¹⁸ and Saraf et al.¹⁶ SEE ranged from 0.123 as observed by Yonguc et al¹⁸ to 6.83 observed by Singh et al,¹⁴ when stature and length of mesosternum were correlated. SEE observed in the present study while considering the correlation between these two parameters is 5.96, which is slightly lesser than that observed by Singh et al¹⁴ and greater than that estimated by Yonguc et al¹⁸ and Saraf et al.¹⁶ When regressing stature on the combined length of manubrium and mesosternum, SEE ranged from 0.077 as observed by Yonguc et al¹⁸ to 6.65 observed by Singh et al.¹⁴ SEE observed in the present study was 5.85 which is slightly lower than that observed by Singh et al¹⁴ but much higher than that observed by Saraf et al¹⁶ and Yonguc et al.¹⁸ SEE indicate the precision of the linear regression equation in predicting the value of dependant variable (stature) based on values of independent variables. Lesser the SEE more is the accuracy of the linear regression equation in predicting stature. All the researchers observed least SEE when stature is regressed on the

combined length of manubrium and mesosternum which is consistent with observations of the present study. Hence, stature

Table 4 : Comparison of correlation coefficients(R), coefficient of determination (R²) and standard error of estimate (SEE) observed in different studies

Study	Sternal parts	R	R ²	See
Menezes et al ⁶	Manubrium	--	--	
	Mesosternum	--	--	
	Combined length of manubrium and mesosternum	--	0.408	4.11
Singh et al ⁴	Manubrium	0.191	0.06	6.82
	Mesosternum	0.255	0.05	6.83
	Combined length of manubrium and mesosternum	0.318	0.10	6.65
Yonguc et al ¹⁸	Manubrium	--	0.448	0.173
	Mesosternum	--	0.138	0.123
	Combined length of manubrium and mesosternum	--	0.547	0.077
Chandrakanth H et al	Manubrium	0.148	--	--
	Mesosternum	0.243	--	--
	Combined length of manubrium and mesosternum	0.259	--	--
Saraf et al ¹⁶	Manubrium	0.680	0.463	2.59
	Mesosternum	0.747	0.558	2.35
	Combined length of manubrium and mesosternum	0.859	0.738	1.81
Present study	Manubrium	0.167	0.028	5.90
	Mesosternum	0.093	0.008	5.96
	Combined length of manubrium and mesosternum	0.207	0.043	5.85

can be most accurately predicted by the linear equation which is derived by considering the combined length of manubrium and mesosternum than other parameters (Table 4).

SEE is highest when stature is correlated with length of sternum than when it is correlated with other parameters like lengths of femur,^{1,9,10} tibia,^{10,11} humerus,^{1,9,10} radius,¹² ulna,¹² hand length^{13,14} and foot length.^{13,14,15} Hence, regression equations for estimating stature derived by considering these parameters are more accurate than those derived from lengths of different parts of the sternum.

Conclusion :

Due to lesser values of correlation coefficient and higher values of SEE, lengths of different parts of the sternum are less reliable in predicting stature than lengths of long bones, hand length, and foot length. Amongst all parameters taken into consideration in the present study, stature can be most reliably predicted by the regression equation which is derived from the correlation between stature and the combined length of manubrium and mesosternum. A smaller sample size is a limitation of the present

study and the authors recommend that studies should be conducted on a larger sample size in different population groups. The findings of the present study will be useful for rapid estimation of stature is relatively fresh but mutilated bodies due to animal or other activities or a badly decomposed body only when long bones are not available or are partially broken and fragmented.

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ORIGINAL ARTICLE

Estimation of Stature by Using Percutaneous Hand Length Amongst the Tamil Population

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Abstract :

Stature is one of the basic data used in the identification of an unknown person. It plays an important role especially when mutilated bodies, advanced stages of decomposition, or skeletal remains cases are concerned. The present study examines the estimation of the stature of a person by using his hand length. It is not always an easy task because the growth & development of an individual may be affected by various factors such as age, sex, race, nutrition & geographical areas, etc. So, we need to have a population-specific regression formula for the Tamil population.

In the present study, we have included 200 medical students (100 male & 100 female) in the age range 17 to 21 years. We excluded those students whose forefathers and parents are of non-Tamil origin. With the help of a vernier caliper, the hand lengths were measured and they were tabulated along with the corresponding heights of the person. Measurement values were expressed in terms of centimeters. All the measurements were conducted by using the same equipment during a reasonable time period of the day to minimize the measurement errors due to diurnal variation. By using these data, the regression formula for stature estimation of Tamil origin people was calculated. It was observed that the length of the hand provides a reliable means for estimating the stature of a person.

Keywords : Stature; Hand length; Tamil population; Height; Identification.

Introduction :

Stature is one of the basic data used in the identification of an unknown person. It plays an important role especially when mutilated bodies, advanced stages of decomposition, or skeletal remains cases are concerned. The present study examines the estimation of the stature of a person by using hand length. It has been one of the commonly used human attributes in describing the identity of an individual from time immemorial even before the introduction of forensic science.^{1,2}

Though many authors have formulated different regression models from different body parts like a trunk, head, upper and lower extremities, and even hand and footprints. It is not always an easy task because the growth & development of an individual may be affected by various factors such as age, sex, race, nutrition & geographical areas, etc.^{3,5} Moreover, there is a paucity of literature on the Tamil adult population. So, we need to have a population-specific regression formula for the Tamil population.

Material and Method :

In the present study, we have included 200 medical students (100 male & 100 female) in the age range 17 to 21 years studying at SRM medical college & research institute, Potheri, Kattankulathur. We have excluded those students whose forefathers and parents are of non-Tamil origin. Further, individuals having bone deformities, dwarfisms, and gigantisms are too excluded from the present study. For each case, we have

obtained written informed consent in the presence of a witness. For female participants, measurements were taken in the presence of a female attendee.

In the present study, the hand length is defined as the linear straight distance between the distal wrist crease and the tip of the middle finger. The participants were asked to place their hands (both hands one after another) in a supine position on the flat surface of a table horizontally with the fingers extended, and adducted, and then measurement was taken using a sliding caliper. Care was taken so that forearm was in the same line with the middle finger.

The stature of each participant was taken by using a height measuring rod. Participants were asked to stand on the floor barefooted with shoulder blocks and buttocks touching the wall with the head oriented in the eye-ear-eye plane i.e., Frankfurt plane. All measurements were expressed in centimeters. To minimize the diurnal variation all measurements were conducted between 9 to 10 am using the same instrument. Further, all measurements were recorded by the same person to minimize error in sampling. Thus, collected samples were tabulated and analyzed by using SPSS software version 17.0.

Ethical Clearance: It was obtained as per our college guidelines.

Results :

From the sample population, we selected equal numbers of male (100) and female (100) participants. In both the sexes, we see most of the participants in the age range of 19 to 20 years, i.e., 56 cases, (50.5%) as shown in Table No. 1.

Table No.2 shows the case distribution according to the stature i.e., height of the person. Amongst the male participants, the minimum and maximum statures were 160.5 cm and 177.5 cm respectively. In female participants, the minimum and maximum statures were 151cm and 167.5 cm respectively.

The maximum and minimum hand lengths are shown in Table

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Table 1 : Cases Distribution According to Age & Sex

Age (Years)	Male	Female	Total	%
17-18	13	15	28	14
19-20	45	56	101	50.5
20-21	42	29	71	35.5
Total	100	100	200	100%

No.3. The maximum and minimum hand lengths in the male group were 16 cm and 21 cm respectively with a mean value of 18.5 cm. For females, the maximum and minimum hand lengths were 15 cm and 20 cm respectively with the mean value of 17.5 cm. It was noticed that there was no statistical difference in the length of right and left hands in both the sexes.

Table 2 : Cases Distribution According to Stature

Stature (Height in cm)	Male	Female
Minimum height	160.5	151
Maximum height	177.5	167.5
Mean	169	159.25
Standard deviation	3.95	4

After analysis of the data, we tabulated the correlation coefficient, regression coefficient, coefficient determination, t-value & p-value as shown in Table No.4. It showed a positive correlation with $r^2 = 0.904$ in males and 0.888 in females.

Regression equations for stature estimation from hand length derived as follows:

Table 3 : Cases Distribution According to Hand Length

Hand Length (in cm)	Male		Female	
	Right hand	Left hand	Right hand	Left hand
Minimum length	16	16	15	15
Maximum length	21	21.02	20	20
Mean	18.5	18.5	17.5	17.5
Standard deviation	1.05		1.10	

For Male:

$$\text{Stature} = 103.20 + 3.604 \times (\text{Hand length}) \pm 2.413.$$

$$\text{For Female: Stature} = 94.53 + 3.671 \times (\text{hand length}) \pm 2.802.$$

Table 4 : Cases Distribution According to data analysis values

Statistical parameter	Sex	
	Male	female
Correlation Coefficient ®	0.952	0.942
Regression coefficient (b)	3.604	3.671
Coefficient of determination (r^2)	0.904	0.888
t value	52.87	35.73
p value	< 0.001	< 0.001

Discussion :

The stature is directly proportional to different body parts and shows a definite biological and genetic association with each other. The mathematical method is more useful in medico-legal cases as it can be applied even when only part of the body is available.⁶

Many earlier studies reported using regression equations,^{2,7,8} and multiplication factors,^{7,9,10-12} for stature determination from hand length. However, very few studies compared these methods for stature determination, especially with hand length.^{8,9}

In the present study, the correlation coefficients in male and female participants are found to be 0.952 and 0.942 respectively. The higher the value of the correlation coefficient towards +1.0 is showing the higher probability of prediction. Other studies showing correlation coefficient for stature from hand length by Chikhalkar BG et al,¹⁰ (in the local population of Mumbai) was 0.6 and Khanapurkar S et al,¹¹ (in the population of Maharashtra) was 0.828. Jyoti Agrawal et al,¹² and Wakode NS et al,¹³ also observed similar findings. Our finding in this regard is slightly different from the works of Chandra A et al.¹⁴

Bharath Shetty et al,¹⁵ conducted a similar stature estimation study consisting of all students and staff of south Indian origin of A.J. institute of medical sciences & research centre, Mangalore, Karnataka, and it was observed that there is a strong relationship between hand length and stature. Subashri A, M.S. Thenmozhi¹⁶ also conducted a similar study at Saveetha dental college, Chennai, Tamil Nadu. In all the studies the age group of participants ranged from 17/18 yrs to 23/30 yrs approximately.

The difference in correlation coefficient between male and female subjects shows a gender-specificity linear regression equation. Furthermore, the difference in correlation coefficient in our study and the study in other areas is in favour of the establishment of the population-specific linear regression equation.

Conclusion :

It is observed that the length of the hand provides a reliable means for estimating the stature of a person. This will be useful for stature calculation not only by forensic scientists but also by anthropologists, archeologists, anatomists, etc., especially in the identity establishment of unknown mutilated bodies or skeletal remains.

Conflict of Interest: Nil**Source of funding:** None to declare**References :**

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ORIGINAL ARTICLE

Estimation of Stature from Percutaneous Tibial Length by Developing A Regression Formula Among the male Meitei Population of Manipur: A Cross-sectional Study

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Abstract :

Studies have reported that population-specific formulae are more reliable for estimation of stature in medico-legal cases. The present work was carried out on indigenous male Meitei subjects of Manipur. The data collected were analyzed to generate a regression formula for estimation of stature. A cross-sectional study was conducted on indigenous Manipuri Meitei males between the age group of 21-25 years on a sample size of 75 from August 2018 to July 2020. The standing height of the subject was measured in a standing position. The tibial length was measured as the distance between the medial most point on the upper border of the medial condyle of the tibia and the tip of the medial malleolus of the tibia. The following is the developed regression equation of stature of male (Y) Meitei subjects on his tibial length (X1): $Y = 87.45 + .84 X1 + 2.36$. The findings of the study have been used in estimating the stature from tibial height by deriving a new regression formula that is specific to the population. It will be of immense importance in medico-legal investigations there by benefitting society in general.

Keywords : Stature; Indigenous; Meitei males; Cross-sectional Study; Tibial length; Regression equation.

Introduction :

Stature, as an individual characteristic, is one of the important parameters for personal identification. "Stature is defined as natural height in an upright position".¹ There exists a strong relationship between stature and dimensions of different body parts, particularly bone lengths, which forms the basis for stature estimation.^{2,3} Tibia accounts for 22% of the total body length.⁴

Studies have reported significant differences in the proportion of limb dimensions due to hereditary, environmental, ethnic, and dietary factors, which also influence the stature of a person.⁵ Therefore, population-specific formulae are more reliable for estimation of stature in medico-legal cases.

According to Bertillon after the age of 21 years, the dimensions of the skeleton remain unchanged.⁶ Earlier studies have established that the Regression equation provides greater reliability in estimating stature.⁷

The present work was carried out on indigenous male Meitei subjects of Manipur. The aim and objectives were to establish a regression formula for determining the stature of indigenous Meitei from tibial height. The data collected were analyzed to generate a regression formula for estimation of stature.

Materials And Methods :

A Cross-sectional study was conducted on Indigenous Manipuri Meitei males between the age group of 21-25 years. The calculated sample size was 72. Considering a dropout rate of

5%, a total of 75 males were studied in the Department of Forensic medicine and toxicology, Regional Institute of Medical Sciences, Imphal. The study period was from August 2018 to July 2020. Inclusion criteria: Only healthy Meitei males between 21-25 years were included. Exclusion criteria: Subjects with any obvious congenital or acquired deformity of the spine or extremities were not included in the study. Approval from the institutional ethics committee (research ethics board of RIMS, Imphal) was obtained before the commencement of the study.

The sample size was calculated from the following equation:

Total Sample size (n) = $[(Z\alpha + Z\beta)/c]^2 + 3$, therefore (n) equals to 72.

$Z\alpha = 2.576$ (99% confidence level)

$Z\beta = 1.282$ (90% power)

$c = 0.5 \times \log [(1+r)/(1-r)]$ equals to 0.465

$r = 0.434$ (from study done by Trivedi A et al⁸)

Procedure :

The Standing Height (Stature) of the subject was measured in a standing position on a standard stadiometer with both feet in close contact with each other the trunk straight along with the vertical board, and the head adjusted in the frankfurt-horizontal plane (eye-ear plane). The measurement was taken in centimeters by bringing the horizontal sliding bar to the vertex. For measuring the per-cutaneous right tibial height, the study subject was asked to sit with the knee placed in the semi-flexed position and the foot partly inverted to relax the soft tissues and make the bony landmarks prominent. Two points were marked by skin marking pencil. The medial most point on the upper border of the medial condyle of the tibia and the tip of the medial malleolus of the tibia was the upper and the lower points respectively. The distance between the two points was measured with the help of spreading calipers to determine the tibial height. All the measurements were

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taken by the investigator with the same instrument to avoid any technical and/or inter-observer error and to maintain reproducibility. The measurements were taken three times and their mean value was considered for the estimation of height.

Table 1 : Demographic profile of the subjects

Demographic profile	Minimum	Maximum	Mean±SD
Age (yrs)	21.0	24.0	22.26±1.01
Tibial length (cm)	25.0	43.0	37.09±3.03
Stature (cm)	148.0	179.0	164.14±7.88

Results and Observations :

It is observed from the table-1 that, the average age of the subjects considered in the present study is found to be 22.26 years with a standard deviation of 1.01 years. The youngest and oldest ages of them are 21 years and 24 years respectively. The mean and standard deviation (SD) of tibial length/per-cutaneous length of the tibia are 37.09 cm and 3.03 cm with minimum and maximum values of 25 cm and 43 cm respectively. The average stature is noticed as 164.14 cm with SD of 7.88 cm. The shortest stature in the sample is found to be 148.0 cm against the tallest of 179.0 cm.

Table 2 : Descriptive statistics of tibial length (PCTL)

Statistics of Tibial length (PCTL)	Male Meiteis
Range in cm	34.0 - 43.0
Mean±SD	39.24± 1.75
SE	.20
CV	4.45
95% Confidence Interval for mean	38.84 - 39.65
t-value (between male & female)	12.34
Df	148
P-value	<0.001
Remark	very highly significant

SD: standard deviation; SE: standard error of mean; CV: coefficient of variation; df: degree of freedom; P-value: probability due to chance factor

A detailed description of tibial length in male subjects is set forth in Table 2 indicating the range of PCTL for males is 34.0 cm to 43.0 cm. Male has a length of 39.24 cm which is found to be highly significant ($P < 0.001$). CV (4.459) for males indicates that the individual tibial length variation among males is less. 95% confidence interval for the mean of males signifies that the normal range of PCTL for males is 38.845 cm to 39.651 cm.

Correlation is significant at the 0.01 level (2-tailed);

In order to establish an average relationship between stature and tibial length, in terms of their original unit of measurement i.e., cm, a simple linear regression equation of stature on tibial length

Table 3 : Simple linear regression equation of stature on tibial length (PCTL)

Regression Statistics	Male Meiteis
Independent variable ($X = \text{PCTL}$)	$X' = \text{PCTL for male}$
Intercept (β_0)	87.45
Regression coefficient (β_1)	.84
Correlation coefficient (r)	.84**
Coefficient of determination (R^2)	.71
Std. error of estimate (SEE)	2.36
P-value	<.001
Regression equation ($Y = \beta_0 + \beta_1 X + \epsilon$)	$Y = 87.45 + .84 X_1 + 2.36$
F-value	179.491
P-value	<.001

(PCTL) is developed taking stature as a dependent variable while the tibial length, independent variable. The proposed equation is given by $Y = \beta_0 + \beta_1 X + \epsilon$; where Y is dependent variable/predicted value; X is, independent variable; β_0 , Y-intercept; β_1 is, regression coefficient/slope of the regression line; ϵ ; is Standard error of estimate (SEE)/residual.

In table-3, relevant regression statistics are depicted along with a developed regression equation based on the present data. The following is the developed regression equation of stature of male (Y) Meitei subjects on tibial length (X_1):

$$Y = 87.45 + .84 X_1 + 2.36$$

Here, $\beta_0 = 87.45$ indicates that the stature of the male is 87.45 cm when his tibial length is 0, in the sense that there is a general difference of 87.45 cm. between the stature of males and his tibial length. Again $\beta_1 = 0.84$ shows that there is an increment of 0.84 cm in stature when one cm enhances his tibial length. The discrepancy between true and estimated value (based on the developed equation) is depicted by ϵ (error term) is witnessed as 2.36 cm. Again $R^2 = .71$ (coefficient of determination), which is highly significant ($P < .001$), highlights that the variation of the stature of a male can be explained by 71% of his tibial length through the developed equation.

The statistical test applied: The equation so developed is further tested by F-test and found to be highly significant ($P < .001$). In other words, the developed equation is treated as the best fit and henceforth it may use to detect the stature of a male for any given value of his tibial length.

Further, the table demonstrates there is a direct correlation between the stature of a male and his tibial length ($r = 0.84$) which is highly significant even at a 0.001 level of significance.

Discussion :

In the present study, the correlation between percutaneous tibial length and stature is established by framing the regression equation among the living indigenous male 'Meitei' population in the state of Manipur which is the major community in the state. Until now no studies have been done so far on this topic.

In the present study, in order to establish the average relationship between stature and tibial length, in terms of their original unit of measurement i.e., cm, a simple linear regression equation of stature on percutaneous tibial length (PCTL) is developed taking stature as the dependent variable while tibial length as the independent variable. The following is the developed Regression

derived the following linear regression equation was derived: Height in cm = $84.74 + 2.27x$ (PCTL) ± 3.67 , which exemplifies the fact that the regression equation derived will be population group/region-specific. This justifies the present study on the indigenous Meitei population. The estimated stature was 167.66 cm for males and concluded that there is a positive correlation between stature and percutaneous tibial length which is also similar to the present study.

Chavan SK et al¹³ in the year 2009 estimated the mean height of males to be 167.89 cm \pm 6.21 cm. Mean PCTL was 37.32 cm \pm 2.18 cm for males. They also derived a regression formula for males but their findings are different from the present study which may be due to differences in environmental, ethnic, and dietary factors which influence the stature of the person.

Duyar I and Pelin C¹⁴ conducted a study on 231 randomly selected Turkish, ages ranging from 18-34 years for estimation of height from the tibial length in different stature groups. The derived regression equation for different stature groups was : short stature = $951.94 + 1.890 \times TL$, medium stature = $944.82 + 2.057 \times TL$, Tall stature = $1224.15 + 1.530 \times TL$, general formula stature = $678.68 + 2.738 \times TL$.

Their findings concluded that group-specific formulae were more accurate for subjects in the extreme height categories and grouping depending on tibia length could be used to identify the stature group to which a specimen belongs. The results obtained by them were different from the present study result which may be due to various factors like health and nutrition, stress, socioeconomic conditions, climate, changes in body proportions over time and between populations, and genetic variations which also influences the growth of bones thus giving different results.

The results of the present study validate and support the hypothesis that there exists a strong relationship between stature and the percutaneous length of the tibia. The present study also clearly demonstrates that the derived regression equation can be used for the estimation of stature from the percutaneous length of the tibia in indigenous male Meiteis of Manipur.

Conclusion :

Studies have reported significant differences in the proportion of limb dimensions due to hereditary, environmental, ethnic, and dietary factors which influence the stature of the person. This highlights the need for the development of population-specific regression formulae. Tibia being subcutaneous is accessible for measurement in living subjects. In the present study, the correlation between percutaneous tibial length and stature is established by framing regression equations among the living indigenous Meitei male population in the state of Manipur. This cross-sectional study has been carried out on 75 indigenous Meitei male subjects between the age group of 21 to 25 years of age living in Manipur. The findings of the study have been used in estimating the stature from tibial height by deriving a new regression formula that is specific to the population. It will be of immense importance in medico-legal investigations thereby benefitting society in general.

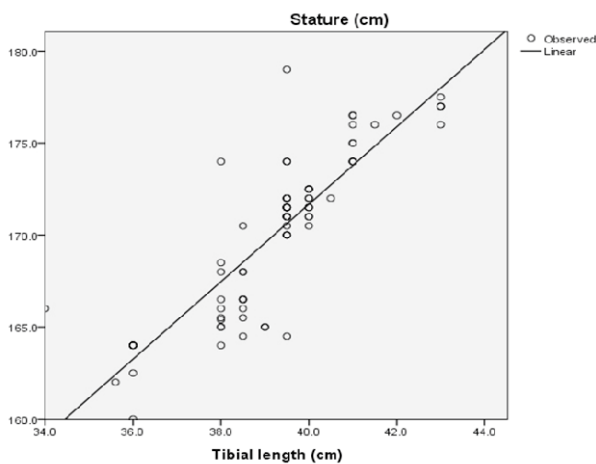


Fig. 1: Showing average relationship between stature of male and his tibial length through a fitted regression line



Fig. 2 : Measurement of Percutaneous Tibial Length (PCTL) with spreading calipers

equation of stature of male (Y) Meitei subject on his tibial length (X1): $Y = 87.45 + .84 X1 + 2.36$. A similar study has also been conducted by Chibba K & Bidmos MA,³ Didia BC et al,⁹ Saraji N¹⁰ & Mukta R et al¹¹ on different population groups.

In the present study, the regression formula derived for male Meitei subjects is $Y = 87.45 + 0.84X1 \pm 2.36$ where X is the value of PCTL (percutaneous tibial length) whereas in a study done by Bhavna et al¹² in their study on male shia muslims in Delhi,

Conflict of Interest: Nil

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ORIGINAL ARTICLE

Estimation of Stature Using Cephalic and Facial Measurements

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Abstract :

Stature (living height) is one of the primary characteristics for the identification of a person along with other biological profiles – age, sex, and race. The need for Identification of a person can occur in situations like a mass disaster, unidentified bodies, and many civil cases and criminal cases. As any part of the human body can be found as evidence, there is a need for a study to investigate the significant correlation between stature and cephalon-facial dimensions in the human body. The study was done on 400 medical students of south Indian origin. The study showed a significant correlation between cephalic measurements and stature.

Keywords : Identification; Stature; Anthropometry; Cranial measurements; Cephalometry.

Introduction :

Forensic Anthropology is the utility of scientific techniques devised in biological anthropology (a division of anthropology that examines human organic variants) to forensic conditions. 'Anthropos' means man and 'metron' means to measure. Anthropometry has two branches - Somatometry and Osteometry. Somatometry is the measurement of a living body or cadaver including the head and face.³ Cephalometry deals with the measurement of the head and face while craniometry deals with the study of skull measurements. On the other hand, osteometry deals with the measurements of skeletal bones other than the skull.⁴

Identification is the determination of the individuality of a person using unique physical and biological features. The need for Identification of a person can occur in situations like a mass disaster, unidentified bodies, and many civil cases and criminal cases.⁵

Stature (Living height) is one of the primary characteristics for the identification of a person along with other biological profiles – age, sex, and race (the big four). Maximum stature is attained by the age of 21 - 25 years.⁶ There is the ratio between stature and other parts of the human body, these measurements can help in calculating stature in those cases where the whole body is not available.

Each population varies in its anthropometrical measurements according to their race, hereditary, climate, nutritional status, and many other factors.⁸ Therefore, the present study is to estimate the relationship between stature and cephalo-facial measurement in the south Indian population.

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Materials and Methods :

The present cross-sectional study was done on 400 Medical students and other subjects (200 males and 200 females) who are from south India. The study was conducted after obtaining approval from the institutional ethical committee of Yenepoya medical college. Materials used are measuring tape, digital vernier caliper, spreading caliper, and stadiometer.

Ethical clearance: Prior approval was obtained from the institutional ethical committee.

Sample size formula :

Sample size was derived by the formula $n = 1 + 2C(s/d)^2$ [10].

Where $C = (z_{\alpha} + z_{1-\beta})^2$ If we take $d = 1$, then $n = 391.18$, n approximated to 400.

Inclusion criteria :

Healthy subjects in the age group of 18 to 25 are those who are of south Indian origin (age and place of origin will be confirmed from ID proof).

Exclusion criteria :

1. Participants who have undergone any cranial or facial interventions.
2. Participants with any congenital or acquired craniofacial defects.
3. Participants with deformity in lower limbs.
4. Participants who have a deformity in the vertebral column.

Methods of Collection of data:

All measurements were recorded by the same researcher. Recording of measurements was taken at the same time to avoid diurnal variation. Errors of measurements were avoided by taking an average of two measurements. Stature along with five cephalo-facial measurements – maximum head length, maximum head breadth, horizontal circumference, bigonial breadth, and morphological facial length was recorded.

Data analysis :

Regression modeling was used for estimation. Data analysis was performed by SPSS (version 17) for windows. Alpha value was set as 0.05. Microsoft excel, the word was used to generate graphs and tables.

Results & Discussion :

A total of 400 students participated in the study, out of which 200 were male and 200 were females. Participants belonged to the age group of 18 to 25 years. The percentage of male participants was more in the age group of 22 years (29%) and less in 25 years (2%). The percentage of female participants was more in the age group of 19 years (26%) and less in 23 years (4%).

The mean ages of the study subjects (males: 21.42 ± 1.71 ; female: 20.62 ± 1.90) were statistically significant between genders ($p < 0.0001$). The t value was 4.447.

The mean height (males: 171.66 ± 5.75 ; female: 153.55 ± 11.22) of the study population was found to be statistically significantly different ($p < 0.001$) between genders. The t value was 20.314. gender differences with respect to maximum head length (males: 18.16 ± 1.19 ; female: 17.12 ± 1.27), maximum head breadth (males: 12.89 ± 0.93 ; female: 12.03 ± 1.13), horizontal circumference (males: 54.98 ± 1.41 ; female: 52.47 ± 2.74), bigonial diameter (males: 11.62 ± 1.43 ; female: 9.89 ± 1.29) and morphological facial length (males: 11.45 ± 0.68 ; female: 10.47 ± 1.16), were statistically significant ($p < 0.0001$).

Table 1 : Frequency of males according to age.

MALES	FREQUENCY
18 Year	8
19 Year	26
20 Year	38
21 Year	10
22 Year	58
23 Year	44
24 Year	12
25 Year	4

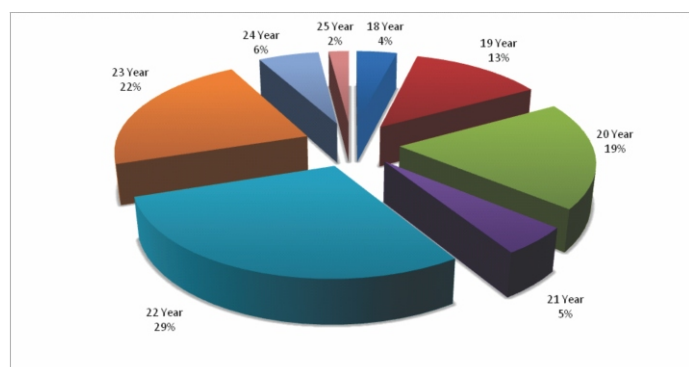


Fig. 1: Frequency of male participants according to age. Percentage of male participants was more in the age group of 22 years (29%) and less in 25 years (2%).

Recorded stature is more in males (184.20) compared to females (175.50). Maximum head breadth (14.80), and morphological Facial length (13.30) were more in females whereas in males head circumference (58.30) and bigonial breadth (14.30) were more whereas head length was found similar in both males and females participants (19.40).

All the correlations were statistically significant (p values less than 0.0001). The correlation of cephalic and facial measurements with stature in males ranged from 0.606 to 0.633 whereas in Male participants were more in number in age groups of 20 years, 22 years, and 23 years. Rest all age groups females were more in numbers. Female's coefficient ranged from 0.687 to 0.754.

Table 2 : Frequency of females according to age.

FEMALES	FREQUENCY
18 Year	20
19 Year	52
20 Year	30
21 Year	45
22 Year	22
23 Year	8
24 Year	13
25 Year	10

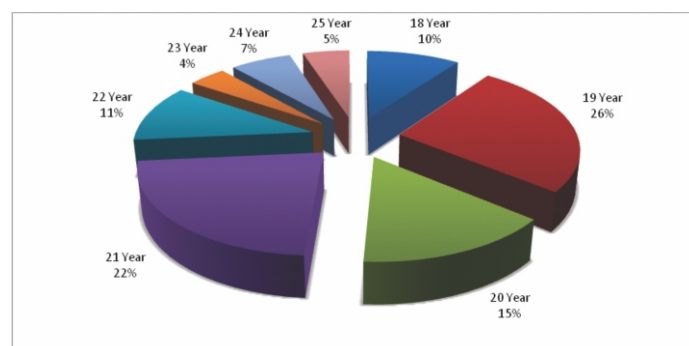


Fig. 2: Frequency of female participants according to age. Percentage of female participants was more in the age group of 19 years (26%) and less in 23 years (4%).

Table 3 : Comparison of males and female age group.

AGE	MALE	FEMALE
18 Year	8	20
19 Year	26	52
20 Year	38	30
21 Year	10	45
22 Year	58	22
23 Year	44	8
24 Year	12	13
25 Year	4	10

Table 4 : Descriptive statistics for age, stature, Cephalic and facial measurements.

Variables	Gender	Minimum	Maximum	Mean	Std Dev	S.E. Mean	t-value	p-value
Age	Male	18.00	25.00	21.42	1.71	0.12	4.447	< 0.0001
	Female	18.00	25.00	20.62	1.90	0.13		
Stature	Male	158.00	184.20	171.66	5.75	0.41	20.314	< 0.0001
	Female	138.10	175.50	153.55	11.22	0.79		
Maximum head length	Male	14.10	19.40	18.16	1.19	0.08	8.480	< 0.0001
	Female	14.10	19.40	17.12	1.27	0.09		
Maximum head breadth	Male	10.60	14.70	12.89	.93	0.07	8.373	< 0.0001
	Female	10.20	14.80	12.0	31.13	0.08		
Horizontal circumference	Male	52.40	58.30	54.98	1.41	0.09	11.497	< 0.0001
	Female	46.10	57.40	52.47	2.74	0.19		
Bigonial diameter	Male	8.10	14.30	11.62	1.43	0.10	12.623	< 0.0001
	Female	8.10	13.80	9.89	1.29	0.09		
Morphological Facial length	Male	9.80	12.80	11.45	.68	0.05	10.261	< 0.0001

Table 5: Correlation coefficient between stature with cranial & facial dimensions

Parameter	MALE		FEMALE	
	Corr. Co-eff.	p-value	Corr. Co-eff.	p-value
Stature Vs Maximum head length	0.633	< 0.0001	0.687	< 0.0001
Stature Vs Maximum head breadth	0.625	< 0.0001	0.708	< 0.0001
Stature Vs Horizontal circumference	0.606	< 0.0001	0.754	< 0.0001
Stature Vs Bigonial diameter	0.613	< 0.0001	0.731	< 0.0001
Stature Vs Morphological facial length	0.673	< 0.0001	0.728	< 0.0001

Analysis interprets those females were more correlated than males.

Summary of Regression Equations :

The regression equation derived for each of the cephalo-facial measurements is as following:

- Regression equation for prediction of stature from maximum head length:
For male: $116.194 + 3.05 \times \text{head length}$
For female: $49.439 + 6.082 \times \text{head length}$
- Regression equation for prediction of stature from maximum head breadth:
For male: $121.984 + 3.853 \times \text{breadth}$
For female: $68.868 + 7.041 \times \text{breadth}$

- Regression equation for prediction of stature from horizontal circumference:

For male: $35.870 + 2.470 \times \text{head circumference}$

For female: $3.088 \times \text{head circumference} - 8.492$

- Regression equation for prediction of stature from bigonial diameter:

For male: $142.99 + 2.466 \times \text{bigonial diameter}$

For female: $91.067 + 6.314 \times \text{bigonial diameter}$

- Regression equation for prediction of stature from morphological facial length:

For male: $106.825 + 5.664 \times \text{facial length}$

For female: $79.439 + 6.082 \times \text{facial length}$

Conclusion :

The present study was conducted to find out the correlation between cephalo-facial measurements and stature. Recorded stature was more in males. The recorded head length was found similar in both male and female participants. Maximum head breadth, morphological facial length was more in females whereas in males head circumference and bigonial breadth were more.

The correlation of cephalic and facial measurements with stature in males ranged from 0.606 to 0.633 whereas in females coefficient ranged from 0.687 to 0.754. Females were more correlated than males.

In cephalic measurements, head length in males had maximum correlation with stature but females had the least correlation. Maximum head breadth in both males and females had a moderate correlation. Head circumference was least in the case of males but had the highest correlation in females. In facial measurements, bigonial breadth had a moderate correlation with male stature but in females, it had the highest correlation. The facial length has a maximum correlation with male stature but a moderate correlation with female stature.

Our findings may be of value to practitioners in instances of isolated cranium or cases in which only the cranium is the best possible detail remaining particularly in case of a mass disaster. The estimated stature using the equation can be compared with the recorded or reported stature of missing individuals. If identification factors such as sex, ethnicity, age, and stature correlate with one individual, then the person can be considered as identified.

For the accuracy of the equations, further study should be conducted on a larger population. This would also help in determining to what extent the equations may overestimate or underestimate the shortest and tallest individuals in the population, respectively, and whether a new equation needs to be calculated for use at these extremes.

Conflict of Interest: Nil

Source of funding: None to declare

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ORIGINAL ARTICLE

A Confidential Survey among Medical Practitioners on Workplace Violence in Tamilnadu

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Abstract :

Hospital is a place where mixed emotions, from rejoices of begetting a baby to lamenting the loss of our loved ones, co-exist. Recently a third emotion in the form of violence against Medical Practitioners is creeping in. It is high time to unveil the extent of these violent incidents. Hence we have attempted to bring out the reality of this burning issue. This cross-sectional study included responses from 540 victims of violence among 800 medical practitioners. The participants were randomly chosen across Tamilnadu and were given a pre-tested questionnaire through Google forms after obtaining consent and disclosing confidentiality. Data were analyzed using Microsoft SPSS software Version 24.0. In this study, 68% of medical practitioners had experienced some form of workplace violence. Most of them were working in private establishments. Verbal threats were the most common form of violence. Emergency and critical care areas were the most vulnerable locations, relatives of the patients committed most of the violent attacks. Only 6% of the 540 victims had sought legal intervention. Violent outbreaks against medical practitioners are still rampant in our society despite the government's preventive measures. We can curtail such occurrences by implementing stringent Laws and bringing a change of attitude in a soft-skilled medical man to report such incidents and seek timely legal intervention.

Keywords : Violence against Medical practitioners; Workplace violence; Victims; Legal intervention.

Introduction :

Health care is one of the professions that still works based on a welfare model in this predominantly capitalistic country.¹ Hospital is a place where mixed emotions, from rejoices of begetting a baby to lamenting the loss of our loved one, co-exist. Recently a third emotion in the form of violence against medical practitioners is creeping in. Today it has become inevitable that every medical practitioner will face some form of violence at their workplace. In their global campaign for violence prevention, World Health Organization reports that the chance of facing violence at the workplace is highest among medical professionals.² WHO also states that 8 to 38% of Medical professionals suffer physical violence at some point in their career.³ In India, more than 75% of the doctors have faced workplace violence, and 46.3% of the doctors opine that fear of violence is the leading cause of stress, says a study by the Indian medical association.^{4,5} Literature highlights various reasons like insufficient government policies, human resources, poor infrastructure, political pressure, commercialization of healthcare, poor doctor-patient communication, the burden of diseases, and pre-conceived internet-based ideas by patients to cause violent outbreaks in healthcare establishments.⁶ The prevalence of violence against medical professionals is about 56% to 75% across the world. Literature in India shows the

majority of such violent outbreaks to be about 40% to 78%⁷⁻⁹ with 3.7% experiencing physical assault,¹⁰ and the trend is still increasing. Violent outbreaks against medical professionals are grossly under reported and hardly debated in the news or public forums. Hence we have designed this cross-sectional study to identify the pattern of violence experienced, prevalence, and susceptible group amongst the doctors, their nature of the working environment, and the aftermath of such violent outbreaks among the victims of violence across Tamil Nadu.

Materials and Methods :

This cross-sectional study used a pre-tested questionnaire as a Google form designed to identify and collect information from those medical practitioners who had exclusively experienced some form of violence at their workplace. We also used an informed consent and a confidentiality disclaimer for this study. We included 540 responses who claimed to have experienced some form of violence at their workplace among 800 randomly chosen medical practitioners across Tamilnadu. We obtained ethical clearance from the institutional human ethics committee before the commencement of the study. We calculated the sample size based on the prevalence of violence among doctors as reported to be 38% by Kesavan. R et al.¹¹ Using the formula, $n = 4pq/d^2$ where P is 38, q is 100-38, q = 62, and d is the absolute precision (5%), we estimated the sample size to be 451 after adjusting 20% nonrespondents. The data was retrieved from Google forms to microsoft excel sheets and analyzed using SPSS version 24.

Ethical clearance: We obtained prior approval from the Institutional Ethics Committee.

Results :

This cross-sectional study conducted among medical

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practitioners observed that 540 (68%) had experienced some form of violence at their workplace. Table 1 shows the demographic pattern of our study population. There were 260 (48%) women and 280 (52%) men, thus making an equal distribution. Most of the participants, 383 (71%) of our study population, have specialized in some field of expertise. 190 (35%) were from surgical specialty including Orthopedics, 90 (17%) were from Obstetrics and Gynecology, 66 (12%) were from emergency & critical care, 164 (31%) were from medical specialty including general practice, and 30 (5%) were either into diagnostics or administration. Most medical practitioners 354 (66%) in our study population were working in private establishments. All the participants in our study population were

Table 1 : Demographic pattern of our study Population (n= 540)

S No	Characteristics	Frequency (%)
1	<u>Gender</u> Males Females	280(52%) 260(48%)
2	<u>Qualification</u> MBBS Specialization	157 (29%) 383 (71%)
3	<u>Subspecialty</u> Surgical and allied fields Medical and allied fields Obstetrics and Gynecology Emergency & Critical care Diagnostics&Administrators	190 (35%) 164 (31%) 90 (17%) 66 (12%) 30 (5%)
4	<u>Nature of the workplace</u> Government Non Government	186 (34%) 354 (66%)
5	<u>Region of Practicing.</u> Urban Rural	270 (50%) 270 (50%)
6	<u>Years of work experience</u> Less than 10 Years More than 10 Years	311 (58%) 229 (42%)

Table 2 : Nature of violence as experienced by our study participants over the last five years.

S.No.	Nature of the violent act	Frequency (%)
1.	Intimidating Gestures	335 (62%)
2.	Verbal threats	442 (82%)
3.	Physical threats	142 (26%)
4.	Physical Assault	54 (10%)
5.	Damage to Equipments / Property	232 (43%)

distributed equally across rural and urban areas. 311 (58%) of the participants had a work experience of less than a decade.

Table 2 shows the nature of the violent act as experienced by study participants during their professional practice. We framed the types of violent acts based on the World Health Organization's definition of violence against health care workers³ and Section 319 of the Indian Penal Code. Among the 540 participants, 442 (82%) of the medical practitioners had experienced verbal threats. 335 (62%) had experienced Intimidating gestures, 232

Table 3: Distribution of violent outbreaks across the various locations in a clinical establishment.

S.No.	Locations where violence occurred	Frequency (%)
1	Emergency and Critical care areas	342 (63%)
2	Out-Patient Department	309 (57%)
3	Other locations, including In-Patient wards	120 (22%)
4	Billing Section	106 (20%)

(43%) had reported instances of damage to equipment or property, respectively.

Table 3 shows the distribution of violent outbreaks across the various locations in a clinical establishment. Among 540 medical practitioners who were victims of violence, 342 (63%) were from emergency and critical care areas, 309 (57%) from the Out-

Table 4 : Circumstances that resulted in violent outbreaks:

S.No.	Circumstances	Frequency (%)
1	Misunderstanding and communication	327 (61%)
2	Breaking Bad news	298 (55%)
3	Financial issues	216 (40%)
4	Lack of reasonable care and Facilities	114 (21%)

Patient department, followed by in-patient wards and billing sections.

Table 4 Shows circumstances that resulted in violent outbreaks. Among 540 medical practitioners, 327 (61%) events were results of misunderstanding and communication issues, 298 (55%) were during events of breaking bad news, 216 (40%) events were

Table 5 : Perpetrators of Violence.

S.No.	On who committed the act of violence.	Frequency (%)
1	Patients	179 (33%)
2	Relatives of the Patient	373 (69%)
3	Sympathetic Bystanders	134 (25%)
4	Politically incited Mob	80 (15%)

because of financial problems, and 114 (21%) were due to a lack of reasonable care and facilities.

Table 5 shows the offenders who had committed the violent acts. Patient relatives committed most of the violent attacks, 373 (69%) followed by attacks by the patients themselves 179 (33%). 25%

Table 6 : Response to the violent outbreak by the Medical Practitioners:

S.No.	Response by the Medical practitioners	Frequency (%)
1	Remained calm and ignored	281 (52%)
2	Solved the issue without any legal intervention	227 (42%)
3	Informed the police and filed a case in the court of Law	32 (6%)

and 15% of the violent attacks were committed by sympathetic bystanders and politically incited mobs, respectively.

Table 6 shows the response to the violent outbreak by the medical practitioners facing violence at their workplace. Only 32 (6%) participants who have experienced some form of violence had reported the incident to the police and filed a case. 281 (52%) had remained calm, and 227 (42%) of the participants solved it independently without any legal intervention.

Among the 32 participants who reported the issue to the police, 25 (80%) claimed that they were not satisfied with the legal intervention which was sought for. Among 540 participants, 441 (82%) claimed that they had some change in their professional attitudes like defensive medical practice and lack of motivation after having experienced violence at their workplace.

Discussion :

Today violence at the workplace is an inevitable professional consequence for a medical practitioner. Although not an uncommon incident, surprisingly, very few studies have been done on the medical practitioners who were victims of violence. We have included 800 participants with a blend of medical practitioners across various specialties, working in private and public sectors with a wide range of work experience.

Among the 800 participants, we collected information from 540 medical practitioners who claimed to have experienced some form of workplace violence.

In this cross-sectional study, the prevalence of violent outbreaks among medical professionals was 540 (68%) among 800 participants, which correlates with the data provided by the Indian medical association and other studies.^{12,13} Most of the 383 (71%) individuals in our study group have specialized in some field of expertise, and 354 (66%) of them were from non government institutions. Out of the 540 victims of violence in this study, 190 (35%) individuals were from surgical and allied fields, followed by 164 (31%) and 90 (17%) from medical specialty and Obstetrics & Gynecology, respectively.

Verbal abuse and insults were the most common forms of violent behavior as experienced by 442 (82%) of our study participants, followed by intimidating gestures 335 (62%) that correlates with the observations by Ambesh P, Sing G et al, and other Indian literature.¹²⁻¹⁴ 142 (26%) and 54 (10%) of the participants had experienced physical threats and assaults, respectively, which correlates with the observations made by Ambesh P et al, in their literature.¹²

In our study, 232 (43%) participants claimed to have experienced violence in the form of damage to their equipment and property. This fact is hardly being reported in literature globally. In our study group, most respondents, 342 (63%), claimed that emergency departments and critical care areas were the most vulnerable locations for violent outbreaks. This outcome of our study correlates with literature available globally.¹⁵⁻¹⁷ 327 (61%) claimed that misunderstanding and communication issues were the most common causes of violent outbreaks, which correlates with literature published by Gosh K et al, Pratibha VS, and

Barathi K et al.¹⁴⁻¹⁹ The most common offenders faced by the victims of violence in our study were the relatives of the patient 373 (69%). Similar findings were observed in literature globally.¹⁴⁻¹⁷

In our study, among the 540 medical practitioners who were victims of violence, 281 (52%) chose to remain calm and ignored such incidents, and 227 (42%) had solved the issue without any legal intervention. Only 32 (6%) among the 540 victims of violence sought legal intervention, indicating a gross under reporting of such violent incidents. Out of the 32 individuals who had sought legal intervention, 25 (80%) were not satisfied, indicating a gross inadequacy in the prevailing legal system intended to protect a medical man.

Conclusion :

A medical practitioner is a funambulist balancing his profession on one side and the unmatched hope and expectations of his patients on the other. Our study shows that most medical practitioners face some form of violence at work, which knocks them into the abyss of fear, anxiety, and lack of motivation and forces them into a defensive medical practice. Today, in India, there are laws already in place to protect medical practitioners. In addition, about 23 states and union territories that have implemented stringent laws like the medicare service persons and medicare service institutions (prevention of violence and damage or loss of property) act, 2008.²⁰ Despite all such measures, violent outbreaks are still rampant, thus proving their inadequacy. Another reason for this is the attitude of the soft-skilled Indian medical practitioner. He is unwilling to overcome his guilt, shame, and fear of revenge resulting in the under-reporting of such violent incidents. Hence apart from overhauling existing laws, a medical practitioner, who becomes a victim of violence, must shun his feelings, devote some time, and not shy away from reporting and conquering the situation legally. If these changes don't materialize, horrific instances of violence against doctors will sadly continue to persist.

Conflict of interest : The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

The Pattern of Substance Use and Current Injecting Characteristics among People Who Inject Drugs in New Delhi: A Cross-Sectional Study

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Abstract :

Substance use represents a global health crisis with its devastating consequences. Knowing the type and pattern of drug use, which usually varies across the countries, is indispensable in implementing tailored interventional studies among substance users, particularly people who inject drugs (PWID). We aimed to assess the pattern of substance use among PWID receiving opioid substitution therapy (OST) and to evaluate the characteristics of current injecting practice. This cross-sectional study was conducted between November 2016 to March 2018 among PWID receiving OST at a tertiary care center in New Delhi. A total of 100 PWID satisfying inclusion criteria were included, and the desired information on the pattern of substance use was collected using the interviewer-administered questionnaire method. Alarmingly, about 58% of PWID self-reported a history of injecting drug use in the preceding three months, in the frequency of twice or more than twice a day among them (n=49, 85%), despite current OST. Alcohol (51%) followed by cannabis (28%) were the most common gateway drugs. Overall, the majority of PWID used smack (Heroin) (91%) along with a cocktail of drugs like pheniramine (Avil) (91%) and buprenorphine (81%). Peer pressure (64%) was the leading reason cited for initiation of substance use. Targeted interventional strategies should also be extended to school-going children since most substance users initiate substance use with readily available gateway substances during childhood and adolescents' period. Effective implementation of the existing substance-related laws and rigorous securitization of drug sales is the need of the hour.

Keywords : Substance use; Gateway drugs; Illicit drugs; Opioids; People who inject drugs; Opioid substitution therapy.

Introduction :

Substance use remains a global health crisis, with an estimated 269 million users in 2018. Although cannabis was the most common substance used, opioids resulted in significant morbidity and mortality. In India, a national household survey reported that 2.5% of the population aged 15-74 years used opioids in the past year, and heroin was the most commonly used substance than pharmaceutical opioids.² It also revealed that approximately 0.85 million people who inject drugs (PWID) are present in India.²

The pattern of substance use tends to change across the world, from time to time, due to various factors such as availability, cost, socio-cultural factors, and prevailing laws of the land.³ This change in trends is also evident from the preference of new psychoactive substances and pharmaceutical drugs over conventional illicit drugs such as natural opioids by substance users. Further, polysubstance use is also increasingly common in the recent past among substance users.^{1,3}

The majority of the Indian studies on prevalence and pattern of substance use were conducted either among the general population or among substance users visiting de-addiction centres for substance dependence, for instance, alcohol.^{2,4-10}

However, there is a paucity of data available on the pattern of substance use among PWID, who suffer from significant morbidity, mortality, and medicolegal issues than other substance users.^{11,12} It is also highly relevant to know the pattern of drug use before starting OST because the longer duration and high-frequency usage of opioids before OST are related to poor outcomes after OST.^{13,14} In this backdrop, the present study was carried out to assess the pattern of substance use, reasons behind the initiation, purchase profile, and characteristics of current injecting practice among PWID.

Material and Methods :

This cross-sectional, observational study was conducted between November 2016 and March 2018. All the PWID aged more than 18 years, currently receiving OST, and consented to participate in the study were included. PWID aged more than 18 years but having a mental illness and not consented to participate in the study were excluded. Institutional Ethics committee clearance was obtained before the commencement of the study.

All the PWID were explained in detail about the purpose of the study and informed that their information would be confidential and professional secrecy would be maintained. Written informed consent was obtained from all the participants before starting the interview. The researcher used structured questionnaire to collect self-reported information on the type, duration of substance use, details of ever and current use and their characteristics through face-to-face interviews. For the present study, PWID was defined as "Drug users with a history of injecting heroin or any other form of opioid at least once in the preceding 12 months". "Polysubstance use" was defined as using more than one licit or

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illicit drug in the last 12 months. 'Current injecting practice' is defined as injecting any licit or illicit substance for purposes other than medical indications in the preceding three months.

Statistical Analysis :

The data was entered in MS excel spreadsheet, and analysis was done using statistical package for social sciences (SPSS) for windows version 21.0. Categorical variables were presented in number and percentage (%), and continuous variables were presented as mean \pm SD and range.

Results :

In this study, 100 male PWID were found eligible as per inclusion criteria. The mean age of initiation of substance use was 21.18 years (SD: 7.71, Range 7-55). (Table 1) The mean total duration of illicit drug use was 14.08 years (SD: 8.02, Range: 2-36), and the mean total duration of injecting drug use was 4.13 years (SD: 4.16, Range: 1-25). (Table 1)

Table 1 : Mean Age of Substance Use

Variable	Mean (years)	Standard Deviation (years)	Range (years)
Mean age of initiation of substance use (n=100)	21.18	7.71	7-55
Mean total duration of overall substance use (n=100)	14.08	8.02	02-36
Mean total duration of injecting use (n=100)	4.13	4.16	1-25

The most common substance used for the first time among our study population was alcohol (51%), followed by cannabis (28%). Overall, the most common substance used by our study participants was smack (heroin) (91%) and pheniramine (avil) (91%), followed by buprenorphine (81%), and cannabis (80%).(Table 2)

Table 2 : Pattern of Substance Use

Variable	Subgroups	Total in number	Total in percentage
Gateway Drug	Alcohol	51	51%
	Cannabis	28	28%
Ever used substances by PWID*	Heroin/Smack	91	91%
	Pheniramine (Avil)#	91	91%
	Buprenorphine#	81	81%
	Cannabis	80	80.0%
	Alcoholic beverages	66	66%
	Morphine (I.V)	22	22%
	Diazepam#	12	12%
	Phenergan (I.V)	4	4%
	Buprenorphine (oral)	1	1%
	Diazepam (oral)	1	1%
	Heroin/Smack	91	91%

*Multiple frequency tables, hence total does not correspond to total sample size.

Tablets are grinded and mixed with water/ solution and taken through intravenous route.

A most common reason cited by PWID for initiation of substance use was peer pressure (64%), to gain pleasure (16%), and depression (9%). (Table 3)

Table 3 : Reason behind using drugs, monthly expenditure and sources of procurement

Variable		Total in number	Total in percentage
Reason for starting and continuing the substance*	Peer's influence	64	64%
	Pleasure	16	16%
	Depression	9	9%
	Unemployment	6	6%
	Curiosity	5	5%
	Domestic quarrel	3	3%
	Financial burden	2	2%
	Stress in job	1	1%
Average monthly expenditure (in rupees)	1000-5000	76	76%
	>5000	18	18%
	500-1000	4	4%
	<500	2	2%

Alarming, 96% of PWID procured drugs from open markets, local drug stores or both, and only 3% reported borrowing from friends. Only one PWID reported that the source of substances from the drug syndicate, the details of which were not revealed by the user. Majority of PWID (76%) spent between rupees 1000 to 5000 towards the purchase of drugs, followed by rupees >5000 (18%), and rupees 500 to 1000 (4%) per month (Table 3).

Although under opioid substitution therapy, about 58 % of PWID self-reported the history of injecting drug use in the preceding three months. Smack or heroin was the most commonly injected drug (n=41, 71%), followed by buprenorphine (n=13, 22%). Among current PWID (n=58), the majority of the drugs injected in the frequency of twice or more than twice a day (n=49, 85%) frequency followed by once a day (n=6, 10%) frequency. (Table 4).

Table 4 : Pattern of Current Substance Use

Variable	Subgroups	Total in number	Total in percentage
Injected any substance in the preceding 3 months	Yes	58	58%
	No	42	42%
Substances injected in the preceding 3 months (n=58) *	Smack/Heroin	41	71%
	Buprenorphine	13	22%
	Avil	12	21%
	Diazepam	2	3%
Injecting Frequency (n=58)	≥ 2 /day	49	85%
	Once a day	6	10%
	2-5 times/week	3	5%

*Multiple frequency tables, hence total does not correspond to total sample size.

Discussion :

The present study evaluated the pattern of substance use among PWID receiving OST in a tertiary care centre. The significant findings of this study were as follows: All PWID were polysubstance users, and the mean age at initiation of substance use was 21.18 years. Further, the mean total duration of injecting drug use found to be 4.13 years. Besides heroin, the pharmaceutical drug pheniramine (avil) found to be the most common substance used by PWID. Peer's pressure was identified as the most common reason for initiating and continuing the substance use. Unfortunately, 58% of PWID self-reported having current injecting practices in the preceding three months, despite ongoing OST.

Early substance use is critical due to the development of problematic substance use in the future and elevated negative life consequences, including physical and mental disorders.¹⁵ It is also hypothesized that between 13-21 years of life, a delay of one year to initiate drug use may result in a 4-5% drop in the likelihood of developing lifelong substance use in the future.¹⁶ The mean age of first substance use (21.18 years) among PWID found in the present study corresponds to studies from Chandigarh, India and Maryland, USA.¹⁷ However, studies from Uttar Pradesh and Gujarat⁷ found delayed mean age at initiation of illicit drug use, 28.2 years and 26.9 years respectively.

Gateway drugs are the first substances abused by substance users before ending up using illicit drugs. A nationwide study on substance use among children in India reported that alcohol, tobacco, and inhalants are the primary gateway drugs. Present study revealed that alcohol and cannabis were the most common gateway drugs among PWID. This is most likely due to the easy availability of alcohol in the hands of adolescents despite legal restrictions and the spiritually sanctioned use of cannabis in the country.

Although heroin is the most commonly used opioid in India (1.14%),² followed by pharmaceutical opioids (0.96%) and opium (0.52%), it is also worth noting that polysubstance use is more frequently reported in opioid users.¹⁸ Often, people who are using opioids also use other drugs such as alcohol and benzodiazepines to potentiate the intoxicating effects.¹⁹ This is also evident from our study that found almost all PWID were polysubstance users. In the present study, heroin and pheniramine (avil) were used by the majority of subjects (91%), followed by buprenorphine (81%), cannabis derivatives (80%), and alcoholic beverages (66%). Caution is needed while interpreting the predominance use of heroin among PWID in the present study because the study population included PWID with a history of injecting opioid-related substances to become eligible for OST. Although buprenorphine was used in OST under supervision, many PWID reported injecting buprenorphine by mixing water or other solutions. The results are partially in line with another study from Delhi, which revealed that pheniramine (avil) and buprenorphine was the most commonly used drugs by the PWID, followed by heroin in the last three months. However, Spasmoproxyvon (an opioid drug with dextropropoxyphene, dicyclomine hydrochloride and paracetamol) was documented to

be used by 27% of PWID in their study was not found in our study population.²⁰ Studies from Uttar Pradesh¹¹ and Nepal²¹ identified that most PWID used to inject 'south Asian cocktail', which includes injecting a combination of opioids, benzodiazepines, and antihistamines. Another study from 11 Indian states found that the non-medical use of pharmaceutical opioids, for example, buprenorphine, pentazocine are the most frequently injected substances among PWID, followed by heroin.¹²

Substance use may also arise from a constellation of risk factors as follows: hereditary factors, a person with poor communication skills, academic failure, anti-social behaviour, anxiety, depression, unstable personality, low socio-economic status, peer pressure, recreation, curiosity, better relaxation, euphoria, to improve creativity, to overcome stress, sexual pleasure enhancement, and to aid meditation.²²⁻²⁴ Further, exposure to the drugs and market availability also can influence the initiation and maintenance of substance use.²⁵ In the present study, peer's influence (64%) was the main reason for initiating substance use, followed by pleasure. A similar finding was observed by studies from Mumbai,²⁶ Assam,⁸ and Odisha.²⁷

The source of the drugs is crucial in preventing the supply chain and reducing the prevalence of prescription drug misuse and illicit substance use. Generally, the drugs like pharmaceutical opioids, BZD, and antihistamines are readily procured from the local pharmacies due to unregulated and unchecked sales of these drugs without medical prescription.¹¹ Open market, local drug store or both was the source for most (96%) of the subjects to procure the substances. Similar findings were observed by Bardhan et al⁸ and Jatau et al.²⁸ Although opiates are prohibited for cultivation, possession, and use under the Narcotics and Psychotropic Substances (NDPS) Act, 1985, the menace of trafficking is still at large through every level.²⁹ The availability should be curtailed by strict enforcement of the act, which is the need of the hour. Interestingly, none of PWID reported a source of drug from hidden web (deep web), a sophisticated web system for numerous illegal activities including anonymous purchase of controlled drugs.³⁰ This could be due to various factors such as lack of knowledge, poor socioeconomic status, illiteracy, complexity of the network, and its extreme rarity in the country.

PWIDs are more vulnerable to injection skin site infections, thrombophlebitis, blood borne infections, and overdose due to frequent injection practices. In a systematic review by Colledge S et al., about 68% of PWID inject daily or more frequently.³¹ It is also observed that PWID, who are attending OST, injects less frequently than PWIDs not attending OST.³¹ In the present study, despite ongoing treatment with buprenorphine, about 58% self-reported injecting drug use in the preceding three months. The majority of current PWID (85%) injected twice or more than twice per day, which needs to be highlighted. Knowing the frequency of injection practices will be beneficial to issue an adequate number of needles and syringes under needle syringe programs by government and non-governmental organizations.

Limitations :

Some limitations of the present study are cross-sectional study

design, smaller sample size, selection bias, and recall bias with the self-reported information. Because of the cross-sectional design, no comparisons were made on the pattern of drug use between pre-and post-OST. The larger sample size could have resulted in better generalizations of the results. Further, the predominance of heroin use over other substances is due to the selection bias as the study population comprised the individuals under opioid substitution therapy. Despite these limitations, the present study adds to the growing literature on the pattern of ever and current substance use among PWID receiving OST.

Conclusions :

Knowledge of illicit drug use patterns is paramount for any country, especially developing countries like India, for effective intervention through a multidisciplinary approach. Since early identified drug use as early as seven years in the present study, targeted interventional strategies should also extend to school-going children. Mass awareness and education about the devastating physical and mental complications of substance use should be made among children, adolescents, and young adults. Despite stringent punishment under the NDPS act, illicit drugs are still readily available in the hands of users through open markets and drug stores. Hence, effective implementation of the existing laws and regularising the sale of drugs is the need of the hour. This study also underlines the continuing high frequency of injecting substances by PWID, although undergoing opioid substitution therapy. A large, multicentric study is needed to compare the effectiveness of OST in reducing injecting drug use among PWID.

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Conflict of Interest : The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

Profile of Unnatural Deaths in Adult Females in Bangalore North

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Abstract :

Unnatural death is a death caused by external causes (injury or poisoning) which includes death due to intentional injuries such as homicide or suicide, and death caused by unintentional injury in an accidental manner. The sudden, accidental, unexpected, or traumatic death of a female shatters the lives of the survivors or the family, especially, when their children are young. Such deaths among females remain under-reported globally and studies on this area are scarce. So, this retrospective descriptive study was done to assess the socio-demo graphic profile of deceased adult females, to assess the manner of unnatural deaths, and to suggest measures to prevent unnatural deaths in adult females. A total of 51 cases were studied during the study period. The third decade of life was the most common age group. 88% of females were married and housewives and 62% of deaths occurred within 7 years of marriage. In 84.3% of cases manner of death was suicidal and hanging was the most common method. This study indicates that married, mainly housewives are vulnerable to a spectrum of stress problems leading to unnatural deaths. A change in attitude and mind set of society, judiciary, and most importantly of males who are supposed to be guardians of females, should be sensitized to make the home/workplace a safer and happier place for a female, thereby preventing the number of suicides among them.

Keywords : Unnatural deaths; Female; Suicides; Hanging.

Introduction :

Unnatural death is a death caused by external causes (injury or poisoning) which includes death due to intentional injuries such as homicide or suicide, and death caused by unintentional injury in an accidental manner.¹ Unnatural death whether accidental or suicidal or homicidal has to be subjected to post-mortem examination to rule out foul play.² Women of India know violence. For most of India's history, females have been targeted as unimportant, and burdensome. The women are often subjected to violence from their husbands and from relatives in their natal as well as marital homes. Dowry-related violence occurs among all subgroups of India's population, but the rates are higher among the poor and lower castes. In many cases, the husband and his family continue for years to demand additional dowry by physically and verbally abusing the bride. In the majority of cases, young wives, unable to fulfill their husbands' demands for more dowries, continue to be victimized until they eventually commit suicide. More and more women in this part of the country are now coming out of the safe territory of their homes for education and employment and thus exposing themselves like males to related causes of death, like road traffic accidents and occupational deaths.

Among married females, unnatural deaths are more common in middle and lower-middle socioeconomic groups. Several factors like age, occupation, lack of emotional and financial support,

inability to bear a child, failure in love, and scolding by parents of unmarried girls are the reasons which may influence the unnatural death. Such deaths among females remain under-reported globally and studies on this area are scarce. So this study was taken up to find out the profile of unnatural deaths among adult females. The aims and objectives of the study are to assess the profile of unnatural deaths in adult females and to determine the cause and manner of unnatural deaths viz, suicides, homicides, and accidents.

Materials and Methods :

The present study is a descriptive retrospective study. We collected data from post-mortem records of all cases of unnatural deaths for a period from January 2019 to December 2019. A standardized proforma specially designed for this purpose was used to collect details of each case. Post mortems conducted of unnatural deaths in adult females between the age group 18 to 50 years were included in the study. Negative and obscure autopsies were excluded from the study. Further, a comparative evaluation of data was analyzed.

Ethical Clearance: Prior approval was obtained from the Institutional ethics committee.

Results :

A total of 235 cases were subjected to postmortem examination in one year, out of which 175 (74.46%) deaths were due to unnatural causes. Among 175 unnatural deaths, 51 cases (29.14%) were of adult females between 18 to 50 years of age. Age-wise distribution showed that 18 (35.29%) were in the age group of 21 to 25 years followed by 9 cases (17.64%) were in the age group of 26 to 30 years (Figure 1). 45 cases (88%) of unnatural female deaths were from the married group, out of which 18 cases (40%) occurred within 4 to 7 years of marriage followed by 10 cases (22.2%) within 1 to 3 years of marriage

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(Figure 2). Occupation of the deceased victims showed a maximum number of cases i.e. 45 (88.24%) were housewives followed by 3 cases each (5.88%) were students and working women (Figure 3). Our study showed that in 25 cases (49.02%), the time of incidence was between 12 pm to 6.00 pm which is followed by 10 cases each (19.6%) which occurred between 6 pm to 12 am and 12 am to 6 am i.e. from 6 pm to 6 am (Figure 4). The cause of death was asphyxia in a maximum number of cases i.e. 40 (78.43%), followed by 3 cases (5.89%) each of head injury and hypoxic-ischemic encephalopathy (Figure 5). According to the present study, suicide was the most common manner of death, accounting for 43 cases (84.31%), followed by accidental (9.8%) and homicidal (5.8%) (Figure 6). It was observed that out of 43 suicidal cases, hanging was the most common method adopted by the deceased in 40 cases (93.02%) followed by 2 cases (4.65%) of poisoning. The reason for suicide was dowry harassment in 32

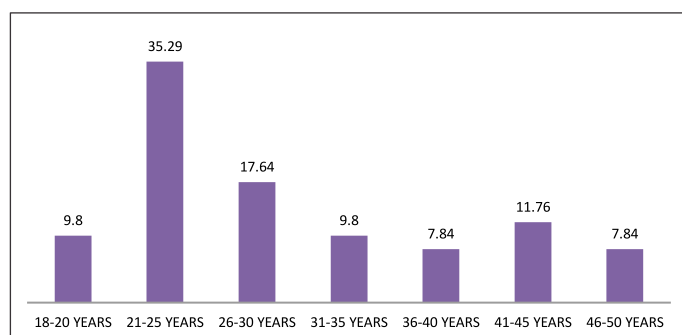


Fig. 1: Age-wise distribution of cases

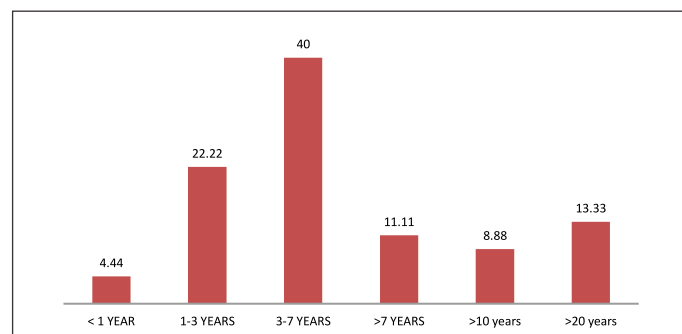


Fig. 2 : Distribution of cases based on the duration of the marriage

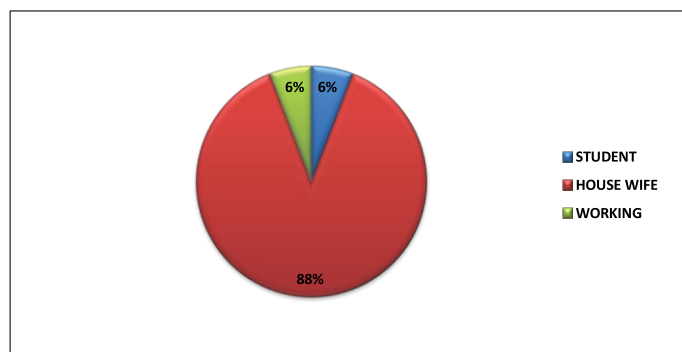


Fig. 3 : Distribution of cases based on the occupation of deceased

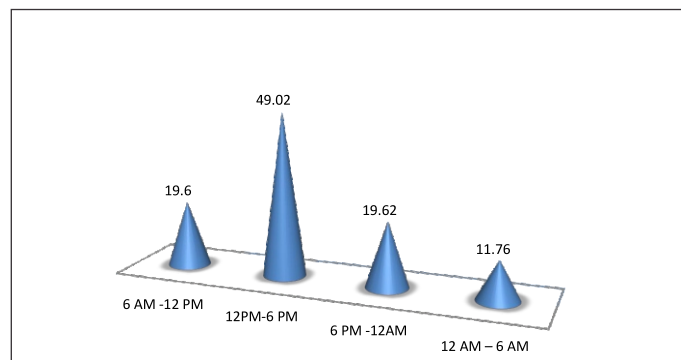


Fig. 4: Distribution of cases based on time of incidence

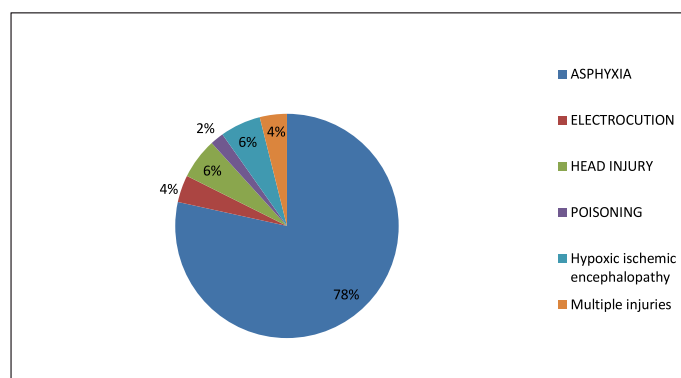


Fig. 5: Distribution of cases based on cause of death

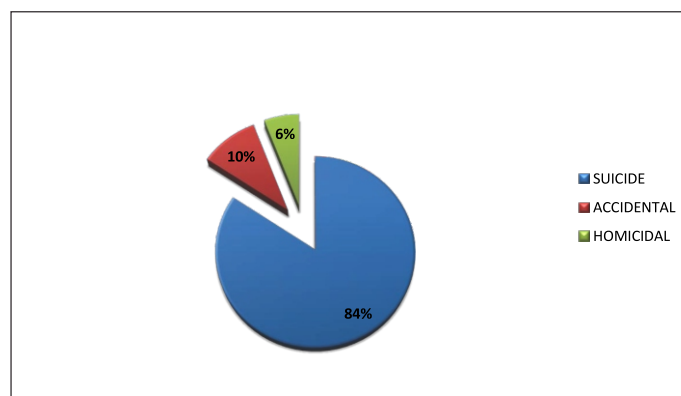


Fig. 6: Distribution of cases based on manner of death

cases (74.41%) followed by 8 cases (18.66%) who committed suicide due to a quarrel with the husband or his family.

Discussion :

The present study is a descriptive study of unnatural deaths of adult females between 18 to 50 years of age, which were autopsied at a tertiary care center for a period of 1 year. A total of 235 cases were brought for post-mortem examination out of which 175 (74.46 %) deaths were due to unnatural causes. Out of 175 unnatural deaths, 51 cases (29.14%) were of adult females between 18 to 50 years of age. This finding of incidence of unnatural female deaths is consistent with studies by Sharma BR

et al.³ and Ananda K⁴ where the incidence observed was 28% and 25% respectively. It was observed that a maximum number of cases i.e. 18 (35.29%) were in the age group of 21 to 25 years followed by 9 cases (17.64%) in the age group of 26 to 30 years. The findings in the present study are consistent with other studies.⁴⁻⁷ The reason is the age of marriage and females will not be mentally mature to tolerate the stress of married life.

According to the present study, most cases i.e., 45 cases (88%) of unnatural female deaths were from the married group, followed by 6 cases (12%) of the unmarried group. Maximum deaths i.e. 18 cases (40%) occurred in 4 to 7 years of marriage which is followed by 10 cases (22.2%) which occurred within 1 to 3 years of marriage. These findings are consistent with other studies where married females constituted maximum unnatural deaths among females.^{4,5,8} The reason for the high incidence of cases within 7 years of marriage is mainly dowry-related deaths and the victim is mentally not mature enough to handle the situation.

In the present study, it was observed that a maximum number of cases i.e., 45 (88.24%) were housewives followed by 3 cases each (5.88%) were students and working women. Other studies⁴⁻⁷ also showed that housewives constituted the maximum bulk of unnatural deaths in females. The possible reasons for the above findings may be that economically dependent women like housewives are more susceptible to domestic violence. It was observed that in the majority of cases i.e. 25 (49.02%), the time of incidence was between 12 pm to 6.00 pm which is followed by 10 cases each (19.6%) which occurred between 6 pm to 12 am and 12 am to 6 am i.e. from 6 pm to 6 am. These findings are consistent with the findings of other studies.^{4,9} The possible reason for the above finding may be that, in the afternoon, as most of them were gone out to work, the victim takes advantage of loneliness in the house.

In this study, it was observed that in a maximum number of cases i.e., 40 (78.43%), the cause of death was asphyxia followed by 3 cases (5.89%) each of head injury and hypoxic-ischemic encephalopathy. The findings are consistent with the study by Ananda K.⁴ These findings are in contrast to other studies 6-8 where burns were the most common cause of death. According to the present study, suicide was the most common manner of death, accounting for 43 cases (84.31%), followed by accidental (9.8%) and homicidal (5.8%). This is consistent with the findings of other studies.^{4,5} However it is, in contrast, to a study by Mohan Kumar TS et al.,¹⁰ where the accidental manner of death was most commonly reported, particularly in road traffic accidents.

In the present study, it was observed that out of 43 suicidal cases, hanging was the most common method adopted by the deceased in 40 cases (93.02%) followed by 2 cases (4.65%) of poisoning. The reason is hanging causes sudden and painless death. The findings are consistent with other studies.^{4,9} However the findings differ from other studies.^{1,5} where poisoning was the most common method of suicide. According to the present study, the reasons for the unhappy life of victims leading to suicide were dowry harassment as the main reason in 32 cases (74.41%) followed by 8 cases (18.66%) committed suicide due to quarrel with the husband or his family. The findings are consistent with

studies by Gunthethi BK⁵ and Sahu G et al.⁹ who reported dowry as the main reason for suicide. The findings differ from the study by Ananda K⁴ who reported depression in life as the main reason for suicide.

Conclusion :

This study indicates that married, mainly housewives are vulnerable to a spectrum of stress problems leading to unnatural deaths, especially in the first seven years of marriage. The study also revealed that intentional deaths mainly suicides are responsible for unnatural deaths of females. These deaths are associated with dowry harassment, and family disputes, highlighting the importance of establishing conveniently available counseling services.

Recommendations :

A change in attitude and mind set of society, judiciary, legislature, and the most important of a male person (husband/father) who is supposed to be the guardian of a woman should be sensitized to make home/workplace a safer and happier place for a woman and can prevent a number of suicides among adult females. The laws against dowry should also be made more stringent and proper education for parents should be done to prevent dowry-related issues. As most of the victims are young dependent housewives, they can be engaged in some recreational activities to prevent depression and unnatural fatalities among them.

Funding : Nil

Conflicts of Interest : None

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ORIGINAL ARTICLE

An Autopsy Study of the Pattern of Unnatural Deaths among Youth at a Tertiary care Teaching Hospital in South India

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Abstract :

Mortality among youth owing to unnatural causes is on the rise. Hence, the present study was undertaken to estimate the number of such deaths, and assess the manner of death and the commonest cause of death. A total of 255 cases of unnatural deaths among youth aged between 15 and 29 years, autopsied at a tertiary care teaching hospital in South India were studied for a duration of 18 months from November 2015 to April 2017. Unnatural deaths among youth constituted 25.91%, 1/4th of all medico-legal autopsies. Males outnumbered females. Most of the victims were 24 to 26 years old male and 21 to 23 years old female. Most of the victims were Hindu. Socio-economically, most of the victims belonged to the middle class. Most of them were urban residents belonging to nuclear families. The majority of the victims were secondary school students. Most of the unnatural deaths were suicides; with victims aged 27 to 29 years. Hanging was the most commonly preferred method of committing suicide. The commonest reason was ill-health. Road traffic accidents claimed 43 lives, victims were mostly 24 to 26 years old and died due to head injury. Homicides accounted for 5.49% of unnatural deaths. Most of the homicidal deaths were due to injuries inflicted by sharp weapons, consequently, the majority of victims succumbed to shock and hemorrhage due to multiple injuries.

Keywords : Youth; Attempted suicide; Head injury; Traffic accidents; Homicides; Autopsies.

Introduction :

Unnatural deaths are tragic incidents whether they are suicidal, homicidal or accidental. If death occurs exclusively by injury or is hastened due to injury in a person suffering from a natural disease, the manner of death is unnatural or violent. Violence may be suicidal, homicidal, accidental, or of undetermined or unexplained origin.¹

Youth is defined as the time of life between childhood and maturity.² The United Nations defines 'youth' as persons between the ages of 15 and 24.³ According to the Government of India, the youth age-group is defined as 15 to 29 years. Youth in this age group comprises 27.5% of the population and 34% of India's Gross National Income is contributed by them.⁴

Road traffic injuries are the leading cause of death among 10-24-year-olds. Approximately, 1000 children and young adults under the age of 25 years are killed in road traffic crashes every day.⁵ Suicide rate in India is among the highest in the world. At ages 15-29 years, suicide is the second leading cause of death in both sexes.⁶ Worldwide, homicide is the fourth leading cause of death in people aged 10-29 years.⁷

According to a United Nations report, India has the largest youth population in the world, with 356 million 10-24-year-olds.⁸ Bangalore, the capital of Karnataka with a population of

over 12.3 million, is a culturally diverse city with a dynamic youth population and has high suicide and crime rates. As per newspaper reports in 2014, it records the second-highest suicide rate in the country and the city is a motorist's nightmare, as the city has seen the highest number of deaths due to dangerous and reckless driving in the country. The City Crime Records Bureau statistics reported a total of 187 murders in the city in the year 2015.

This study aims to understand the patterns of unnatural deaths among youth in the age group of 15 to 29 years, the socio-demographic characteristics of the study group, and the underlying reasons.

Material and Methods :

The present prospective study was conducted for a duration of 18 months, from 1st November 2015 to 30th April 2017. The data for the study was collected from autopsies of unnatural deaths among youth in the age group of 15 to 29 years. In cases of hospital admission, all possible relevant information was obtained from hospital medical records. In cases of poisoning or suspected alcohol consumption or drug overdose, the routine viscera and blood were subjected to chemical analysis to determine the cause of death. Postmortem examination was carried out as per the standard procedure mentioned in "Autopsy Diagnosis and Technique" by Otto Saphir.⁴³

Inclusion criteria :

All cases of unnatural deaths among youth in the age group of 15 to 29 years were autopsied in the hospital in which this study was conducted.

Exclusion criteria :

1. Decomposed, unknown or unclaimed bodies.

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2. Cases with ambiguous history or incomplete data.

3. Cases with an alleged history of unnatural deaths but which later turned out to be natural deaths based on autopsy, laboratory investigations, circumstantial evidence, and investigation by the police.

Ethical clearance :

The study protocol was carried out after obtaining ethical clearance from the Institutional Ethics Committee.

Results :

During the study period, a total of 255 autopsies of unnatural deaths among youth belonging to 15 to 29 years of age were conducted.

The majority of the victims were male 165 (64.70%), 89(34.90%)

Table 1: Gender-wise distribution of victims of unnatural deaths among youth

Gender	Number of cases	Percentage
Male	165	64.70
Female	89	34.90
Transgender	1	0.40
Total	255	100

were female and 1 (0.40%) was transgender. (Table 1).

Mainly they were in the age group of 24 to 26 years (n=65,

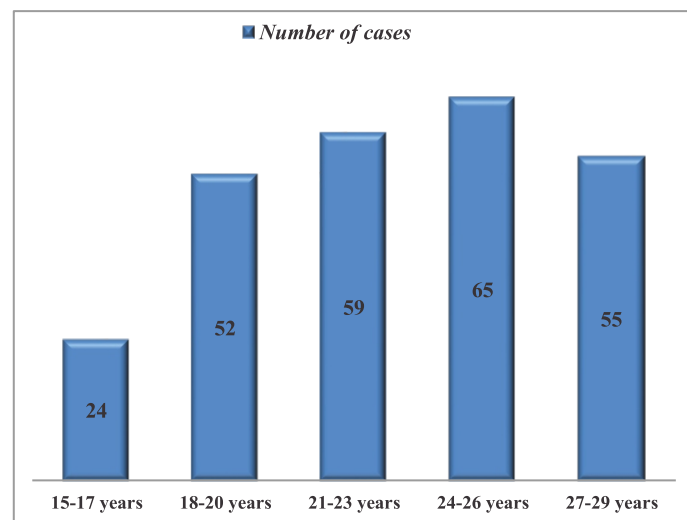


Fig. 1: Age-wise distribution of victims of unnatural deaths among youth

25.50%). The least number of cases were in the age group of 15 to 17 years (n=24, 9.40%) (Figure 1).

Majority were hindus (n=234, 91.76%), followed by muslims (n=17, 6.67%) and the least were christians (n=4, 1.57%).

The student, housewife, and daily wage worker group combined accounted for the majority of victims (n=151, 59.22%). The least number of victims (n=10, 3.92%) were drivers by occupation.

Table 2 : Distribution of victims of unnatural deaths among youth based on their educational qualification

Educational Qualification	Number of cases	Percentage
Illiterate	21	8.24
Primary School	43	16.86
Secondary School	67	26.27
Pre-University College	54	21.18
Diploma	11	4.30
Degree	58	22.75
Post-graduation	1	0.40
Total	255	100

Majority were secondary school students (n=67, 26.27%), followed by degree holders (n=58, 22.75%). 1 victim (0.40%) was a postgraduate. (Table 2).

Most of the victims were urban residents (n=195, 76.47%), rest were rural residents (n=60, 23.53%). The majority of them were unmarried (n=164, 64.31%), followed by married victims (n=86, 33.73). On correlating the gender with marital status, it was found that the highest number of male victims were unmarried (n=128) whereas female victims were married (n=51).

Socio-economically, most victims belonged to the lower middle class (n=59, 23.14%), closely followed by upper middle class (n=58, 22.75%), upper class (n=47, 18.43%), lower class (n=46, 18.03%) and upper lower class (n=45, 17.65%).

Majority were suicides (n=171, 67.06%), followed by accidents (n=70, 27.45%) and homicides (n=14, 5.49%). Suicides claimed

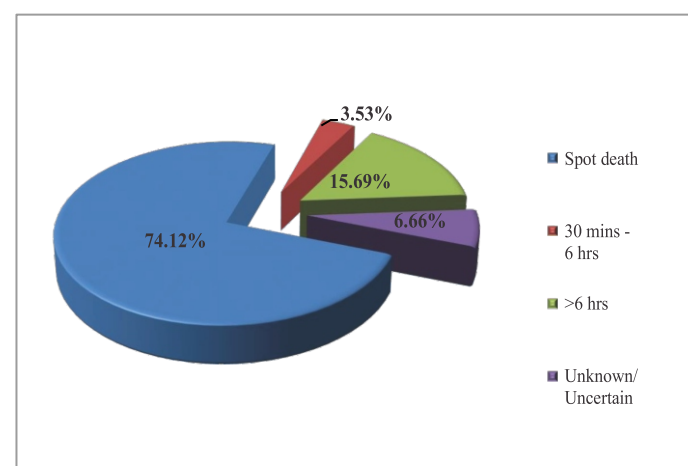


Fig. 2 : Distribution of victims of unnatural deaths among youth based on survival period

the lives of 89 males and 82 females followed by Accidents (63 males, 6 females, and 1 transgender). Homicides accounted for 13 male victims and 1 female victim.

The commonest method of committing suicide was Hanging (n=151, 88.31%), followed by Poisoning (n=16, 9.36%). Most of

them were in the age group of 27 to 29 years (n=43, 25.15%), and the least number were in the age group of 15 to 17 years (n=21, 12.28%). On correlating the gender with age, among males, the majority committed suicide in the age group of 27 to 29 years (n=26), whereas the majority of female suicides were in the age group of 21 to 23 years (n=22). The least number of suicide

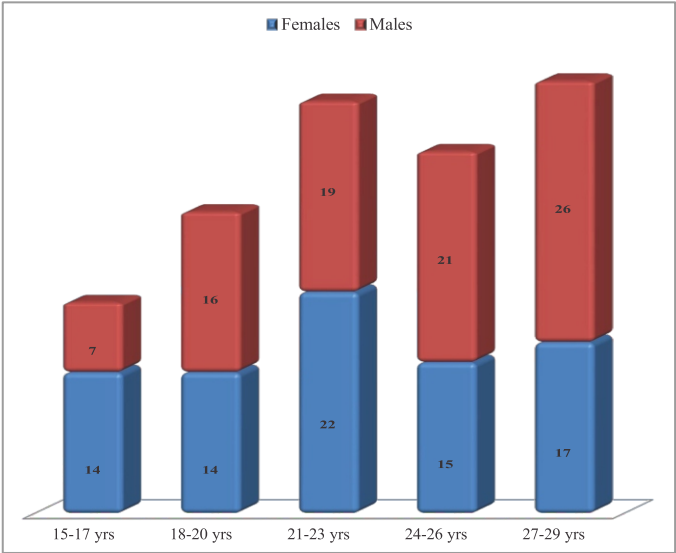


Fig. 3 : Co-relation of age and sex in suicides among youth

victims in both sexes was in the age group of 15 to 17 years (7 males and 14 females). (Figure 3) 28 (16.37%) suicide victims had attempted suicide before, whereas the maximum number, 143 (83.63%) completed suicide in the first attempt.

The commonest reason for committing suicide among youth was ill-health which included physical ailments such as dysmenorrhea, chronic chest pain, chronic renal failure, epilepsy,

Table 3: Distribution of suicides among youth depending upon the reason for committing suicide

Reason for committing suicide	Total	Percentage
Ill-health	34	19.89
Financial trouble	29	16.96
Trivial quarrel with family member, friend or relative	19	11.11
Marital discord	18	10.54
Unknown	14	8.19
Physical and/ or mental abuse by husband and/ or In-laws demanding dowry	13	7.60
Stress/ Anxiety regarding academics	11	6.43
Love failure	10	5.85
Failure in Examination	9	5.26
Death of family member	6	3.50
Harassment/ Eve-teasing	5	2.92
Separation/ Divorce	3	1.76
Total	171	100

and psychiatric illnesses such as depression (n=34, 19.89%) followed by financial trouble (n=29, 16.96%). The least number of suicides was due to separation/divorce (n=3, 1.76%) (Table 3).

Asphyxia as a result of hanging was the cause of death in 150 (87.72%) suicides. The most common poison used to commit suicide was Aluminum Phosphide (n=9, 5.28%) followed by Organophosphorus (n=3, 1.77%). 1 victim (0.58%) died due to shock and haemorrhage as a result of a self-inflicted stab injury.

In accidental deaths among youth, the majority (n=43, 61.43%) were due to road traffic accidents followed by fall from height (n=9, 12.85%). Accidental poisoning due to Carbon Monoxide inhalation owing to a malfunctioning gas geyser in an ill-ventilated bathroom claimed 1 life (1.43%) and accidental suffocation due to obstruction of respiratory passages by sand particles, under which the victim got rapidly buried, owing to a malfunctioning latch which the victim was trying to open while unloading a lorry filled with the sand particles, caused 1 death (1.43%).

Head Injury was the leading cause of death in victims of fatal accidents among youth (n=36, 51.43%), sustained as a result of road traffic accidents in 27 cases, fall from height in 7 cases, and fall of a heavy object over the victim in 2 cases. The second leading cause of death was multiple injuries (n=16, 22.86%), sustained as a result of RTA in 13 cases, fall from height in 2 cases, and fall of a heavy object over a victim in 1 case.

In the present study, the majority of homicide victims succumbed to injuries caused due to sharp force trauma (n=8, 57.14%) followed by blunt force trauma (n=4, 28.58%). 1 victim (7.14%) died due to ligature strangulation and another due to the combined effect of throttling and smothering (n=1, 7.14%).

The maximum number of victims of homicides (n=6, 42.86%) died due to shock and haemorrhage as a result of multiple injuries sustained such as stab wounds, chop wounds, and incised wounds which had been inflicted by sharp weapons. 4 victims (28.58%) succumbed to head injury which had been caused by blunt weapons. 2 victims (14.28%) died due to asphyxia - as a result of ligature strangulation in one case and due to combined effect of throttling and smothering in another. 1 victim (7.14%) died due to septicemia consequent upon the injuries sustained due to sharp weapons and 1 victim succumbed to other complications due to prolonged hospital stay following injuries sustained due to sharp weapons.

Discussion :

In the present study, the male preponderance of 1.85:1:0.01 was observed wherein males accounted for 165 (64.70%) cases, whereas females accounted for 89 (34.90%) cases and transgender accounted for 1 (0.40%) case. These findings are consistent with those of Sharma BR et al,⁹ who reported a male predominance, the male : female ratio being 2.2:1. Similar findings were reported by Vaghela P et al¹⁰ and Wasnik RN.¹¹ In this study, most cases were in the age group 21 to 29 years (n=179, 70.2%). Sharma BR et al,⁹ Vaghela P et al,¹⁰ Wasnik RN,¹¹ Vaghela P,¹² Kumar A,¹³ Bansude ME et al¹⁴ and Meena PR et al,¹⁶ reported similar findings in their studies. However, contradictory findings

were reported by Dake MD et al,¹⁹ wherein the maximum number of unnatural deaths was observed in the age group of 31 to 40 years. In the present study, the maximum number of victims were living in the urban area (n=195, 76.47%) followed by the rural area (n=60, 23.53%). The findings of the present study are similar to those of Wasnik RN,¹¹ wherein incidence was higher in the urban population (61.50%) as compared to the rural population (38.50%). Similar findings were reported by Rathod SN et al¹⁷ and Malik R et al.²⁰ The findings of the present study are in contrast with those of Vaghela P et al,¹⁰ Kumar A,¹³ Kaul A et al¹⁵ and others.^{16,18,19 & 22} In the present study, the majority of the victims of unnatural deaths among youth were unmarried (n=164, 64.31%), followed by married victims (n=86, 33.73). The findings of the present study contradict those of Kumar A,¹³ Bansude ME et al,¹⁴ Kaul A et al,¹⁵ Dake MD et al¹⁹ and Sharma BR et al.²⁶ In the present study, the majority of unnatural deaths were suicides (n=171, 67.06%), followed by accidents (n=70, 27.45%) and lastly homicides (n=14, 5.49%). The findings of the present study differ from those of various studies,^{9,11,16,17,19,20} all of which reported the majority of unnatural deaths in their respective studies as accidents, followed by suicides and homicides. Khalil ZN et al,²¹ observed in their study that the most common manner of unnatural death was homicide (n=2856, 87.5%), followed by accidents (n=317, 9.7%), and the least common was suicide (n=66, 2.02%). In the present study, the most preferred method for committing suicide was Hanging (n=151, 88.31%), followed by Poisoning (n=16, 9.36%). Similar findings were observed by Lalwani S et al²⁵ and others.^{29, 39} The present study differs in its findings from various studies^{6, 27, 28} all of which observed that the most common method was poisoning, followed by hanging, burns, and drowning. In the present study, it was observed that most of the suicides among youth occurred in the age group of 27 to 29 years (n=43, 25.15%). The findings in the present study differ from those of Sharma BR et al²⁶ in which the maximum number of cases belonged to the age group of 21-25 years 442 (31%). In the present study, it was observed that the commonest reason for committing suicide among youth, irrespective of gender, was ill-health which included physical ailments such as dysmenorrhea, chronic abdominal pain, chronic chest pain, chronic renal failure, epilepsy, and psychiatric illnesses such as depression (n=34, 19.89%) followed by financial trouble (n=29, 16.96%), trivial quarrels with a family member, friend or relative (n=19, 11.11%), marital discord (n=18, 10.54%). The reason for committing suicide was unknown in 14 cases (8.19%) whereas 13 suicides (7.60%) were due to alleged abuse by husband and/or in-laws demanding dowry. Stress or anxiety regarding academics claimed 11 lives (6.43%), love failure (n=10, 5.85%), failure in examination (n=9, 5.26%), death of family member (n=6, 3.50%), harassment/eve-teasing (n=5, 2.92%) and least number of suicides were due to separation/divorce (n=3, 1.76%). The findings of the present study differ from those of Sharma BR et al²⁶ where in social difficulties accounted for 35%, followed by the reasons like guilt and shame in 27%, recent loss due to death of the loved person in 14%, fear in 7%, pain in 5%, altruism in 2%, hereditary factors in 1% and psychosocial factors in 2% while substance abuse was found in 7% of the cases. In this study,

among cases of poisoning, the most common poison that was consumed to commit suicide was Aluminium Phosphide (n=9, 5.28%) followed by Organophosphorus compounds (n=3, 1.77%). Similarly, Lalwani S et al,²⁵ in their study, reported that poisoning with Aluminium Phosphide (Celphos) was the most common (n=91, 30.1%) followed by Organophosphorus compounds (n=34, 11.2%). Sharma BR et al²⁶ also observed similar findings in their study. In the present study, it was observed that the majority of the accidental deaths occurred due to Road Traffic Accidents (n=43, 61.43) followed by fall from height (n=9, 12.85%), drowning and electrocution (n=5, 7.14%) each and burns (n=3, 4.29%). Similar results were observed in various studies,^{14,16,18,20,21} all of which reported the maximum number of cases of accidental deaths due to RTA. In the present study, head injury was the leading cause of death among victims of fatal accidents (n=36, 51.43%) followed by multiple injuries (n=16, 22.86%), drowning (n=5, 7.14%), electrocution (n=5, 7.14%), burns (n=3, 4.29%) and blunt injury sustained to chest (n=3, 4.29%). Similar findings were observed in studies conducted by Vaghela P et al¹⁰ and Patel JB et al.²³ Several studies on road traffic accidents^{31, 33, 43} also reported similar findings wherein head injury was the commonest cause of death. The findings of this study differ from those of the study conducted by Vaghela P¹² in which the majority of deaths were due to burns followed by head injury and regional injuries. In this study, the largest number of victims of fatal road traffic accidents were in the age group of 21 to 29 years (n=33, 76.74%). These findings are in concordance with those of Singh YN et al³¹ and Shruthi P. et al³³ but dissimilar to those of Surender J,⁴¹ who reported that the largest magnitude of deaths in the study population was in 31 to 40 years age group 88 (29.6%). In the present study, the majority of homicide victims succumbed to injuries caused due to sharp force trauma (n=8, 57.14%) followed by blunt force trauma (n=4, 28.58%), and 1 victim (7.14%) was killed by ligature strangulation. The findings of the present study are similar to those of two studies,^{38,42} both of which reported that sharp-cutting weapons were used to kill the majority of the victims in their respective study populations. In both the studies, the least number of victims were killed due to ligature strangulation. However, different findings were observed by Rathod SN³⁶ and Rastogi AK,³⁷ where hard & blunt object was used in the majority of homicides followed by sharp cutting weapons. In the present study, the majority of the homicide victims were in the age group of 21 to 29 years (n=9, 71.42%). The findings of the present study are unanimous with various other studies on homicidal deaths,^{19,34,35,38,42} all of which observed 21 to 30 years as the commonest age group among victims of homicides.

Conclusion :

Unnatural deaths among youth aged 15 to 29 years constituted 25.91%, that is, 1/4th of all medico-legal autopsies conducted at our hospital in the time span of 18 months. Males outnumbered females. Most of the victims belonged to the age group of 21 to 29 years, more specifically in the age group of 24 to 26 years, which accounted for 1/4th of all unnatural deaths among youth (25.50%). The majority of the victims were Hindus. A maximum number of

unnatural deaths occurred in the student population out of which most of the victims were secondary school students.

The majority of the victims were urban residents. Most of the male victims were unmarried whereas most of the female victims were married. Socio-economically, the middle class accounted for the maximum number of victims. Suicide emerged as the leading cause of unnatural deaths among youth (67.06%) followed by fatal accidents (27.45%).

The maximum number of youth committed suicide between 12 noon and 6 in the evening, whereas the maximum fatal accidents among youth occurred between 6 in the evening and midnight. Most of the victims of homicides were killed between 6 in the early morning and 12 noon. The maximum number of victims, in all manners of death, were either found dead or died on the spot with the least number of victims surviving for less than 6 hours.

The most preferred method of committing suicide among youth was hanging (88.31%) followed by poisoning (9.36%) in which, more than half the victims (56.25%) consumed Aluminium Phosphide. The majority of suicide victims were aged between 27 and 29 years. Most of the victims (83.63%) had never attempted suicide previously and a minority of victims (4.10%) left behind farewell notes.

The majority of the male victims of accidental deaths among youth died as a result of road traffic accidents (61.43%). Female victims of fatal accidents among youth were equally prone to road traffic accidents and burns. The leading cause of death among all accidental deaths was head injury followed by multiple injuries. The single transgender victim in this study died as a result of accidental burns.

The majority of the homicide victims were males and they were aged between 27 and 29 years. More than half of the victims of homicides (57.14%) in this study were killed using sharp weapons. Consequently, the majority of the homicide victims died of shock and haemorrhage resulting from a combination of stab, chop, and incised wounds.

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ORIGINAL ARTICLE

Sex Determination using Computed Tomography of the Last Thoracic Vertebrae in Indian (Bengali) Population

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Abstract :

Identification of skeletal remains has been challenging for forensic anthropologists, especially during disasters. 92 subjects, comprising 59 males and 33 females in the age bracket of 10 and 88, were scanned using a CT scan in the Indian Bengali population. Wilk's lambda for the model is 0.621 which signifies a good discriminating power of the model. The discriminant function equation (table 4) is, $Df = 0.350 \times EPWu - 0.039 \times EPWI + 0.045 \times SPL + 0.147 \times SPH - 11.357$. Overall 75% of the sample was correctly classified into their group by this model. This study showed a significant difference in measurements of the last thoracic vertebrae for sex discrimination, so this can suggest that the last thoracic vertebra is a useful tool for sex identification, especially in cases of mass disaster where other bones may have been destroyed as an adjunct to other sex identifying tools in crime or death scene for Indian (Bengali) population

Keywords : Forensic; Thoracic vertebrae; CT scan; Sex Determination.

Introduction :

Identification of skeletal remains has been challenging for forensic anthropologists, especially during disaster.¹ Also, in various populations, like India, discrimination of age is very important because, in various medicolegal problems like sex offenses, and heinous crimes, it is essential to establish the correct age. Sex determination methods are based on anthropometric characteristics that are population-specific, because traits that are sexually dimorphic in one population may be less dimorphic in another population. The growth rate is diverse for different ethnic groups and it is essential to develop methods for sex identification using a wide range of skeletal remains in different populations^{2,3}

Anthropometric studies were conducted using traditional methods and by studying the bones of the dead. However, with the advent of radiological modalities like CT scan and MRI, high-quality images can be obtained to get better results. With the increased usage of CT scan for clinical purposes, it is also used to collect data for estimation of biological profiles.⁴

Previous studies showed sexual dimorphism of cervical, thoracic and lumbar vertebrae of the spinal column.^{5,6} The last thoracic vertebra (T12) is easily identifiable due to its unique morphology⁷ and can be used for anthropometric studies. Amongst other vertebrae, the accuracy of T12 is highest.⁸ However, only a few studies have tested the role of the 12th thoracic vertebra (T12) in sex identification using a CT scan.

In this study, we have attempted to assess sexual dimorphism

from the 12th thoracic vertebra from CT scan images and obtain a discriminant function equation for sex determination in Eastern Indian (Bengali) population.

Materials and Methods :

Multi detector Computed Tomography images were taken from 92 subjects, 59 were males and 33 were females, between the age group of 10 and 88 years. These cases were randomly selected from the general population who came for an HRCT Scan of the abdomen for various medical conditions and informed consent was obtained from them and parents/next of kin in case of minors, before participation in this study. Ethical clearance was taken from the ethics committee of Calcutta National Medical College. No additional radiation exposure was given to the study subjects. Patients showing congenital, pathological, or traumatic lesions of the vertebra were excluded.

The CT scan was performed on 16 slice Alexion Machine (Toshiba, Japan) at the CT scan center, Calcutta National Medical College. Routine thoracic CT protocol was followed. All scans were obtained with the following parameters: tube voltage 120 kV, effective mA 120, and slice thickness 1mm. The images were transferred to a commercially available workstation. On the workstation, multiplane reformatting (MPR) of images in the sagittal and coronal planes was obtained using commercially available software (Radi Ant DICOM Viewer).

The following measurements⁹ (Fig. 1) were taken for this study:

Upper-end plate width (EPWu)

Lower end plate width (EPWI)

Spinal process length (SPL)

Spinal process height (SPH)

The results were statistically analyzed using Statistical Package for Social Sciences (SPSS, version 25). Results were expressed in the form of maximum & minimum values, mean, standard deviation, chi-square test, discriminant function, and logistic

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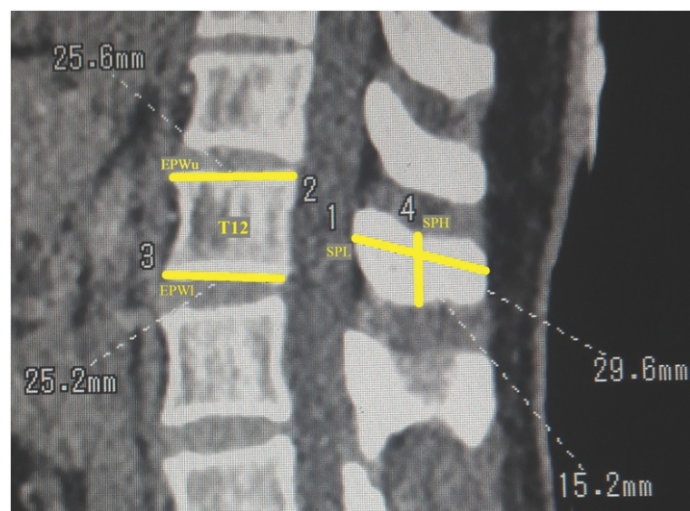


Figure. Measurements are taken from the 12th thoracic vertebra (Sagittal Plane) showing upper-end plate width (EPWu), Lower end plate width (EPWI), Spinal process length (SPL), and Spinal process height (SPH)

regression analysis.

Results :

A total of 92 patients who came to the diagnosis center for doing CT scans of the abdomen were included in this study. Of these 92 patients, 59 were males and 33 were females. The males were in the age bracket of 14 to 88 years (mean age of 43.31 years) and the females were in the age bracket of 10 to 75 years (mean age of 40.18 years) as shown in table 1. The mean values, maximum, minimum, and standard deviation values of the vertebra

Table 1: Descriptive Statistics of Age of Study Population

	N	Minimum	Maximum	Mean	Std. Deviation
Male: Age	59	14.00	88.00	43.3051	17.99066
Female: Age	33	10.00	75.00	40.1818	16.79928

Table 2: Comparison of Measurements (in mm) according to sex

Sex		EPWu	EPWI	SPL	SPH
Male	Mean	27.7847	28.4598	24.0542	15.2068
	N	59	59	59	59
	Std. Deviation	2.40393	4.31959	3.81789	2.46792
	Minimum	22.20	3.03	15.40	10.40
	Maximum	32.60	35.20	39.40	22.70
Female	Mean	24.3485	25.5424	21.2424	12.8058
	N	33	33	33	33
	Std. Deviation	2.58978	2.99656	4.11803	3.33126
	Minimum	19.00	19.50	14.10	1.09
	Maximum	31.40	35.70	32.80	17.90
Total	Mean	26.5522	27.4134	23.0457	14.3455
	N	92	92	92	92
	Std. Deviation	2.96442	4.12668	4.13430	3.02076
	Minimum	19.0	03.03	14.10	1.09
	Maximum	32.60	35.70	39.40	22.70

measurements (in millimeters) are compared between males and females (Table 2).

A discriminant function was performed on the data entering all the variables together with sex as the grouping variable. Wilk's lambda for the model is 0.621 which signifies a good

Table 3: Power of study determined by Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	Df	Sig.
1	0.634	40.097	4	0.000

Table 4: Coefficients contributing to the differentiation of sex

	Function
	1
EPWu	0.350
EPWI	-0.039
SPL	0.045
SPH	0.147
(Constant)	-11.357
Unstandardized coefficients	

Table 5 : Cut-off values for determination of sex

Sex	Function
	1
Male	0.562
Female	-1.005
Unstandardized canonical discriminant functions evaluated at group means	

Table 6 : Predictive classification of sex

		Sex	Predicted Group Membership		Total
			Male	Female	
Original ^a	Count	Male	44	15	59
		Female	8	25	33
	%	Male	74.6	25.4	100.0
		Female	24.2	75.8	100.0
Cross-validated ^b	Count	Male	44	15	59
		Female	11	22	33
	%	Male	74.6	25.4	100.0
		Female	33.3	66.7	100.0
a. 75.0% of original grouped cases were correctly classified.					
b. 71.7% of cross-validated grouped cases were correctly classified.					

discriminating power of the model (Table 3). The discriminant function equation (table 4) is, $Df = 0.350 \times EPWu - 0.039 \times EPWI + 0.045 \times SPL + 0.147 \times SPH - 11.357$. The cutoff point is $\{0.562 - (-1.005)\} / 2 = 1.567 / 2 = 0.7835$ as shown in table 5. So, above this value 0.7835, the cases are male. Below this value of 0.7835, the cases are female. Overall 75% of the sample was correctly

classified into their group by this model as shown in table 6. At the individual group level, 75.8% of females and 74.6% of males were correctly classified. Cross-validated results showed that 71.7% of the cases were correctly classified by this model. After the results were used to get a discriminant equation, the formula was used on a separate sample of 20 cases to validate the results.

Measurements	Constant	Coefficient	Cut-off Value	Accuracy
EPWu	-10.743	0.405	0.6955	75%
EPWI	-7.027	0.256	0.374	75%
SPL	-5.868	0.255	0.358	60.9%
SPH	-5.113	0.356	0.428	59.8%

Discriminant Function = (Measurement × Coefficient) + Constant

If discriminant score \geq cut-off value = male

If discriminant score \leq cut-off value = female

We also performed univariate discriminant function analysis only on dimensions of piriform aperture (shown in Table 7).

When we performed the linear equation function none of the variables showed any significant correlation with age (Male R square = 0.097; Female R square = 0.347). So, age could not be predicted with accuracy from this preliminary study.

Discussions :

Sexual dimorphic features of a skeleton are of fundamental importance while constructing the biological profile of unidentified skeleton remains. Often in actual forensic practice, we get fragmented bones attempts have been made to develop various equations for sex determination. MSCT represents one of the greatest breakthroughs in CT technologies. It has transformed a trans axial cross-sectional CT into a true 3D musculoskeletal imaging. Traits that are sexually dimorphic in own population may be much less in another. This variation within and between population makes it necessary to reevaluate the diagnostic value each time population is studied. To the best of our knowledge, there is no published literature on sex determination from anthropometric measurements from the 12th thoracic vertebra in the Indian population using multislice CT. In the present study, the overall mean value collected from the vertebra of males is greater than females which indicates that there is a presence of sexual dimorphism. In the present study by use of discriminant function analysis, we have seen that all four measurements have contributed to discrimination between two sexes. The degree of accuracy by which the results are classified as 75% of original group cases. 71.7% were cross-validated cases which is similar to the findings of Bard El Dine et al¹⁰ (2015). The relations between results of different researches of different populations confirmed the existence of population-specific differences exhibited in the vertebra. Many factors suggest genetic, racial, nutritional disease, socioeconomic status, and physical activity may alter the degree of sexual dimorphism. In the study conducted by Zheng et al,¹¹ on the Chinese population the predicted accuracy is more than 80%. This is in variation to our study which may be explained by the different sample sizes. In the Egyptian population, the level of accuracy obtained from thoracic vertebra is 93.1% which is higher because of the difference in sample size. It may be thus

concluded that sexual dimorphism is present in different regions of the vertebral column. The accuracy might vary in population and it cannot be used alone in forensic casework for sex estimation. However, it may be used as a useful predictor in sex determination problems in conjunction with other bones. Accurate and reliable modern imaging techniques such as MSCT can in the future pioneer future post-mortem investigation.

In the previous study¹⁰ on Egyptians conducted by Badr El Dine and El Shafei, most of the T12 measurements were sexually dimorphic using Multi Sliced computer Tomography (MSCT) with an accuracy of 93.1%. Hou et al¹² also reported sexual dimorphism of all measurements of T12 in the Chinese population with an accuracy rate of 94.2% using MSCT. Yu et al¹³ reported a statistically significant difference between males and females in most measurements taken from T12 MSCT of Korean samples with an accuracy rate of 90%. Our study has shown an accuracy rate of 75% which is less than that of the previous studies. In previous multicentre studies, a large sample size could predict the model with more accuracy, compared to our study which was conducted on a small population. The current study showed no significant positive correlation of all the measurements with age which is similar to the study done by Ramadan et al on Egyptians. Previous studies like Amores et al¹⁴ done in the Spanish population showed an accuracy of prediction of 80.2% and a study done on Greeks by Gambaro¹⁵ showed an accuracy rate of 79%. These studies were however conducted on the real bone rather than the CT image of the bone.

This study showed a significant difference in measurements of the last thoracic vertebrae for sex discrimination. The percentage accuracy of EPWu, EPWI, SPL, and SPH are 75%, 75%, 60.9%, and 59.8% respectively, while combining all these parameters the accuracy is 75%. So this can suggest that a last thoracic vertebra is a useful tool for sex identification, especially in cases of mass disaster where other bones may have been destroyed as an adjunct to other sex identifying tools in crime or death scenes for the Indian (Bengali) population.

Abbreviations :

CT Scan = Computed Tomography Scan

HRCT = High-Resolution Computed Tomography

MSCT = Multislice Computed Tomography

SPSS = Statistical Package for Social Sciences

Df = Discriminant Function

3D = 3 Dimension

EPWu = Upper End Plate Width

EPWI = Lower End Plate Width

SPL = Spinal Process Length

SPH = Spinal Process Height

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ORIGINAL ARTICLE

Dead Bodies – A Potential Source of Infection for COVID –19

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Abstract :

The recent Covid-19 pandemic has raised a lot of questions regarding the mode of transmission of the virus. The rapid spread across the globe has compelled researchers to focus on this issue. Theories claiming droplet transmission, fomites as well as airborne transmission have cropped up. The primary concern for the autopsy surgeons is whether the dead bodies harbor the virus and if so for how long. The present study was undertaken to find out the possibility of the virus being isolated from the human cadavers by testing at specified intervals after death. Out of the 74 cases examined, 59.5% of cases tested positive 1 day after death and 20.5% were still positive 5 days after death. The difference between males and females was not significant. The age of the subjects in our study ranged from 20 days to 90 years. The results of the study clearly indicate that the virus persists in the human cadavers for a sufficient period of time to act as a potential source of infection. Adequate precautionary measures while packing the body and autopsy examination are of utmost essential to prevent the spread of the disease among the dead body handlers and the family members while performing the last rites

Keywords : Post-mortem; Nasal swab; Covid19; Dead body.

Introduction :

The COVID-19 pandemic has created havoc across the globe since 2019. It first started in the city of Wuhan in China in December 2019.¹ SARS-CoV-2 has been identified as the causative agent for the infection. The rapid spread of the infection across continents has led to questions being raised regarding the mode of transmission of the virus. Various studies have claimed the droplet mode of transmission whereas airborne transmission has also been suggested in a recent study.^{2,4} The risk of infection to close contacts of a positive case of COVID-19 has resulted in framing the preventive guidelines by WHO and the government of different states. Karia in their study emphasized the spread of the virus through objects used on infected patients e.g., thermometers and stethoscope.² In a study conducted in China it was reported that the spread of the virus from the index case was during dining, living together, or via shared transportation.⁵ The spread of infection by asymptomatic individuals has been a cause of concern for health administrators. The possibility of spread from dead bodies also cannot be ruled out. The present study aims to find out whether the SARS-CoV-2 virus exists in human corpses from where it may spread to the contacts.

Ethical clearance: A prior approval was obtained from Institutional Ethics Committee

Materials and Methods :

The observational study was carried out during the period May 2020 to August 2020. A total of 74 dead bodies of both males and females with suspected COVID-19 infections were examined for the presence of the SARS-CoV-2 virus by TrueNat test. The cases

were either brought dead at the hospital with suggestive history or were admitted and expired prior to collection of nasopharyngeal swabs. Consent for the test was obtained from the next of kin. Samples were collected by sterile swabs from the nasopharynx by lowering the head end of the autopsy table to get easy access to the posterior wall of the nasopharynx, maintaining all personal protective measures. The swabs were preserved in viral lysis buffer. Samples from all the cadavers were collected 1 day after death. In those cases where positive results were obtained further samples were collected on the 3rd and 5th day after death with the aim to find out the possibility of the existence of the virus in the corpse in the post-mortem stage. Serial sampling was possible due to a large number of deaths and logistic deficiencies for disposal of the bodies during the pandemic leading to prolonged preservation of the bodies before disposal. In 6 cases the bodies had to be preserved for more than a week due to delay in the disposal. TrueNat testing with confirmation by RdRp (RNA dependent RNA polymerase) gene assay was done in the laboratory of the Department of Microbiology as per ICMR guidelines. The results were analyzed and the chi-square test was applied to find out any significant difference in a positive test among males and females. Necessary ethical approval for the study was obtained from the Institutional Ethics Committee.

Results :

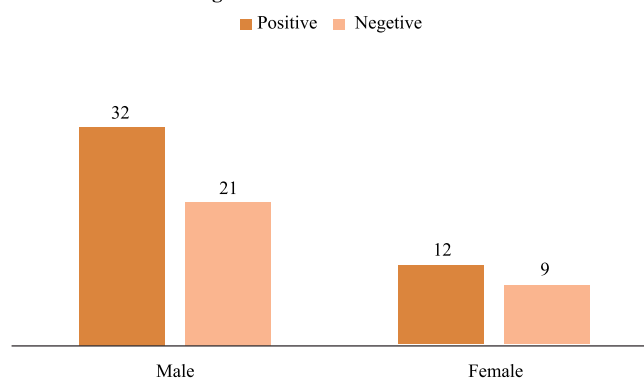
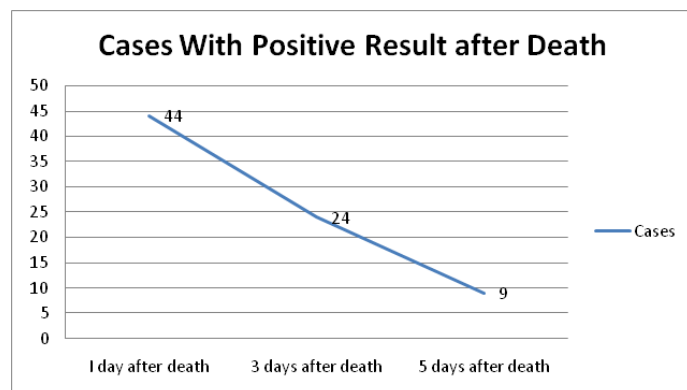
Out of the 74 samples collected 44 (59%) tested positive for the SARS-CoV-2. The age of the subjects ranged from 20 days to 90 years with the median age being 55 years. In the present study, 53 cadavers were males and 21 females. Among the males, 32(60%) were positive while among the females 12 (57%) tested positive (Figure 1). In all the 44 cases that tested positive for SARS-CoV-2, samples were collected 1 day after death. 24 (54%) cases showed positive results with sample collection 3 days after death whereas 9 (20%) cadavers gave positive results with sample collection 5 days post-mortem (Figure 2). The maximum duration after which a sample gave a positive result in our study was the 9th day after death and in 2 cases 8th day of sampling yielded a

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Test result among males and females.**Figure 1:** Results of swab test among males and females**Cases With Positive Result after Death****Figure 2:** Cases with positive results after death

positive result.

Discussion :

In the present study, 74 dead bodies of suspected Covid 19 were tested for the presence of SARS-CoV-2 in the nasopharyngeal swab by means of TrueNat test at serial intervals of alternate days till the 5th day (1 day, 3 days, and 5 days after death). The age of the subjects ranged from 20 days to 90 years. The presence of the virus in dead bodies has also been reported by Syamsun in 39.4% of cases tested by them.⁶ Bouzidi K et al in their study reported 33% positive results from post-mortem nasal swab test with the median age as 65 years.⁷ However in our study a much higher rate (59%) of positive tests was detected 1 day after death. The difference in terms of virus detection among males (60%) and females (57%) was not found to be significant statistically applying the chi-square test ($X^2 = 0.065$ which is less than 3.84, the value corresponding to $P=0.05$).

There was a gradual decline in the cases giving positive results with time. On the first day after death 44 cases were positive where as only 24 cases showed positive results 3 days after death and 9 cases on the fifth-day post-mortem. This decline in the number of positive results was mostly due to the disintegration of the virus in the dead bodies with gradual onset of decomposition. The cadavers were preserved in cold chambers with temperatures

maintained between 4°C – 6°C. In one case SARS-CoV-2 was detected 9 days after death and in 2 cadavers it was detected till the 8th day. Bouzidi reported positive identification of SARS-CoV-2 in one case 29 days after death while Beltempo found positive results 35 days after death.^{7,8} Preservation of the dead bodies in cold chambers retards the process of decomposition to some extent and hence may have facilitated the survival of the virus in the human tissues. However, a positive test indicates that the viral genetic material was detected but the presence of a live virus can only be confirmed by viral culture. On the contrary Riddell et al. have found that infectious viruses could be recovered from the nonporous surface for at least 28 days at a temperature of 20°C and 50% relative humidity.⁹ Increasing the temperature to 40°C and maintaining the humidity reduced the survival period to 24 hours. Further studies are necessary to find out how long the virus can be detected in decomposing bodies kept at room temperature or in an open environment. Another important factor that would determine the post-mortem period up to which virus is detected from the body is the viral load at the time of death. However, it is beyond the scope of the present study to detect the viral load.

Identification of the virus from dead bodies, days after death justifies the precautionary measures recommended for safe handling and disposal of the bodies.^{10,11} Contaminated nasal discharge from the dead bodies especially the decomposed bodies where liquefied discharge increases is definitely a potential source of infection for the dead body handlers and the family members. Fomites as a source of infection have also been highlighted in other studies.^{3,12,13}

The present study also emphasizes the need to test all suspected cases prior to autopsy examination. In positive cases, adequate measures need to be taken while conducting the autopsy and preservation of tissues for histopathological or toxicological analysis. A proper sample collection technique is essential to get correct results as rigor mortis prevents extension of the neck and insertion of the swab which may give false-negative results.

Conclusion :

Post-mortem nasal swab testing for SARS-CoV-2 should be carried out in all suspected cases of death to minimize the risk of transmission from contaminated nasal discharge. The possibility of infection from a decomposed body also cannot be ruled out as tests have shown positive results even in the 2nd week after death. Adequate precautionary measures must be adopted for safe disposal of the bodies and decontamination of the autopsy room along with the instruments.

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Conflict of Interest – None declared

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ORIGINAL ARTICLE

Faciomaxillary Trauma in Road Traffic Accident Cases in Northern India: A Hospital-Based Descriptive Study

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Abstract :

Road traffic accidents (RTA) cause severe facial injuries, among others. A good number of those cases among accidents and emergency departmental casualties account for faciomaxillary injuries of medico-legal importance in developing countries requiring different surgical interventions. Therefore, this paper aims to determine the pattern of facio-maxillary injuries secondary to RTA for better preparedness for emergency medical care. It was a retrospective study based on the hospital medical records of 900 patients who attended emergency services from September 2018 to September 2021 with faciomaxillary injuries with RTA history. The diagnosis was made based on the clinical presentations and radiological investigations. Out of 900 cases of RTA involving faciomaxillary injuries, the highest incidence was found among the age groups of 21-40, with an average of 44.4% with a male and female ratio of 1.6:1. Soft tissue injuries predominated with 72.2% of cases, followed by nasal bone fractures (55.5%). Most RTA cases were reported in October (16.0%). The involvement of two-wheelers was observed in 50% of cases. A gradual rise of facio-maxillary instances were observed during the study period, with 250 cases in 2018-2019 to 450 cases in 2020-2021. The gradual climb of cases of faciomaxillary injuries following RTA in this underdeveloped part of India alarm the urgent attention of all concerned. The reasons are multifaced, and the involvement of young people also reflects the vulnerability of the hazardous exposure of society's most productive age group that needs to be prevented.

Keywords : Traffic fatalities; facial injuries; underdeveloped region; preventive measures.

Introduction :

RTA cause severe facial injuries.¹ Injury to the face accounts for 10% of all accidents and emergency department attendances.² As per the latest WHO estimates, RTAs account for about 1.25 million deaths and 20-50 million non-fatal injuries worldwide each year.³ The injuries thus sustained may include abrasion, laceration, avulsion, hematoma, orbital injury, facial nerve injury, parotid gland and duct injury, vascular injury, bony injuries and facial fractures.⁴ These cases are often medico-legal and require proper documentation and reporting after careful evaluation.⁴ Bones of the middle third of the face present a superficial appearance of strength, but they are comparatively fragile, and they fragment and comminute easily.⁵

RTA commonly cause maxillofacial trauma besides other causes like industrial injuries, sports injuries, altercations like fist fights, gunshots and other penetrating injuries, animal bites, etc. Substance abuse and driver fatigue played a significant role in the aetiology of these incidents.⁶

A comparison may be made between developed and developing nations, where a more chaotic system of roads makes RTA a common problem in developing nations. The older design of cars, lower level of seat belt compliance, and poor infrastructures

contribute to different injury patterns. Head injury, injury to other body systems, cervical spine injuries, and thoracic and abdominal injuries may be associated with facial trauma.¹

Facial injuries, by their nature, result in evident and noticeable alterations of facial profile and soft tissue landmarks. Restoration of all involved structures to pre-injury status is essential, both from an aesthetic and functional point of view.⁷ The management of facial trauma is usually preceded by general management, which includes maintenance of the airway and management of haemorrhage and associated injuries.¹

In the past two decades, facial fracture management has undergone significant changes. These include a diagnostic evaluation with high-resolution scans, fixation with plate and screws, primary bone grafting, early mobilization and rehabilitation, which gives improved outcomes and recovery.⁷

It has been reported that the prevalence of faciomaxillary injuries differs from country to country. The patterns of maxillofacial injuries also vary depending on aetiology, cultural differences and other local factors. Also, the current knowledge base on faciomaxillary trauma in RTA cases is still inadequate. The scientific studies performed, though representing an essential contribution to our understanding of faciomaxillary trauma, do not resolve the problem we face in dealing with the case of a faciomaxillary injury sustained in RTA.

Hence, this study was undertaken to determine the pattern of faciomaxillary injuries suffered by victims of RTA and to analyze their incidences concerning age, sex and aetiology associated among people of the North-Eastern region of India.

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Methods and Materials :

This retrospective study was conducted in the Otorhinolaryngology Department of Assam Medical College and Hospital (AMCH), Dibrugarh, Assam, from September 2018 to September 2021. The diagnosis was made based on history, clinical presentation and radiological investigations like CT Faciomaxillary region, X-ray nose and PNS Waters-View. Follow up was recorded at 2, 6, and 12 weeks after starting pharmacotherapy. Patients received intravenous fluids, antibiotics, analgesics, tranexamic acid, antihistaminics, topical hemocoagulase and first aid. After stabilization, they were referred to their respective departments. The present study hospital is a tertiary referral centre for approximately 7.56 million. Injured patients present directly to study hospitals or are referred from peripheral centres for definitive management. They are assessed initially by the medical staff in the emergency department, who commence treatment and investigations before arranging referrals to respective departments.

Inclusion criteria :

Facial injuries resulting from RTAs are included in this study. Patients who refused admission to the hospital or were referred to higher centres were excluded. The study was carried out with institutional ethical clearance. The data collected were tabulated in Microsoft Excel Worksheet. Computerized analysis was performed using the Statistical Package for Social Sciences (SPSS) 20.0 software (SPSS, Chicago, Illinois, USA) and Microsoft Excel 2019. The categorical variables are summarised as proportions and percentages. Associations between variables were tested using the χ^2 test, and a p-value < 0.05 is considered significant.

Results :

A gradual rise of facio-maxillary instances was observed during the study period, 2018-2019:250, 2019-2020:300 and 2020-2021: 450.

Out of 900 patients, 555 were males, and 345 were females, with a male: female ratio of 1.6:1. Maximum cases were noted in the age group of 21-40 years (44.4%), among whom 265 were males accounting for 48% of the total male cases. The minimum cases were reported among males and females in the elder age group of >80 years. A statistically significant difference was observed between male and female cases, as shown in Table 1.

As shown in Table 2, the incidence of RTA was highest with two-wheelers (50%), while pedestrian incidences of accidents and others comprised only 19.5%. Gender wise analysis showed a significant difference in aetiology among males and females (p-value < 0.01)

A total of 3125 RTA cases attended the casualty services of the reference hospital during the study period. Maximum RTA cases were recorded in October (16.0%), December (11.2%), January (12.8%) and April (12.8%) and minimum in May to July (3.2%, 3.2%, 2.4%), respectively, as shown in Fig. 1.

All patients in the study suffered from facial injuries, and the distribution of these injuries is shown in Fig. 2. All patients in the

study suffered facial injuries. The majority of patients suffered multiple facial injuries, among whom 55.5% had nasal bone fractures, 50% had naso-ethmoidal fractures, and 38.8% had zygomatic fractures. Around 650 (72.2%) suffered from soft tissue injuries, 250 (27.7%) from maxillary and 400 (44.4%) from mandibular fractures. The number of patients suffering

Table 1 : Age-wise distribution of cases

Age in years	Total	Male	Female	p-value for chi-square
0-20	200	125 (22.5%)	75 (21.7%)	0.048
21-40	400	265 (47.7%)	135 (33.7%)	
41-60	175	95 (11.7%)	80 (23.1%)	
61-80	100	55 (9.9%)	45 (13.0%)	
>80	25	15 (2.7%)	10 (2.8%)	

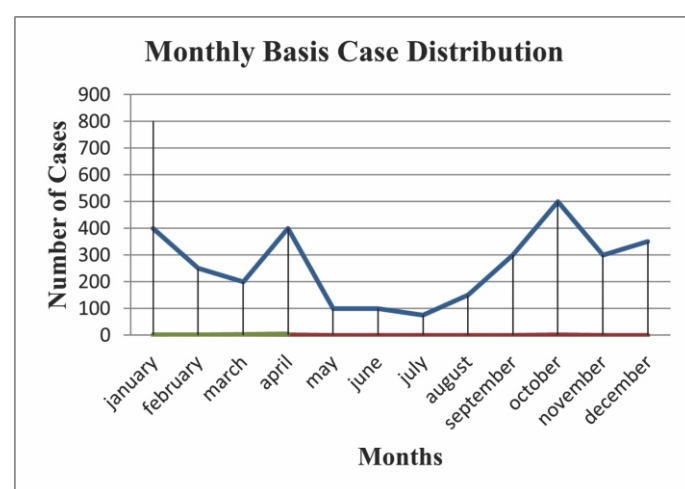
Table 2 : Etiologic distribution of the cases

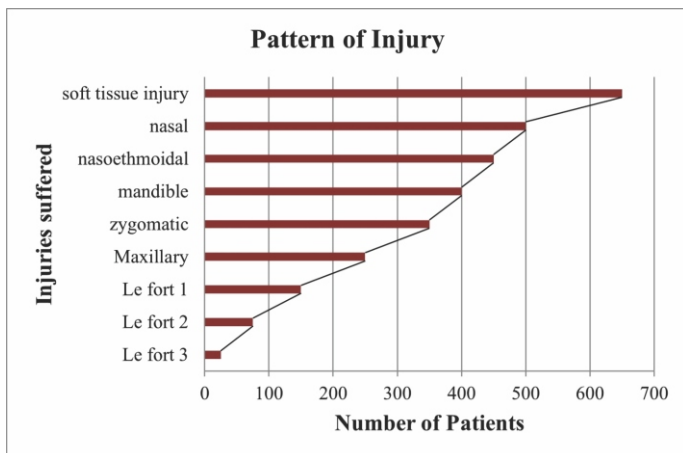
Aetiology	Total (%)	Male (%)	Female (%)	p-value for chi-square
Two wheelers	449 (49.9%)	301 (54.2%)	148 (42.9%)	<0.01
Four wheelers	275 (31.5%)	151 (27.2%)	124 (35.9%)	
Pedestrian	118 (13.1%)	66 (11.9%)	52 (15.1%)	
Others	58(6.4%)	37 (6.7%)	21 (6.1%)	

maxillary and mandibular fractures (Le fort 1, Le fort 2, Le fort 3) was 250 (27.7%).

Discussion :

In this era of fast life and expressways, injuries of the maxillofacial region following motor vehicle accidents, industrial injuries, altercations, etc., are significantly increasing.⁸ Patients present with pain, swelling, epistaxis, malocclusion, peri-orbital oedema, nasal obstruction, nasal deformity, diplopia,





and facial pain; sometimes with facial lacerations, injury to parotid duct, gland, facial nerve, orbit, frontal sinus, avulsion of the nose, hematoma, vascular injury and facial fractures.

Fractures of the maxilla-facial region include 1) the upper third of the face involving frontal sinus, frontal bone, and supra-orbital ridge; 2) the middle a third of the face involving nasal bones, septum, zygomatic arch, blowout fractures of the orbit, Le fort fracture 1,2,3 and 3) lower third of face involving mandible, temporomandibular joint.

In our study, the incidence of cases in males was comparatively higher than in females, with a ratio of 1.6:1. Maximum cases were noted in the age group of 21-40 years, out of which 47.7% were males, while the minimum was in the age group of >80 years, irrespective of gender. The observations are in agreement with similar other studies.^{9,10} As the younger population are more likely to participate in high-risk activities and interpersonal violence; they are thought to be more prone to maxillary injuries¹¹ than elder ones. Another study also found a higher prevalence of maxillary injuries among males, similar to our study.¹² Incidence of RTA was highest with two-wheelers (50%) followed by four-wheelers. A significant difference in aetiology was observed among males and females. The findings agree with some other studies conducted in different parts of India.¹⁰⁻¹³ In contrast to our findings, a recent study from Dubai reported the involvement of pedestrians as the most common in RTAs. However, the same study reported dominance of maxillofacial injuries in RTA with orbital and parathyseal fracture among males aged 31-40 years, similar to our findings.¹⁴ Maximum cases attended our casualty services in October, December, January, and April, while minimum cases were found in the summer months, i.e., May to July. Various authors have reported a high number of RTA in the monsoon season in contrast to our study.^{15,16}

In the present study, most reported injuries were soft tissue injuries (72.2%), followed by nasal bone fractures (55.5%), nasoethmoidal fractures (50%) and zygomatic fractures (38.8%). A similar study showed that midfacial skeleton fractures were four times higher than fractures of the mandible in RTAs, while mandibular fractures predominate among fractures due to assaults.¹⁷

It was also seen that Le fort fractures rarely occurred in isolation, perhaps that these fractures were a marker of higher velocity trauma. Another reason that can be cited here is the poor quality of seatbelts, poor condition of vehicles, noncompliance with helmets, poor infrastructure, alcohol intoxication during driving and many more. Many of these patients suffered an intracerebral haemorrhage, so the neurologically unstable patients had more excellent delays before treatment of their facial trauma. In some emergency cases, facial trauma was treated concurrently with other injuries, like intraabdominal, bone fractures, etc.

The ideal time for treating maxillofacial injuries is a source of debate. Traditionally soft tissue injuries and mandibular fractures were treated as soon as patient condition allowed, whereas mid and upper facial injuries were treated when significant facial swelling resolved. The trend toward mortality in older patients is not surprising due to increased medical co-morbidities with age. This probably also explains the greater likelihood that older patients were likely to be treated non-operatively.¹

Limitation: The present study is a retrospective study conducted to determine the pattern of faciomaxillary injuries suffered by victims of RTA and to analyze their incidences concerning age, sex and aetiology associated with the study population. An in-depth study regarding the causes and associated factors of RTAs and the dimension of morbidity and mortality among RTA cases may help in the management of such cases and planning preventive measures

Conclusion :

The burden of maxillofacial injuries due to RTA is vastly underestimated. The causes of consistent RTA are poor infrastructure, noncompliance and disobeying traffic rules, improper self-protective gear, and alcohol intoxication during driving. Lack of public awareness and lack of proper guidance has led to increasing road trauma trends. There is a need to educate people about preventive measures and establish communication between different health facilities to limit their morbidities.

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ORIGINAL ARTICLE

Analysis of Elderly Deaths in the Custodial Set-Up: A 10-year Retrospective Study

Rajesh Bardale,¹ Nitin Ninal.²*1. Professor, Dept. of Forensic Medicine, Government Medical College Miraj.**2. Assistant Professor, Dept. of Forensic Medicine, Government Medical College Aurangabad.***Abstract :**

Death in a custodial setup is always a heart-rending moment for family members. Moreover, it raises doubt and distrust in the minds of near and dear ones whether such death is because of a natural cause or an unnatural act. The present study aimed to analyze the death of the elder population in a custodial setup (police and prison). This is a postmortem examination based retrospective study. A standard proforma was designed to collect the information to ensure consistency for the whole sample. Only elder inmate death was included in this study. A total of 119 autopsies in custodial setup (police and prison) were performed for 10 years from January 2009 to December 2018 out of which 34 (28.57 %) cases were of an elder inmate. Amongst 34 elder inmates, 31 (91.17 %) were male and 3 (8.82 %) were female. The mean age was 70.4 years. Amongst all deaths, 33 (97.05 %) were because of natural causes. Myocardial infarction was the leading cause of death. The majority of the imprisoned people (91.17 %) were male and most of them (85.29 %) were convicted for the various offense. The present study had identified some features of elder deaths in custodial setup.

Keywords : Death; Custody; Autopsy; Prison; Elderly.**Introduction :**

Death in a custodial setup is always a heart-rending moment for family members. Moreover, it raises doubt and distrust in the minds of near and dear ones; whether such death is because of a natural cause or an unnatural act. If it is because of natural cause then whether such death was avoidable; or whether timely medical aid was given? If it is because of an unnatural act then what were the circumstances that caused such an untimely exit?^{1,2}

Elderly people, who are incarcerated because of varied reasons, pose two-fold problems; firstly, they have progressive age, and secondly, many of these inmates had associated illnesses. Many of these senior citizens live life with the help of medicines. A review of Indian literature reveals that most of the studies conducted on custodial death represent adult populations of all ages or young populations.¹⁻⁶ However, no study is available dealing with the elder imprisoned population. Considering this, the aim of the present study was 1) to examine the death of the elder population in custodial set-up in terms of age, sex, type of custody (prison or police station), medical attention received, and place of death and 2) to examine the presence of any associated disease, history of any psychiatric illness, substance abuse and cause of death.

Material and Methods :

This is a postmortem examination based retrospective study conducted at the Department of Forensic Medicine, Government Medical College and Hospital, Miraj. We examined all available files of inquest papers, autopsy reports, toxicological analysis

reports, histopathology reports, and hospital case papers into the death of people in custody between 2009 and 2018. A standard proforma was designed to collect the information to ensure consistency for the whole sample. Only elder inmate death was included in this study. An elder person is considered as a person who was of 60 years of age or above 60 years for the male and female population. Information collected included age, sex, type of custody (prison or police cell), place of death/incident, medical attention received, presence of any associated disease, history of any psychiatric illness, substance abuse, and cause of death.

Results :

A total of 119 autopsies in custodial setup (police and prison) were performed for 10 years from January 2009 to December 2018 out of which 34 (28.57 %) cases were of an elder inmate. The year-wise distribution of the total custodial deaths and elder death is presented in Fig 1. Amongst 34 elder inmates, 31 (91.17 %)

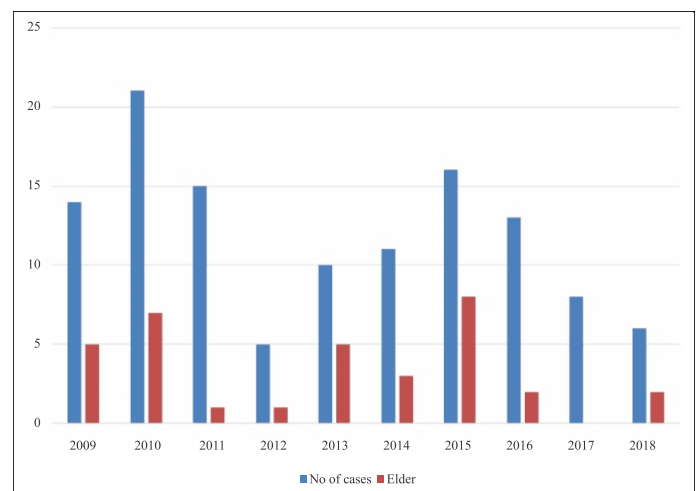


Fig 1: Showing year wise distribution of total custodial deaths and elderly deaths

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Table 1: Age-wise distribution of cases

Age in years	Male	Female	Total
Minimum	60	60	60
Maximum	88	89	89
Mean	70.32	71.33	70.41
Standard deviation	7.03	15.5	07.72

Table 2 : Distribution of cases as per type of custody

Type of custody	No. of cases (%)
Police	01 (2.94)
Prison	33 (97.05)
Prison – Convicted	29 (85.29)
Prison – Undertrial	04 (11.76)

Table 3: Distribution of convicted or under-trial prisoners as per offences

Section	No. of cases (%)
302	27 (79.41)
304 (B) (+ 498 A)	01 (2.94)
306	01 (2.94)
307	02 (5.88)
325	01 (2.94)
376	01 (2.94)

Table 4: Distribution of cases as per Cause of Death

Cause of death	No. of cases (%)
Adenocarcinoma	1 (2.94)
Bronchial asthma	1 (2.94)
Bronchopneumonia	5 (14.70)
Cardiac tamponade	2 (5.88)
Cerebral infarct	5 (14.70)
Hanging	1 (2.94)
Intracranial haemorrhage	1 (2.94)
Myocardial infarction	14 (41.17)
Pulmonary embolism	1 (2.94)
Septicaemic shock	3 (8.82)

were male and 3 (8.82 %) were female. The age distribution of cases is given in Table 1. The mean age was 70.4 years. The type of custody (police or prison) is mentioned in Table 2. Except for one, all deaths (97.05 %) were from prison and amongst them 4 (11.76 %) were under-trials. Table 3 shows the distribution of convicted or under-trial prisoners as per various provisions of

law. Maximum cases (79.41 %) were convicted under Section 302 of the Indian Penal Code (IPC). Table 4 shows the cause of death of elder inmates. Amongst all deaths, 33 (97.05 %) were because of natural causes. Myocardial infarction was the leading cause of death (41.17 %) followed by bronchopneumonia (14.70 %) and cerebral infarct (14.70 %). Table 5 shows the presence of associated illness in the inmates. 30 (88.23 %) inmates suffered from one or more co-morbidity or underlying illnesses and

Table 4 : Distribution of cases as per Cause of Death

Co-morbidity	No. of cases (%)
Bronchial asthma	1 (2.94)
Chronic obstructive pulmonary disease (COPD)	2 (5.88)
Diabetes mellitus (DM)	1 (2.94)
Hemiplegia	4 (11.76)
Hypertension (HT)	3 (8.82)
Hydronephrosis	1 (2.94)
Ischaemic heart disease (IHD)	2 (5.88)
Miliary tuberculosis	1 (2.94)
Parkinson's disease	1 (2.94)
Senile debility	2 (5.88)
More than one –co-morbidity (like presence of DM + HT+ IHD or DM + IHD or HT with cerebral infarct with dementia/multi-infarct dementia etc.)	12 (35.29)

amongst them 12 (35.29 %) inmates suffered from more than one illness (or underlying disease) like the presence of diabetes plus hypertension or hypertension with ischaemic heart disease or hypertension with hemiplegia or hypertension with cerebral infarct or dementia/multi-infarct dementia. 4 (11.76%) inmates had hemiplegia, 3 (8.82%) had multi-infarct dementia, 2 (5.88%) developed senile debility and 1 (2.94%) had Parkinson's disease (table 5). 31 (91.17 %) inmate received medical attention. The minimum duration of terminal hospitalization was 50 minutes and the maximum duration was 27 days. 31 (91.17 %) inmates died in the hospital and 3 (8.82 %) died in prison. 1 (2.94 %) inmate was suffering from psychiatric illness at the time of admission to prison and 2 (5.88 %) inmates developed a psychiatric illness in the prison and was on treatment. 3 (8.82 %) inmates developed cataract while in prison and were treated for the same.

Discussion :

Elderly people are considered to be the cornerstone of society. By virtue of their knowledge and experience, they guide their children and grandchildren. For society, their presence and experience are an asset. However, sometimes circumstances arise and these people are put behind the bars. Once they are imprisoned, they become isolated from family and society and many people live marginalized life. Moreover, physical frailty makes them more vulnerable.³ The situation becomes worse when these people have any associated longstanding illness or

have co-morbidity.

Studies from United Kingdom and United States of America had revealed that in past few years, the number of elder offenders in the prison has risen considerably.^{3,7,8} No such data is available from India. Considering the present study, about one-fourth (28.57 %) of elder deaths in custody were observed in the total number of custodial autopsies conducted between 2009 and 2018. The mean age of an elder imprisoned person was 70.4 years. The majority of the imprisoned people (91.17 %) were male and most of them (85.29 %) were convicted for the various offense. Sentence period ranged from two years to life imprisonment. As noted in other studies of all age groups,^{1,2,9,10} female prisoner represents a small number of the prison population (8.82%). Similar to elderly male prisoners; female old prisoners also face problems of progressive age and frailty. It was reported from United Kingdom that there was inconsistent access to breast and cervical screening for female inmates.³

Considering the aging prisoner population and the duration of awarded punishment, age-related deaths in prison are predictable.³ In the present study, the majority of deaths (97.05%) in the elder population were natural and the findings are consistent with other studies having an adult population of different age groups.^{1,2,4-6} Myocardial infarction (41.17 %) remained the leading cause of death followed by bronchopneumonia (14.70 %) and cerebral infarct (14.70 %). One case (2.94 %) was of hanging in the prison. The inmate was convicted and was suffering from COPD. He committed hanging in the toilet of the prison and the suspension point for ligature was an iron bar of the window. In the present study, 30 (88.23 %) inmates suffered from either a single co-morbidity or more than one co-morbidity. About 12 (35.29 %) inmates had more than one associated illness or underlying disease. In a study conducted in United Kingdom, it was found that about 85% of male prisoners over 60 years of age had at least one chronic illness. The most common illness was psychiatric, cardiovascular, musculoskeletal, and respiratory disorders.^{3,8} Individual with debility needs special attention. In the present study, 4 (11.76%) inmates suffered from hemiplegia, 3 (8.82%) had multi-infarct dementia, 2 (5.88%) developed senile debility and 1 (2.94%) had Parkinson's disease. Some of these neurological or physically disabled prisoners may require social care or personal assistance in day-to-day tasks like bathing or getting dressed or using the toilet or using stairs or cleanliness of cell or personal hygiene. These prisoners may face great difficulties while using these facilities. Sub-section (s) of Section 2 of the Rights of Persons with Disabilities Act 2016, "person with a disability" means a person with long-term physical, mental, intellectual, or sensory impairment that, in interaction with barriers, hinders his full and effective participation in society equally with others.¹¹ As per Section 15 of the Rights of Persons with Disabilities Rules 2017 every establishment shall comply with the standards relating to the physical environment for public buildings as specified in the Harmonized Guidelines and Space Standards for Barrier-Free Built Environment for Persons with Disabilities and Elderly Persons as issued by the Government of India, Ministry of Urban Development in March, 2016.¹² However, the said document does

not mention appropriate designs for prison or police cell for persons with a functional or physical disability.¹³

At present, the prisons in India are overstretched and under-resourced. Many prisons in India were built during British rule for housing young prisoners. These prisons are poorly designed to meet the needs of older prisoners, especially if a prisoner is suffering from functional or physical disability.

The age of an older offender rarely has any bearing on the sentence passed by the courts and therefore the older offender will have to stay in the prison to complete the sentence. It was found in the United States that people aged 55 and above account for 8% of the prison population. The aging people are placed in special geriatric facilities for proper care and assistance.³ Time has arrived that India should consider revising the policy on the elderly and disabled prisoners. There is a need to have a multi-disciplinary strategy to deal with this population 1) Creating appropriate and user-friendly infrastructure, 2) Establishing specialist medical and paramedical care services; and 3) Developing appropriate geriatric units to help and assist these aging prisoners.

The limitations of the present study are 1) small sample size, 2) retrospective nature of the study and 3) sample size from limited districts of the State. More meaningful and comprehensive data can be obtained by having a multi-centric longitudinal study for adopting correctional measures and reforms while dealing with geriatric prisoners. The present study had identified some features of elder deaths in custodial setup. Up to a certain extent, these results can be utilized by the authorities to frame a protocol while dealing with elder prisoners.

Conflict of Interest: None

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ORIGINAL ARTICLE

Suspicious Deaths in Newly Married Females in the Southern Marathwada Region

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Abstract :

Though females are important pillars of our society, dowry deaths continue to be a burning issue in Indian society in low as well as in high economic classes for many years. The unnatural deaths of newly married females due to dowry are routine headlines of every newspaper. Dowry is a payment of cash or valuable gifts to the groom from the bride's family at the time of marriage. It has become a social menace in modern India leading to the cruelty of women which includes physical violence, causing financial and emotional stress on the parents of the bride, which leads to marital conflict. The purpose of this study is to observe the magnitude of unnatural deaths among newly married females. An observational study was conducted in Dr. S. C. Government Medical College, Nanded (MS) the period from February 2014 to July 2015. A total of 1726 medico-legal autopsies were performed during the study period, of which 347 (20.10%) were married females. In 149 (42.94%) cases, suspicious deaths among newly married females were observed, of which 90 (60.4%) cases were within 3 years of married life. The burn was the most common (63.76%) cause of death & most of them (60.40%) were suicidal in nature. In 30 (20.13%) cases, crime was registered for dowry death.

Keywords : Newly married females; Dowry; Burns.

Introduction :

If we look scientifically at nature, it is clear that female plays a key role in the continuation of species. A mother is central to society in her role of moralizing the child, who then is the future of the country. Considering all the above criteria women should be praised, protected, respected, and considered far superior to males, instead, the picture is quite unfortunate in our society. Though females are important pillars of our society, they are given secondary roles and most of the time they are meant machines for producing children. The male dominating society has kept females suppressed by keeping them uneducated and unemployed restricting them from outside the world. Torture of wives, daughters, sisters, and other female members is a common phenomenon.

According to the World Health Organization, women in South East Asia region have the highest rate of burns, accounting for 27% of global burn deaths and nearly 70% of burns deaths in the region.¹ In India during 2011, the total number of deaths due to burns excluding homicide was 36442 out of which 23896 (65.57%) were females. According to National Crime Record Bureau, the total number of dowry deaths in the years 2007 and 2011 were 8093 and 8618 respectively.²

The Crime Rate Analysis against women in India showed a sharp increase in the crime rate from 8.8% in 2007 to 9.4% in 2011, which is a serious matter from the safety and security point of Indian women. This was mainly due to an increased number of

dowry deaths, torture of women, and sexual offenses.²

Dowry is one of the most important factors amongst all others responsible for the crime/unnatural death of females in India. Dowry might have started as an innocent custom, a symbol of love from parents to their daughter on the eve of her marriage. The purpose of this practice was probably meant to help new couples start their life in comfort. But it has, in recent years grown into a social evil with many instances of bride burning and suicides. These are now-a-days symptoms of social corruption.

Therefore, the autopsy study of suspicious deaths of newly married females within seven years of marriage is decided to observe the socio-demographic profile among such deaths and to study the quantum of dowry deaths.

Material and Methods :

Study design: A observational study of suspicious deaths among newly married females was conducted using hospital records during the period of February 2014 to July 2015. Before performing the medico-legal autopsy, all these cases were studied in detail from indoor case records, hospital records (where applicable), history obtained from relatives of the deceased, and police inquest. A standard proforma was used to collect information. A careful and complete autopsy was performed in each case. The viscera and necessary samples were preserved in required cases.

Inclusion: Cases of suspicious deaths of females within seven years of their marriage or deaths within 30 years of age of married females which have been brought for medico-legal autopsy.

Exclusion:

1. Death due to mass casualties or road traffic accidents.
2. Death of married females where the age of the female is more than 30 years.
3. Death due to natural disease.

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4. Unidentified and Decomposed female dead body.

The data were analyzed systematically.

Ethical Committee Approval – Yes, Institutional Ethics Committee, Dr. SCGMC Nanded.

Results:

During the study period, a total of 1726 medico-legal autopsies were performed, out of which 347 (20.10%) were married females. In 149 cases (42.94%), the suspicious death of newly

Table 1: Distribution of cases according to the age of the victim

Sr.No.	Age of the Victim	No. of Cases	Percentage
1.	Less than 20 years	04	2.68%
2.	21-25 years	102	68.46%
3.	26-30 years	43	28.86%
Total		149	100%

married females was observed, of which 90 (60.4%) victims died within 3 years of married life while 45 (30.20%) victims died in 4-7 years of marriage.

The mean age of females was 24.26 years (Std Deviation 3.12 years), 102 (68.46%) females were from age group 21-25 years followed by 43 (28.86%) in 26-30 years and if we combine deaths of female victims below 20 years (2.68%) and 21-25 years (69.13%) then it would be 71.81% which is highly significant. Most of the victims were from rural areas i.e., 113 cases (75.84%) and a minimum number of victims was from urban areas i.e., 36 cases (24.16%). In 109 (73.15%) cases, the female had children while 40 (26.85%) females died before they had children. It was

Table 2 : Distribution of cases according to education

Sr. No.	Education Of Deceased	No. of Cases	Percentage
1.	Illiterate	13	8.72
2.	Primary	34	22.82
3.	Secondary	67	44.97
4.	Higher Secondary	29	19.46
5.	Graduate	6	4.03
6.	Post-Graduate	0	0
Total		149	100

observed that a maximum [87 (58.39%)] deaths were observed in females living in a joint family as compared to a nuclear family [61 (40.94%)].

A maximum number of newly married females [130 cases (87.25%)] had poor education which includes primary,

Table 3 : Distribution of cases according to Cause of Death

Sr No.	Cause of Death	Cases(n)	Percentage
1.	Burns	95	63.76
2.	Poisoning	21	14.09
3.	Hanging	13	8.72
4.	Drowning	10	6.71
5.	Physical Assault	04	2.68
6.	Snake Bite	05	3.36
7.	Electrocution	01	0.67
Total		149	100

secondary, and higher secondary school education and a minimum number of deaths (4.03%) occurred in females who did their graduation.

Table 4: Distribution of cases according to the manner of death.

Sr. No.	Manner of Death	Cases (n)	Percentage
1.	Accidental	39	26.17
2.	Suicidal	90	60.40
3.	Homicidal	20	13.42
Total		149	100

Burn (63.76%) was the most common cause of death among newly married females followed by poisoning (14.09%), hanging (8.72%), drowning (6.71%), and physical assault (2.68%).

Most of the female deaths were suicidal (60.40%) in nature followed by accidental (26.17%) and the least was homicidal (13.42%). Burns was the most common cause of unnatural death in newly married females, of which 33.56% were suicidal in nature, 18.79% were accidental & 11.41% were homicidal in

Table 5 : Frequency of distribution of dowry victims

Sr. No.	Type of Victims	Cases(n)	Percentage
1.	Dowry victims	30	20.13%
2.	Non-dowry victims	119	79.87%
Total		149	100

nature. Out of 21 cases of poisoning, most of the deaths were suicidal (12.08%) followed by accidental (2.01%) in nature. All 13 deaths by hanging were suicidal in nature.

Table 5 showed out of a total of 149 cases, 30 (20.13%) were

dowry victims and 119 (79.87%) were non-dowry victims. In dowry deaths, crime was registered under section 304 (B) and section 498 (A) of IPC. It was observed that 66.67% of dowry deaths occurred in the age group of 21-25 years followed by 26-30 years (26.67%). The minimum number of alleged dowry deaths was observed in the age group below 20 years of age (6.66%).

Discussion :

According to Census India 2011, Nanded district had total population of 33,61,292, out of which males and females were 1,730,075 & 1,631,217 respectively. It constituted 2.99% of the total Maharashtra population.³

In this study table, no 01 showed most commonly involved age group was 21-25 years i.e., 103 cases which constituted 69.13% of deaths of newly married females, these findings are similar to the study carried out by Kulshreshtha P.⁴ et al (70.08%), Darji J.A.⁵ et al (70.87%), Shrivastava A.K.⁶ et al (73.43%), and Jaswinder Singh⁷ et al (63%).

The maximum number of deaths in newly married females was from rural areas (75.84%) in the present study. Similarly, more rural area victims were observed by Parchake M.B.⁸ et al (77.04%), Verma R.K.⁹ et al (66.52%), Darji J.A.⁵ et al (57.28%), and Pawar C.K.¹⁰ et al (55%). This might be because this medical college hospital is a tertiary care center having a maximum catchment area in the rural region of the district and surrounding districts.

According to the table no 02 it was observed that most of the females (44.97%) who died due to unnatural causes within seven years of marriage were educated only up to secondary school which is almost similar to a study carried out by Zine K.U.¹¹ et al (45.04%) and Pankaj Prajapati¹² et al (30.44%). This might be due to the fact that female professionals who are not dependent economically on their family members are less affected by violence and dowry death as compared to less-educated females who are usually dependent on their families.

The cause of death mentioned in table no 03 suggests burns were the most common cause (63.76%) followed by poisoning (14.09%) amongst newly married females. Kulshreshtha P.⁴ et al observed burns were the most common cause of unnatural death of young women (61.53%) followed by poisoning (13.67%). The study was carried out by Parchake M.B.⁸ et al (61.99%), Dere R.C.¹³ et al (50%), Numan Hussaini¹⁴ et al (49.40%), Zine K.U.¹¹ et al (49.40%), Akhilesh Pathak¹⁵ et al (45%) and Shrivastava A.K.⁶ et al (44.06%) also observed findings similar with this study. Females working more in the kitchen and easy access to inflammable material and fire find it easy for committing suicide by burns.

Radhika R.H.¹⁶ et al observed that the most common cause of death was hanging (78.33%) followed by poisoning (11.66%) and only 8.33 % of deaths were due to burns. Sane M.R.¹⁷ et al also found hanging was the most common cause of death (71.8%) followed by poisoning. This might be due to the demographic variables of different studies.

The present study table no 04 showed 60.40% of the deaths in newly married females were suicidal in nature followed by accidental (26.17%) and homicidal (13.42%). The study was carried out by Darji J.A.⁵ et al (66.99%), Parmar V.N.¹⁸ et al (53.13%), Shrivastava A.K.⁶ et al (50.35%), and Verma R.K.⁹ et al (47.98%) observed similar findings where the most common manner of death among females was suicidal. Suicide is the preferred way to end life rather than fight the problem, probably due to the alcohol addiction of the husband, unemployment of the husband, and the widely prevalent dowry system where the newly married victims were tortured for “cash/ kinds” in such a way that no option was left except to end their unhappy married life. Besides dowry, ill-treatment/torture by mother-in-law, extra-marital affairs, and the non-adjusting nature of wives in joint families, the economic dependence of husband on their parents and nearly complete dependence of women on their husbands & / or in-laws were other contributory factors affecting the marital unhappiness were the other reasons leading to suicidal deaths⁶.

The study by Zine K.U.¹¹ et al (53.7%) & Numan Hussaini¹⁴ et al (52.2%) observed that the most common manner of death is accidental in nature which is in contrast with our study. This might be due to females spending most of the time in the kitchen and thereby meeting fire following inadequate precautions while cooking on cooking gas, kerosene stove, and open unguarded chulha.

In the present study, 30 cases (20.13%) were dowry deaths booked under various sections like 306 IPC, 304 (B), and 498 (A) IPC. The study by Radhika R.H.¹⁶ et al noted 60 cases of dowry deaths that were booked under sections IPC 304 (B) and IPC 498 (A). This explains the magnitude of dowry-related problems in India. Even in many cases, the reason behind committing suicide was dowry but the parents due to some unknown reasons refuse to lodge complaints.

Conclusion :

Newly married females below 30 years were victims in this study and most of them were educated only up to higher secondary school. There are number of government programs that encourage girl education only the proper implementation is necessary. If we educate the females only and married to illiterate husbands, then also the picture is not going to change and also there is a need for premarital counseling. Most of the victims were from rural areas and burning was the most common cause of death. Dowry-associated deaths were also observed, so this social devil needs to be fought and eradicated totally from India.

Conflict of interest – No

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ORIGINAL ARTICLE

Lateral Cephalometric Assessment of Facial Soft tissue Thickness for Craniofacial Reconstruction in an Indian Population-A Retrospective Study

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Abstract :

Facial soft tissue thickness (FSTT) is a pertinent tool for forensic anthropologists to aid in facial reconstruction, a process that combines both art and science to recreate a recognizable face from an unidentified skull. The facial profile, together with the age and gender of a person is related to FSTT, which is required for accurate facial reconstruction and recognition. These FSTT data are anthropological and differ in various ethnic groups. Until now, no study exists in which the FSTT of the population of Haryana has been measured. Thus, this study aimed to assemble data by deriving mean FSTT in males and females of Haryana origin using lateral cephalograms. Lateral cephalograms of 150 subjects were collected and retrospectively categorized into three skeletal classes (based on convex, straight, or concave facial profile). FSTT was determined at different fixed anatomical landmarks on the lateral cephalograms using the adobe software. There was no significant difference in the FSTT among males and females. Significant differences in FSTT among various anatomical landmarks were present among the different skeletal classes. This research provides valuable data for forensic facial reconstruction and identification of young adults in the study population.

Keywords : Facial soft tissue thickness; Forensics; Skeletal classes; Lateral cephalogram.

Introduction :

Forensic facial reconstruction (FFR) is the scientific art of visualizing a face on the skull for personal identification.¹ This can be performed as a simulation of the facial soft tissue over the anonymous skeletal remains of the skull, to aid in categorizing the unknown deceased individual to assist in the forensic investigations.² The procedures like DNA and fingerprint analysis, investigating the dental records are the preliminary techniques used and FFR is the last resort when the other techniques fail to give valuable results.³ The skeletal body parts and osteological analyses of the skull provide indispensable information about the facial morphology, nevertheless, they cannot be used alone.⁴ Modelling the soft tissue structures covering the skull is a significant part of the process of facial reconstruction.⁵

Skull examination helps to determine age, gender, and ancestry but soft tissue features such as nose profile, ear profile, eyelid shape, and mouth profile are difficult to evaluate only from the skull profile.⁶ The facial profile—i.e., convex, concave, or straight, associating the skeletal class II, III, or I, respectively—is comparatively easy to determine from the skull and is important in facial recognition. There is variation in the soft tissue thickness among the different skeletal classes.⁷

In the early days, clay-based techniques were used for facial recreation to identify the corresponding individual. This technique was skill-based and, these reconstructions lacked objectivity.⁴ Over several decades various methods have evolved for assessing the FSTT like puncture, conventional radiographic imaging techniques employing X-ray radiation such as Computer Tomography (CT) imaging, and various modalities utilizing non-ionizing radiation have also been used, e.g., Ultrasonography (US), Magnetic Resonance Imaging (MRI) and recently, Cone Beam Computer Tomography (CBCT) which is a 3D imaging technique.⁸ FSTT has been carried out in various races using cadavers through the puncture.⁹⁻¹² The precision of this method is uncertain and it has an integral fault, of dehydration of the human soft tissue which is noticeable during the early stages.⁹ CT imaging gives better accuracy in establishing the FSTT, but it has potential radiation hazards. MRI is expensive and the US is technique sensitive and lacks anatomic detail.^{3,13} These techniques are not economical, time-consuming, technique-sensitive procedures and are not routinely accessible.^{8,14} CBCT is an established imaging technique for the maxillofacial region. The advantages of CBCT are low radiation dose and three-dimensional reformatting. But it's costly, lacks soft-tissue detail, and is not widely available.¹⁵ Conventional X-ray imaging is simple, less time-consuming, and inexpensive. Digital Lateral cephalogram is a conventional imaging modality routinely used due to its low radiation dose and simplicity of use.¹⁶

India is a diverse country and the facial features differ according to the various states and racial origin. Geographical regions are distinguished from each other by climate, location, human habitats, agricultural diversity, and topography. Data of FSTT at particular anthropological landmarks differs in various ethnic

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groups. In the literature search, limited data was found on FSTT among the Haryana population. In the present study, we report the differences in FSTT according to the skeletal features and gender, which are essential for accurate facial reconstruction.

Hence, the study was designed to determine the FSTT in the Haryana population using digital lateral cephalogramsto determine the difference in FSTT between males and females of different skeletal classes and examine the relationship between tissue thickness, gender, and skeletal classes.

Materials and Methods :

This retrospective study was carried out by evaluation of lateral cephalograms of 150 patients aged between 15-25 years reporting to the Department of Oral Medicine and Radiology of the institution for orthodontic treatment. The study was approved by the Ethical Committee of the Institution. Patients who underwent orthodontic treatment, patients with head and neck pathology, facial fractures, facial deformities, asymmetries, and distortions were excluded from the study.

Lateral cephalograms were taken in a cephalostat (Orthophos XG 5 DS/Ceph; Sirona Dental System, Bensheim, Germany) in maximal intercuspation with the lips at rest and the Frankfort horizontal plane parallel to the floor. The lateral cephalometric X-ray images were calibrated by 10%. The images were imported into Adobe Photoshop 7 software to measure the thickness of 10 anatomical landmarks. The measure tool was used to perform the linear and angle measurements. (Figure 1)

The images were classified into 3 skeletal classes based on the ANB angle, which indicates the relative position of the maxilla to the mandible and allows the measurement of the extent of jaw position discrepancy. (Figure2) The 3 skeletal classes were classified as follows: Class I (ANB angle = 2–40), Class II (ANB angle > 40), and Class III (ANB angle < 20)

After setting the Frankfort horizontal plane (FHP) on the lateral cephalogram, the soft tissue thickness was measured at the following anatomical landmarks:(1) glabella (2) nasion (3) rhinion (4) subnasale (5) labrale superius (6) stomion (7) labrale inferius (8) labiomentale (9) pogonion and (10) gnathion (Figure 2). These landmarks were measured perpendicular to the bony surface. General descriptive analyses such as mean, standard deviation, and range were calculated for each anatomical landmark. Average soft tissue thicknesses were calculated, taking into consideration the gender and the skeletal classes of the individuals.

The mean thickness of the parameters amongst the three skeletal classes was assessed by one-way analysis of variance (ANOVA). Bonferroni Post Hoc Test was further applied to evaluate the statistically significant parameters. To assess the intra-observer error, cephalometric X-ray films from 30 subjects were selected randomly, and the measurements were repeated after an interval of 4 weeks. Random 75 cephalograms were also measured again by the second co-investigator for any interobserver error. The p values were significant at 0.005. The statistical analysis was performed by SPSS software version 14.



Figure 1- Measurement of Anatomical landmarks with Adobe Photoshop

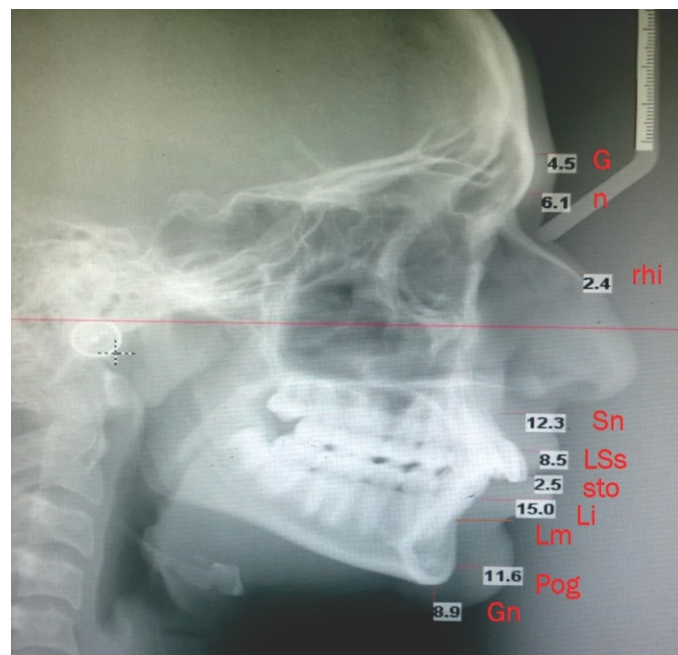


Figure 2-Lateral cephalogram depicting the anatomical landmarks

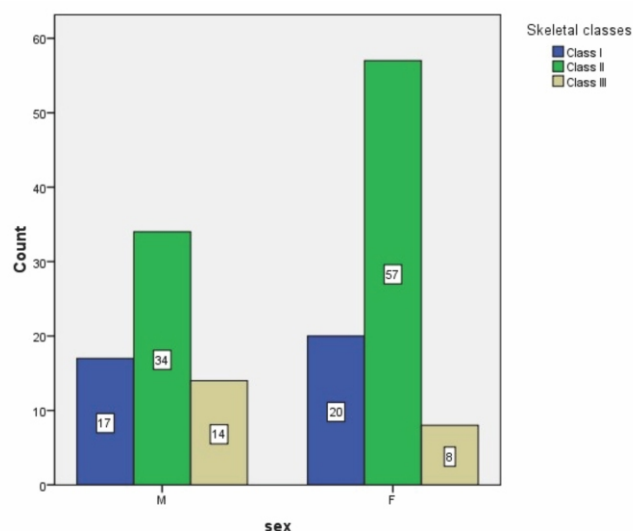


Figure 3- Gender distribution among the skeletal classes

Results :

There were 65 males and 85 females in the present study. The descriptive statistics regarding the mean age and number of participants according to skeletal division is described in Table 1. ANB angle showed a statistically significant difference between

the three skeletal classes. Figure 3 shows the gender distribution in each skeletal division. Table 2 describes the mean thickness among the three skeletal classes by one-way ANOVA. Statistically, significant difference was seen among the various landmarks according to one-way ANOVA between Class I and III. Bonferroni Post Hoc Test was performed to further assess the difference between skeletal classes. No significant difference was seen between the parameters between skeletal classes II & I except Glabella & Nasion ($p < .005$). Statistically, a significant difference was seen in several parameters in skeletal classes I & III Glabella, Rhinion, Nasion, Stomion, Labia inferioris, and labiamentale ($p < .005$).

Table 1: Descriptive values of age and gender according to the various skeletal classes

Skeletal classes	sex	N	Mean	Std. Deviation	Minimum	Maximum	Median
Class I	M	17	19.35	3.807	15	28	18.00
	F	20	18.25	2.693	15	23	18.50
	Total	37	18.76	3.252	15	28	18.00
Class II	M	34	18.09	3.204	13	27	17.00
	F	57	19.32	2.941	12	25	20.00
	Total	91	18.86	3.082	12	27	19.00
Class III	M	14	20.14	4.348	14	28	19.50
	F	8	18.62	4.373	15	28	17.00
	Total	22	19.59	4.317	14	28	18.50
Total	M	65	18.86	3.674	13	28	18.00
	F	85	19.00	3.036	12	28	19.00
	Total	150	18.94	3.316	12	28	18.00

The kappa ratio for the intraobserver analysis was 0.8 and the interobserver analysis was 0.7 indicating that the measurements were reproducible and no significant difference was observed on repeated measurements.

Discussion :

Facial reconstruction involves a methodological skill to reconstruct the antemortem face from the unidentified anthropological skeletal relics. Facial reconstruction by this technique is an end recourse to recreate an individual's facial appearance for personal identification. Numerous facial identification cases have been performed by this resort and it is valuable to record FSTT in profile view.¹⁷

Thus, the present study aimed to derive mean FSTT in males and females of Haryana origin using a lateral cephalogram measuring 10 different landmarks. All measurement points on the upper facial region showed a decrease in FSTT when compared to the other region, which can be attributed to the fact that the soft tissue of this region is adherent to bony tissue and exhibits relatively simple growth patterns.

In the present study, no significant difference was seen in the FSTT in males and females. Similar results were observed by Perlaza in Columbian adults¹⁸. This is contradictory to previous studies.^{5,12,13} It is possible that improving nutritional status, especially of girls, has important implications. The early maturation of girls may be offset by the greater amount of physical work required of them.

Mean values of FSTT of various parameters were highest for Class II, followed by Class I and Class III. The shape of the teeth has an impact on the thickness of the soft tissue. Comparison between skeletal classes I (straight facial profile) and II (convex facial profile), for point (LM & LI), indicated that soft tissue was significantly thicker in class II than in class I. The mandible in the

Table 2 : Mean thickness among three skeletal classes

Parameters	CLASS I			CLASS II			CLASS II			IP value
	M	SD	SE	M	SD	SE	M	SD	SE	
ANB angle	3.6176	.722740	.175290	7.06176	1.8776	.322009	1.5787	.39642	.105964	.000
Glabella	.81706	.294861	.071514	.86632	.362128	.062104	.49536	.31791	.084973	.001
Nasion	1.09076	.443368	.1075331	.02097	.375555	.064407	.60350	.41179	.110042	.001
Rhinion	.48029	.165861	.040227	.54012	.199004	.034129	.30829	.18681	.049925	.001
Subnasale	2.65271	.995686	.241489	2.48103	.904413	.155106	2.1656	2.7969	.832	.002
Labrale superius	2.49947	1.120845	.271845	2.25644	.913274	.156625	1.4954	.93544	.2501	.016
Stomion	1.61853	.661279	.160384	1.06774	.395897	.067896	.88193	.66238	.177023	.001
Labrale inferius	2.54676	.993607	.240985	2.99018	1.1140	.191053	1.684	.6814	.1820	.001
Labiamentale	1.74582	.539892	.130943	1.90076	.710957	.121928	1.02821	.680609	.181900	.000
Pogonion	1.73053	.598633	.145190	1.74271	.656839	.112647	1.18307	.839500	.224366	.033
Gnathion	1.01565	.370133	.089770	1.01229	.467479	.080172	.66700	.386245	.103228	.033

chin region has a lesser growth i.e., the mental aspect is located posteriorly in case of class II malocclusion as compared to class I.¹⁹ We found significant differences in soft tissue depth for at least two points i.e., Glabella & Nasion between Class I and II.

Comparison between classes I and III revealed significant differences at several points. (Table 1)

The facial reconstruction procedure involves the assessment of many parameters. To simplify the procedure the average thickness of the parameters of all the 3 skeletal classes should be used wherein no significant difference was observed. Each skeletal pattern has its unique profile and it is imperative to evaluate the skeletal class and occlusion before commencing the process of facial reconstruction.²⁰ It's a usual trend that the thickness of parameters in the upper part of the face is reduced in comparison to the lower part as the mandibular parameters are attached to their bony counterparts.⁵ The present study suggests that the mean thickness of the 3 skeletal classes for different points should be used.

Previous studies in the literature have got comparable results. Utsuno et al¹⁹ studied the Japanese population and found the mean thickness values of class I were in the range of the mean values of class II and III from the Subnasale to the Labiamentale. Kurcugolu et al²¹ performed a similar study in a Turkish population and observed that the mean thickness was significantly different at the Nasion, Subnasale, and labrale superiaris, Stomion, Labia inferius, and Gnathion. Chen et al²² observed significant differences at inferius & Labiamentale in the Chinese population. Dong et al²³ suggested that multiple factors including nutritional status and BMI should be taken into consideration while assessing FSTT,

Very few studies have been carried out on the Indian population. Kotrashetti et al studied facial soft tissue thickness in South Indian adults on Lateral cephalogram, lateral oblique, and postero-anterior views. They derived a regression equation and the parameters nasion, subnasal, labial superioris, stomion, labrale inferius, gnathion, inferior border of zygomatic, and sub zygomatic were the suitable parameters in terms of estimating FSTT in association with age, sex, and BMI.

Therefore, according to the results of present study and previous studies its essential to aim at obtaining the databases of soft tissue thickness of populations of different origins and races. A thorough anthropological analysis of the skull, for assessment of the skeletal classes, is essential before initiating craniofacial reconstruction.

Limitations and future prospects :

As it is a two-dimensional study, maximum landmarks cannot be studied. Further research should be carried out to assess the FSTT in different age groups including juveniles. Prospective studies aiming at associating FSTT with anatomical structures like body fat and musculature should be performed. FSTT can be assessed using three-dimensional imaging modalities like CT, CBCT, MRI, and US, and a comparison of each study can give valuable results.

Conclusion :

The present study provides valuable information regarding the differences in mean FSTT between three skeletal classes in the Haryana population-based on lateral cephalograms. This data is important in understanding the craniofacial characteristics of the population and its potential for forensic identification. The data can also be used in cases of anthropological research and facial rehabilitation for plastic reconstructive surgeries.

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Conflict of Interest :

The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

Histopathological Changes in Skin and Subcutaneous Tissues at Ligature Site in Cases of Death Due to Hanging and Strangulation

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Abstract :

The ligature mark on the neck is considered the principal, most important and specific sign of death in hanging. But, the presence of a ligature mark alone is not diagnostic of death from hanging as this can also be a purely cadaveric phenomenon as it may be produced if a body has been suspended after death. Also, there is difficulty for forensic pathologists to differentiate between hanging and strangulation based on analysis of the gross appearance of ligature marks alone. Only a few have conducted histopathological studies of the neck tissues in such deaths to confirm the type and cause of the death. It was hypothesised that, in such cases, evaluation of histopathological findings of neck structures if undertaken would be more conclusive in establishing the cause of death. An observational cross-sectional study of histopathological changes in skin and subcutaneous tissues at ligature site in cases of death due to hanging and strangulation was conducted in the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram. Considering the various histopathological changes, skin compression, skin haemorrhage, and cellular infiltration of the skin were more marked in strangulation than hanging. Skin congestion/plethora and rupture and oedema were equally present in both hanging and strangulation. The haemorrhage of subcutaneous tissue was more marked in strangulation than in hanging. Congestion of subcutaneous tissue was equally present in hanging and strangulation. Rupture of skin was the commonest histopathological finding either when a hard ligature or soft ligature material was used. The study concludes that a detailed evaluation of the gross and histopathological findings of the neck structures if undertaken would be more conclusive in establishing the cause and manner of death to aid the administration of justice.

Keywords : Hanging histopathology; Strangulation histopathology; Asphyxia; Ligature mark; Ligature material.

Introduction :

The act of unnatural death may be accomplished in different ways like trauma, poisoning and violent asphyxia. In violent asphyxia, the entry of air into the air passage is prevented. Hanging and strangulation are common types of violent asphyxial which prevent the entry of air to the lungs. Hanging is one of the most common methods of suicide in India, other types of hanging are, homicidal hanging, judicial hanging, and autoerotic hanging.¹ Hanging can also occur accidentally, while at work during playing, exhibiting hanging exercises or showing some performances in the circus etc. Lynching is a type of homicidal hanging. Hanging differs from strangulation in which the neck is constricted irrespective of any effect caused by the weight of the body.² The various structures damaged in hanging and strangulation include the soft tissue like skin, subcutaneous tissue, fascia, muscle, blood vessels and lymph nodes and the bony and cartilaginous tissues like the hyoid bone and larynx.² Strangulation is assumed to be homicidal until the contrary is proved otherwise. Various forms of strangulation are ligature strangulation, throttling, mugging, garroting etc.³ The ligature mark on the neck is the principal, most important and specific sign of death in hanging.⁴ The ligature mark is usually situated over and above the thyroid cartilage between the larynx and the

chin and is a pressure abrasion. Depending upon the type of ligature material it will be a patterned pressure abrasion with or without grooving. Initially, it will be pale colour and as time advances it becomes yellow-brown or dark-brown and hard like parchment, due to the drying of the slightly abraded skin.⁵ Any article such as rope, cord, metallic chain and wires, leather strap, belt, bed sheet or other cotton or synthetic material, turban etc. which are readily available will be used for suicidal hanging.⁶ Ligature mark on neck depends on the composition of ligature, width and multiplicity of ligature, the weight of the body suspended and degree of suspension, the tightness of encircling ligature, the length of time the body has been suspended, position of the knot and slipping of ligature during the suspension.⁵ Sometimes, the pattern of the ligature material is impressed on the skin and characteristic diagonal marks of the strands of the rope are seen.⁶ The presence of a ligature mark alone is not diagnostic of death from hanging like this and this can also be a purely cadaveric phenomenon as it may be produced if a body has been suspended after death. Often a body is suspended after the murder to stimulate suicidal hanging. Casper has observed that a mark similar to the one observed in persons hanged alive can be produced if suspended within two hours or even a longer period after death.⁵ Internal findings include bruising into the soft tissues, injury to the blood vessels and congested lymph nodes of the neck. The solid structures of the neck like the hyoid and larynx are also damaged in some cases. But, Smith and Fiddes (1955) have said that hyoid bone is practically never injured.¹¹ On the other hand, Weintraub (1961) found a hyoid bone fracture in 27 % of cases of hanging.¹² Fracture of thyroid cartilage was more frequent in persons over 40 years of age in whom thyroid cartilages ossified.⁴ Fractures of hyoid bone and larynx are almost

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exclusively due to homicidal strangulation especially when the structure is ankylosed or ossified. Weintraub (1961) reported fracture of the hyoid bone in 50% of cases in manual strangulation and one in two cases of ligature strangulation. All the fractures occurred through the greater horn of the body or

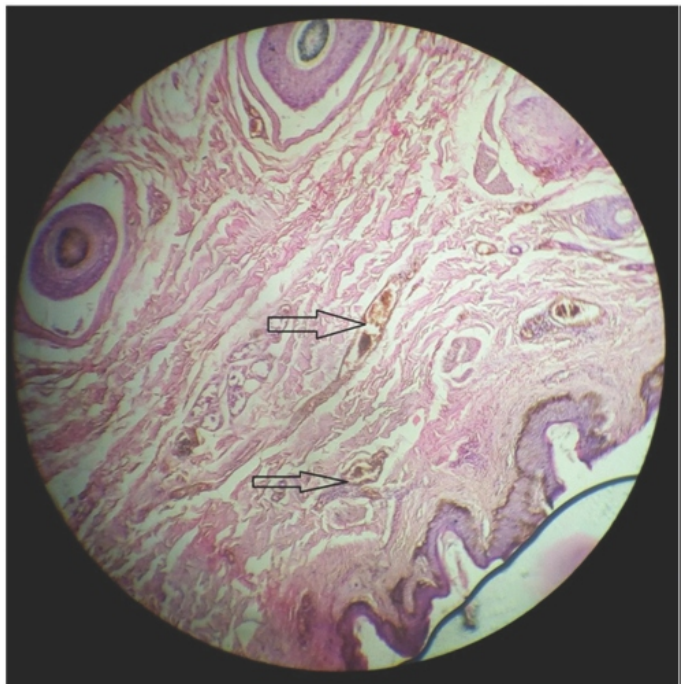


Image 1: 10x magnification of skin showing multiple vascular Congestion

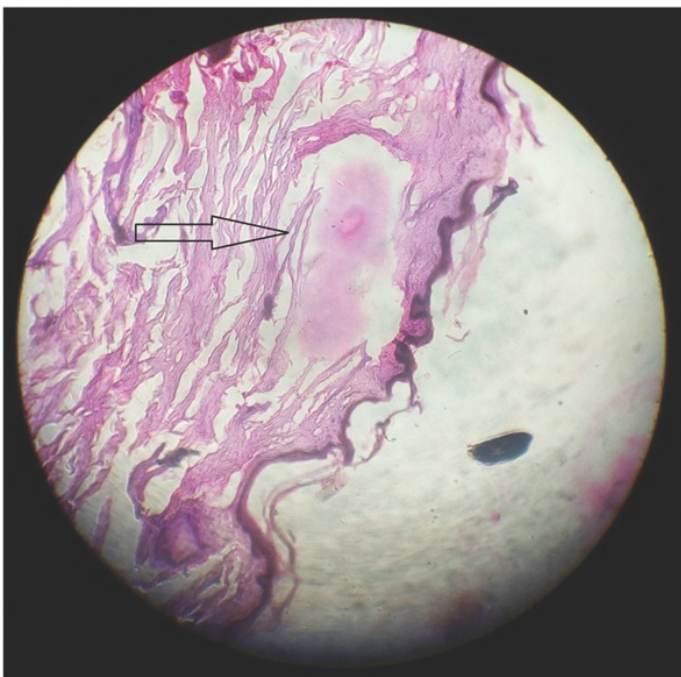


Image 2: 10x magnification of skin showing homogenously stained fluid in the interstitium (oedema of skin)

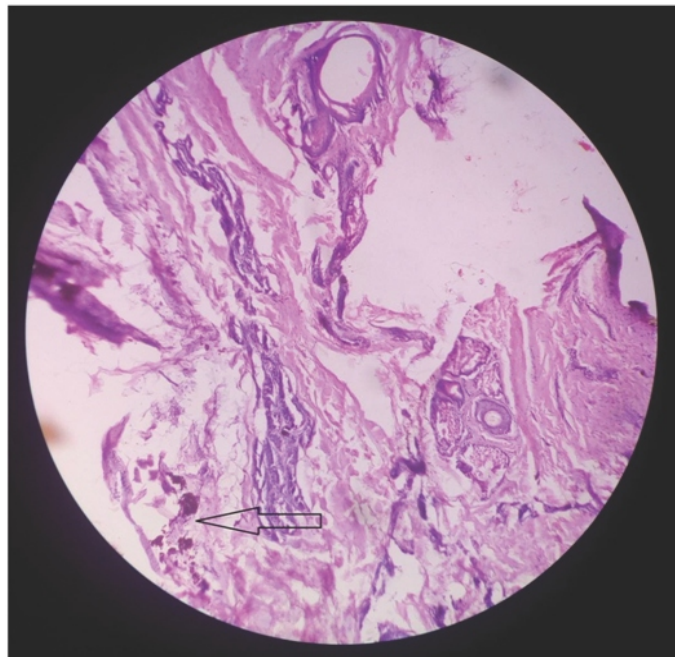


Image 3: 10x magnification of skin showing multiple haemorrhages in the dermal layers

through the joint between the body and greater horn. In cases with faint ligature marks, pseudo ligature marks are seen in obese persons and infants due to skin folds, coagulation of subcutaneous fat in refrigeration, body swelling of neck tissue in decomposition ligature mark-like marks seen on the neck. It will be difficult to differentiate these marks from the pressure abrasion caused by ligature material.⁶ In routine autopsy examination, mostly the above-mentioned, gross external and internal findings are noted in the structure of the neck (in hanging and strangulation deaths). Whereas, only a few have conducted histopathological studies of the neck tissues in such deaths to confirm the type and cause of the death. In this study, it was hypothesised that evaluation of histopathological findings of neck structures in such cases, if undertaken as a routine would be more conclusive in establishing the cause of death.

Materials and Methods :

This is an observational cross-sectional study approved by ethics committee of the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram. Informed consent had been taken from deceased family members prior to the study. A study of histopathological changes in skin and subcutaneous tissues at ligature site in cases of death due to hanging and strangulation was conducted in the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram during the period February 2016 to June 2017. Seventy-five cases were included in the study. Of the seventy-five cases, seventy cases were from victims of hanging and five cases were from victims of strangulation. The details mentioned in the inquest report, relevant personal history and other available records were collected from the accompanying police officer or a friend or

relative. A detailed autopsy was performed using modified Letulle's technique. Then flap dissection of the neck was carried out and gross findings were noted. A portion of the skin and subcutaneous tissue from the ligature site was preserved in 10% formalin for histopathological examination. Routine histopathological methods were used to prepare the slides and findings were, recorded with the help of a Pathologist. Data were entered into an excel sheet and were analysed using IBM SPSS 20. The objective of the study is to identify the various histopathological change in the skin and subcutaneous tissue at ligature site in cases of death due to hanging and strangulation in comparison with normal tissue. The study population included cases brought for post-mortem examination in the mortuary wing of the Department of Forensic Medicine with a history of death due to hanging and strangulation. Cases were selected from dead bodies brought to medical college with a history of death due to hanging/ strangulation as per the investigating agency. Cases excluded from this study were decomposed bodies, cases with other injuries on the neck and cases with an unknown history.

Ethical clearance: A prior approval was obtained from the Institutional Ethics.

Results :

Histopathological changes that occurred in the skin and subcutaneous tissue were studied in detail and the following results were obtained. In cases of hanging and strangulation in the skin, compression, rupture, congestion, cellular infiltration, oedema and haemorrhage were found and in subcutaneous tissue, there were haemorrhage and congestion. Skin compression was present in 38 (54.3%) cases of hanging and 4 (80%) cases of strangulation. Rupture of the skin was present in 51 (72.9%) cases of hanging and present in 4 (80%) cases of strangulation (Table 1). Congestion of skin was present in 43 (61.4%) cases of hanging and 2 (60%) cases of strangulation. Cellular infiltration of the skin was present in 9 (12.9%) cases of hanging and 1 (20%) case of strangulation (Table 2).

Oedema of the skin was present in 46 (65.7%) of cases of hanging

Table 1 : Comparing histopathological changes in hanging and strangulation (compression of skin and rupture of skin)

Compression of skin	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	32	45.7	1	20
Present	38	54.3	4	80
Total	70	100	5	100
Rupture of skin	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	19	27.1	1	20
Present	51	72.9	4	80
Total	70	100	5	100

Table 2: Comparing histopathological changes in hanging and strangulation (Congestion of skin and Cellular infiltration of skin)

Congestion of skin	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	27	38.6	2	40
Present	43	61.4	3	60
Total	70	100	5	100
Cellular infiltration of skin	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	61	87.1	4	80
Present	9	12.9	1	20
Total	70	100	5	100

and 3 (60%) of cases of strangulation. Haemorrhage of the skin was present in 20 (28.6%) cases of hanging and 5 (100%) cases of strangulation (Table 3). Congestion of subcutaneous tissue was present in 28 (40%) cases of hanging and 2(40%) cases of strangulation. Haemorrhage of subcutaneous tissue was present in 15 (21.4%) cases of hanging and 3(60%) cases of strangulation (Table 4).

Discussion :

Compression of skin: Indicates decreased thickness of the skin layers and increased basophilia.⁸ Rupture of skin: Means discontinuity/ breakage of epidermal and/or dermal layers of the skin.⁸ Oedema of skin: Escape and abnormal accumulation of fluid (homogenous, dark stained fluid) in the interstitium.⁹ Compression of skin was observed in 54.3 % of the cases of hanging in the present study. Whereas, it was observed in only 43.95% of the cases in the study by Anil Yadav. K Jyothi Prasad observed it in only 33.73% of the cases. In strangulation compression of skin was observed in 80% of cases. In cases of

Table 3 : Comparing histopathological changes in hanging and strangulation (Oedema of skin and Haemorrhage in skin)

Oedema of skin	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	24	34.3	2	40
Present	46	65.7	3	60
Total	70	100	5	100
Haemorrhage in skin	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	50	71.4	0	00
Present	20	28.6	5	100
Total	70	100	5	100

Table 4: Comparing histopathological changes in hanging and strangulation (Congestion of subcutaneous tissue and Haemorrhage of subcutaneous tissue)

Congestion of subcutaneous tissue	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	42	60	3	60
Present	28	40	2	40
Total	70	100	5	100
Haemorrhage of subcutaneous tissue	Hanging		Strangulation	
	Frequency	Percentage	Frequency	Percentage
Absent	55	78.6	2	40
Present	15	21.4	3	60
Total	70	100	5	100

hanging, rupture of skin was the commonest and was present in 72.9% of the cases. Anil Yadav observed a rupture of skin in 33.3% of the cases. K Jyothi Prasad noted rupture of skin (breaking of skin) in 25.3% of cases. He had also studied the waviness of skin (wrinkling) in 36.4%

of the cases. Rupture of skin was present in 80% of cases of strangulation.

Congestion of skin was present in 61.4 % of cases of hanging in the present study, whereas, it was present in only 28.5% of the cases in the study by Anil Yadav. Congestion of the skin was observed in 60% of strangulation cases in the present study. Cellular infiltration of the skin was observed in 12.9% of cases of hanging. It is the least common histopathological finding in hanging. In a study conducted by Anil Yadav, it was present in 32.9% of the hanging deaths. Cellular infiltration was present in 20% of the cases of strangulation in the present study.

Oedema of the skin was present in 65.7% of the cases. It is described as escape of fluid (homogenous, dark stained fluid) into surrounding tissue.⁹ Oedema of skin was not studied by any one before. In strangulation, the most common finding was haemorrhage in the skin which was present in all the cases of strangulation, but it was present only in 28.6% of the cases of hanging. Gross internal injury to neck structures was present in 80% of the cases of strangulation. In one case of strangulation, gross internal neck injuries were absent in which histopathological changes could be demonstrable. The above findings can be explained on the basis that strong pressure, which is often more than required, will be applied in any case of strangulation. The victim may try to pull the ligature away using their fingers in an attempt to save them self which could also lead to the above findings. Congestion and Haemorrhage of subcutaneous tissue in hanging subcutaneous tissue showed congestion and haemorrhage. Congestion was present in 40% of the cases while haemorrhage was present in 21.4% of the cases of hanging. In a similar study by K Jyothi Prasad congestion of underlying tissues was observed in 42.16% and the hemorrhagic collection was noticed in 21.68%. In a study by Anil Yadav,

congestion and haemorrhage in subcutaneous tissue were present in 52.7% and 20.8% of the cases respectively in hanging. Findings in both the above studies are consistent with the present study. In strangulation congestion of subcutaneous tissue was present in 40% of the cases, and haemorrhage of subcutaneous tissue was present in 60% of cases. Anil Yadav described that congestion and haemorrhage of subcutaneous tissue were present in all the cases of strangulation.

Skin compression, skin haemorrhage, and cellular infiltration of the skin were more marked in strangulation than hanging. Skin congestion/plethora, rupture and oedema were equally present in both hanging and strangulation. The haemorrhage of subcutaneous tissue was more marked in strangulation than in hanging. Congestion of subcutaneous tissue was equally present in hanging and strangulation. Rupture of skin was the commonest histopathological finding either when a hard ligature or soft ligature material was used. The second commonest histopathological finding in cases of hanging was compression of skin when a hard material and congestion of skin when a soft material was used. Thus, hard materials lead to easy compression of skin while soft material led to easy congestion of skin than compression. In some cases, histopathological findings were present when gross findings were absent.

Limitation of the study is that the number of cases in hanging and strangulation are 70 and 5 respectively. These numbers are far from similar. The root cause of this fact is that the number of strangulation cases that are brought for autopsy examinations are very low compared to the number of hanging cases.

Conclusion :

Based on the analysis of the various histopathological changes the present study concludes that a detailed evaluation of histopathological findings of the neck structures like skin compression, skin haemorrhage and haemorrhage of subcutaneous tissue if undertaken, would be more conclusive in establishing the cause and manner of death and to aid the administration of justice. This study also provides a foundation on which to base future studies like identifying the nature of ligature of material used in asphyxial deaths, based on histopathological findings.

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ORIGINAL ARTICLE

Patterns of Frontal Sinus Aplasia in Adult Nigerians

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Abstract :

Frontal sinus (FS) aplasia shows side, gender, population, and racial variations. Its identification is important in forensic investigations and endoscopic surgeries through the FS. This study aimed at determining the patterns of FS aplasia in adult Nigerians. Brain computed tomographic images of 336 patients aged ≥ 20 years were retrospectively evaluated at the radiology department of a tertiary hospital in Nigeria following ethical approval from the institution's ethical board. The frontal bone was assessed bilaterally for FS agenesis. Data were categorized based on gender and 10 years age groups and analyzed using statistical package for social sciences version 23. Chi-square was used to evaluate for gender and side differences in the prevalence of FS aplasia. A p-value of <0.05 was considered statistically significant. The prevalence of FS aplasia was 44,13.1% with higher bilateral (31,9.2%) than unilateral (13,3.9%) occurrence. The prevalence of unilateral FS aplasia was 2.1% and 1.8% on the right and left sides respectively. There was a statistically significant side difference in the prevalence of FS aplasia ($p=0.001$). The gender and age differences in the prevalence of FS aplasia were not statistically significant ($p=0.380, 0.746, 0.391$). The patterns of FS aplasia varied from previously documented reports and may not be useful in sex determination and age estimation of unknown skulls in the studied population. Furthermore, preoperative radiological identification of FS aplasia is imperative to minimize complications during endoscopic surgeries through the FS.

Keywords : Frontal; Sinus; Aplasia; Agenesis.

Introduction :

The frontal sinuses (FS) are paired lobulated mucosal lined air cavities housed in the squamous part of the frontal bone, posterior to the superciliary arches.¹ They are separated by a bony intersinus septum that is rarely at the midline.² Each of them develops independently with associated asymmetrical pneumatization and unequal resorption of diploe.³ The FS is the only sinus that is not radiologically visible at birth.² Its development commences directly as an upward extension of the anterior portion of the nasal capsule in the fourth foetal month. The FS is radiographically evident by 5-9 years of age.⁴ The sinus reaches the adult size by 20 years and remains stable from bone resorption with advancing age.⁵

The FS may be absent, commonly referred to as FS aplasia or agenesis.³ The agenesis of the FS is variable in different population groups.⁴ This FS variant can be used as an auxiliary tool for personal identification.^{5,6} Preoperative identification of the FS agenesis is paramount to otorhinolaryngologists prior to endoscopic sinus surgery and to neurosurgeons performing minimally invasive skull base procedures via the frontal sinus, in order to minimize complications.^{4,7} It is important to recognize FS aplasia to prevent misdiagnosis as FS pathology.⁸ Therefore, this study aimed at determining the prevalence of FS aplasia in adult Nigerians.

Materials and Methods :

This descriptive cross-sectional retrospective study was conducted in the radiology department of Delta state university teaching hospital Nigeria. Prior to the commencement of this study, ethical approval was obtained from the hospital's Research and Ethics Committee; EREC/PAN/2020/030/0371. Three hundred and thirty-six (336) brain computed tomography (CT) images of 199 and 137 adult male and female patients respectively, taken between 1st June 2015 to 30th June 2020 were utilized in this study. These patients were aged between 20 and 99 years. CT images of patients below 20 years, images with artifacts, sinonasal pathologies, skull congenital anomalies, facial trauma, or surgery were excluded from this study.

In total, 672 frontal sinuses were evaluated in axial images, as well as coronal and sagittal reformatted images. The age and gender of the patient were recorded. The side with absent frontal bone pneumatization and no ethmoid cells extending above the supraorbital margin was identified as FS aplasia.⁹ Data were analyzed using statistical package for social sciences (SPSS) version 23 (IBM corporation, Armonk, New York, USA). Categorization of data was done according to gender and 10-year age groups. The age of the patients was presented in means and standard deviations while the frequency of the FS aplasia was presented in percentages. A Chi-square test was used to evaluate for gender, age, and side differences in the frequencies of the variants. A p-value of <0.05 was considered statistically significant.

Results :

This study evaluated 336 images of 199 males (59.2%) and 137 females (40.8%) with an age range of 20-99 years and an average age of 53.29 ± 18.18 years. The average age in females (56.18 ± 18.87 years) was slightly higher than that in males (51.29 ± 17.46 years). The CT images studied were classified into

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10 years age groups. The 50-59 years age group had the highest proportion (19.9%) followed by 60-69 years (16.4%). The older age groups namely; 80-89 years and 90-100 years had the least proportion of patients (5.7% and 2.1% respectively). There were more females than males in the 50-59, 60-69, 80-89, and 90-100 years age groups. On the other hand, the 20-29, 30-39, 40-49, and 70-79 years' age groups had more males than females (Table 1).

Table 1 : Gender distribution in the different age groups.

Age-group (years)	N	%	Female	%	Male	%
20-29	40	11.9	14	10.2	26	13.1
30-39	50	14.9	15	10.9	35	17.6
40-49	52	15.5	18	13.1	34	17.1
50-59	67	19.9	30	21.9	37	18.6
60-69	55	16.4	26	19.0	29	14.6
70-79	46	13.7	18	13.1	28	14.1
80-89	19	5.7	10	7.3	9	4.5
90-100	7	2.1	6	4.4	1	0.5
Total	336	100	137	100	199	100

The absence of FS was seen in 44 (13.1%) patients and was more predominant in females (22, 16.1%) than in males (22, 11.1%). Bilateral FS aplasia was more prevalent (31, 9.2%) than unilateral FS aplasia (13, 3.9%). Both bilateral and unilateral FS aplasia had a higher prevalence in females than in males, however, the gender difference was not statistically significant ($p=0.074$, 0.187) (Table 2). Out of the 13 skull images with unilateral FS aplasia, 7 (2.1%) and 6 (1.8%) had FS aplasia on the right and left side respectively. All the 6 (4.4%) females with unilateral FS aplasia had the variant on the right side while in males, 1 (0.5%) patient had it on the right and the remaining 6 (3.02%) had FS aplasia on the left (Fig. 1 and 2). The prevalence of FS aplasia on each side was higher in females than in males. However, this was not statistically significant. ($p=0.380$ and 0.746) (Table 3). We report a statistically significant side difference in the prevalence of FS aplasia ($p=0.001$).

The unilateral FS aplasia had a prevalence of 5.5%, 4.3%, and 4.0% in the 60-69, 70-79 and 30-39-year age groups respectively. This variant was not observed in the 40-49, 80-89, and 90-100-

Table 2 : Prevalence of FS aplasia

Variant		Prevalence				
		N	Bilateral		Unilateral	
			N	%	N	%
FS aplasia	Female	137	16	11.7	6	4.4
	Male	199	15	7.5	7	3.5
	Total	336	31	9.2	13	3.9

Table 3 : Prevalence of FS aplasia on either sides

FS aplasia	Female		Male		Total		P Value
	N=274	%	N=398	%	N=672	%	
Right	22	8.0	16	4.0	38	5.7	0.380
Left	16	5.8	21	5.3	37	5.5	0.746
Total	38		37		75		

Table 4 : Prevalence of FS aplasia in the different age-groups

Age-group (years)	Unilateral aplasia	%	Bilateral aplasia	%
20-29	1	2.5	5	12.5
30-39	5	4.0	3	6
40-49	0	0	3	5.8
50-59	2	3.0	6	9
60-69	3	5.5	9	16.4
70-79	2	4.3	4	8.7
80-89	0	0	1	5.3
90-100	0	0	0	0
Total	13		31	

year age groups. The prevalence of bilateral FS aplasia was 16.4%, 12.5%, and 8.7% in 60-69, 20-29, and 70-79-year age groups respectively. The least prevalence was seen in 80-89 (5.3%) and 90-100 (0%) years age groups (Table 4). The differences in the prevalence of these variants in the different age groups were not statistically significant (0.391). Table 5 shows the comparison of FS aplasia in different populations.

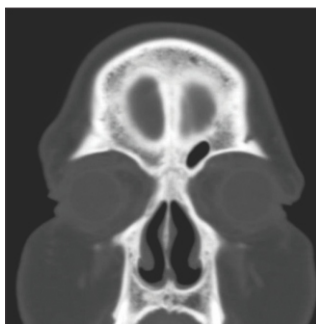
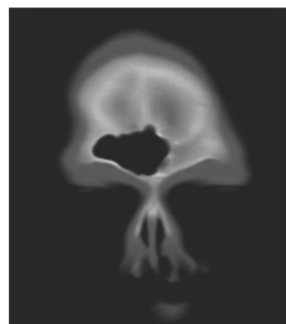
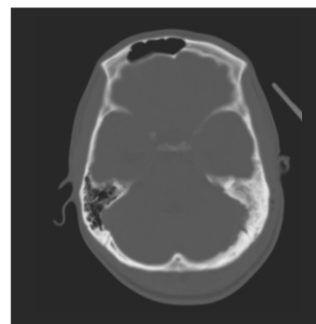
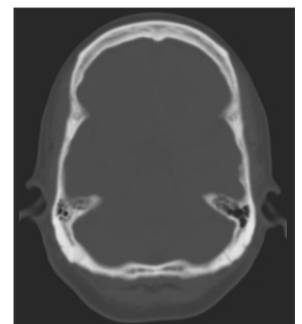
Discussion :

The prevalence of FS aplasia in this study was 13.1% as documented in a previous study.¹⁰ This was lower than 58% documented in a Nigerian study by Amusa et al.¹¹ This difference may be attributed to the differences in sample size and methodology whereby, Amusa et al,¹¹ evaluated the FS endoscopically on 24 cadaveric specimens while this study utilized skull CT images of 336 patients. A Brazilian study by Simoes et al.¹² evaluated 1005 CT images and recorded a very low prevalence of FS aplasia (1%). Another study in Brazil used 100 macerated skulls to study the FS and reported the absence of FS in 24% of the skulls.⁷ The finding of this study was higher than the prevalence of other CT studies in Turkey and Saudi Arabia.^{8,13-15} This implies that the prevalence of FS aplasia varies within the same population group and between races. The hot climate in the geographical area of the current study may explain the low prevalence of FS aplasia. This is based on literature reports that link a low prevalence of FS aplasia to warm climatic regions. FS agenesis is more prevalent in colder climatic regions as an adaptive mechanism to facilitate the conservation of heat and insulation.³ The under-development of the FS in the African

Table 5 : Comparison of FS aplasia in different populations.

Author	Country	Methodology	N	Aplasia		
Aydinlioglu et	Turkey	CT	1200		2	3.8
Ponde et al. ⁷	Brazil	Cadaveric	100	24.7	11.7	3.4
Cameriere et al. ¹⁷	Turkey	Radiograph	99		2	10
Cakur et al. ⁴	Turkey	DVT	410		1.22	0.73
Amusa et al. ¹¹	Nigeria	Endoscopy	24	58	8	50
Patil et al. ¹⁸	India	Radiograph	100		3	1
Verma et al. ⁵	India	LC	149			5.4
Dasar and Gokce ¹³	Turkey	CT	400	7.2		
Nategghian et al. ²³	Iran	CT	65		13.8	13.8
Soman et al. ¹⁶	India	LC	200		3	6.5
Pandeshwar et al. ¹	India	Radiograph	100		8	6
Benghiac et al. ²²	Romania	CT	30		2.13	0
Simoes et al. ¹²	Brazil	CT	1005	1		
Dafalla	Sudan	CT	506			11.7
Alshaikh and Aldhuraish, ¹⁵	Saudi Arabia	CT	219	7.3		
Shireen et al. ¹⁹	India	Radiograph	400		2	1.25
Gadekar et al. ²	India	Radiograph	400			8
Gungor and okur ⁸	Turkey	CT	132	5.6		

DVT- Dental Volumetric Tomography, LC- Lateral Cephalogram, CT- Computed Tomography.

**A. Left FS aplasia****B. Right FS aplasia****FS aplasia****FS aplasia**

population has also been attributed to the customary carrying of heavy loads on the head.¹¹

FS aplasia occurred more bilaterally (9.2%) than unilaterally (3.9%). This was also observed by Amusa et al.¹¹ in Nigeria, however, the prevalence of bilateral FS aplasia in their study was very high (50%) possibly due to the small sample size used. Soman et al.¹⁶ also reported a higher prevalence of bilateral FS aplasia (6.5%) compared to unilateral FS aplasia (3%) on lateral cephalograms studied in India. Similarly, this pattern was

observed in radiographs (10% and 2%) and CT images (3.8% and 2%) studied in Turkey by Cameriere et al.¹⁷ and Aydinlioglu et al.³ FS aplasia was more predominant compared to bilateral FS aplasia in the radiographic studies carried out in India. Their prevalence was 3%, 1%, 8%, 6% and as documented by and Shireen et al.¹⁹ respectively. Likewise Cakur B,⁴ analyzed dental volumetric tomographic images of 410 patients and reported more unilateral (1.22%) than bilateral FS aplasia (0.73%). This pattern was also documented among Jordanians and Saudi Arabians.^{9,20}

Verma et al.⁵ and Dafalla et al.²¹ only observed the agenesis of the FS bilaterally with a frequency of 5.4% and 11.7% in India and Sudan. On the contrary Benghiac AG,²² observed the variant unilaterally with a prevalence of 2.13% in Romania. According to Nateghian et al.,²³ the absence of the FS unilaterally or bilaterally occurred with an equal prevalence of 13.8% in Iranian adults. The patterns of FS aplasia, therefore, vary in different population groups probably due to genetics, race, ethnicity, and geographical location.

FS aplasia was more commonly seen in females (16.1%) than in males (11.1%), however, the difference was not statistically significant ($p=0.074$). Aydinlioglu et al.³ documented the same pattern in Turkey, however, their frequencies were lower than the observed frequencies in the present study (5.9% and 3.8% for females and males respectively). On the contrary, Al-Balas et al.²⁰ reported a male preponderance in the FS agenesis among Jordanians. This present study found a higher frequency of bilateral FS aplasia in females (11.7%) than in males (7.5%) and this was consistent with two Turkish studies by Aydinlioglu et al.³ (5.1%, 1.3%) and Cakur et al.⁴ (0.49%, 0.24%). These scholars ascribed this to gender differences in the craniofacial development, growth hormone, and thickness of the frontal bone.

The prevalence of unilateral right FS aplasia was 2.1%. This was higher than 1.0% reported by Gadekar et al.² in India and lower than 9.2% documented by Nateghian et al.²³ in Iran. The prevalence of unilateral right FS agenesis was higher in females (4.4%) than in males (0.5%), corresponding to the reports by Aydinlioglu et al.³ (4%, 1.6%) and Nateghian et al.²³ (16.7%, 4.9%). The unilateral left FS aplasia had a lower prevalence (1.8%) compared to the findings by Gadekar et al.² (3.3%) and Nateghian et al.²³ (4.6%). This left FS agenesis in the present study was only observed in males (3.02%). A higher prevalence in males than in females was documented by Nateghian et al.²³ (4.9%, 4.2%) and Aydinlioglu et al.³ (2%, 1.9%). However, Cakur et al.⁴ did not observe unilateral left FS aplasia in males and documented a very low frequency in females (0.49%).

The current study established a statistically significant side difference in the occurrence of FS aplasia and this could possibly be ascribed to the independent embryonic development of each sinus.³ The variation of FS aplasia in different populations has been attributed to gender, ethnic, geographic, and racial differences, climatic conditions, frontal bone anatomy, mechanical masticatory stress, the sample size, age, and the examining technique with different landmarks used for evaluation.^{4,10,11,22} The findings of this study revealed that the occurrence of FS aplasia is not dependent on age or gender. Therefore, this variant may not be useful in sex determination and age estimation during forensic investigations within the studied population.⁹ That in the absence of FS, the sphenoid sinus together with other standard methods of identification may be applied in forensic investigations. Furthermore, it is important for surgeons to be cognizant of the existence of FS agenesis preoperatively for safe endoscopic surgeries.⁴

Conclusion :

The pattern of FS aplasia varied from previously documented reports and may not be useful in sex determination and age estimation of unknown skulls in the studied population. Furthermore, preoperative radiological identification of FS aplasia is imperative to minimize complications during endoscopic surgeries through the FS.

Strength of Study :

The study utilized CT images in the evaluation of the FS since CT accurately depicts the anatomy and pathology of the paranasal sinuses.

Limitation of Study :

This was a single-center study with a small sample size hence the findings cannot be generalized.

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Conflict of Interest : None

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ORIGINAL ARTICLE

A Retrospective Observational Study of Appearance and Fusion of Ossification Centres in Lower Limb Radiographs of Patients Reported in the Tertiary Health Care Centre

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Abstract :

Bone ossification study is the most important part of age determination. Earlier studies were predominantly done on upper limb bones & joints; hence this bone ossification study of lower limb bones gives the opportunity to correlate earlier findings with the present study. A Retrospective cross-sectional study has been done in order to study bone ossification patterns in western Maharashtra. Lower limb radiographs of patients of the age group ranging from 1 month – 25 years reported from 1st April 2017 to 31st March 2020 at the tertiary hospital were studied for appearance and fusion of ossification centres. Out of 429 patients, 236 were male and 193 females. Cases were divided joint-wise into two groups for appearance & fusion study. Age of appearance & fusions compared with Gaulstaun's chart & other studies, which are found mostly similar with some variations of 1-2 years attributed to region & sex of the individual. Complete fusion of epiphysis is a more accurate indicator of age than the stage of fusion. In general, females show appearance & fusion of ossification centres, 1-2 years earlier although with some exceptions. We recommend more such studies be undertaken, region-wise with more sample size.

Keywords : Ossification study; Hip; Knee; Ankle.

Introduction :

Age determination is essential in cases of living & dead, not only for identification purposes but also for various civil and criminal purposes. Bone is vascular and mineralized special connective tissue, which is remarkable for its characteristic growth mechanism.¹ Bony age can be determined from the study of growing ends of long bones. Determination of age presents a task of considerable importance & a mistake committed in this regard may be of serious consequence and may result in a miscarriage of justice.² India is a diverse country that differs in climatic, hereditary & dietetic factors which affect skeletal growth; hence it is not reasonable to formulate a uniform standard for the epiphyseal union to apply all over India.³ From the findings of various researchers, it is evident that there is a difference in the age of epiphyseal union in India and abroad and also in different states of India.⁴ Although Upper limb bones have more accuracy for age estimation, in situations where the upper limb is not available or can't be radiographed, lower limb bones may provide equally vital information regarding age. Very few studies have been done in India, especially in the western Maharashtra region on the ossification of lower limb bones. Most references for ossification are drawn from textbooks in India, which are based on old studies done decades earlier. For example, Modi's Medical Jurisprudence & Toxicology³ refers to studies done in pre-independent India like Galstaun's for the appearance & fusion of ossification centres; hence it is necessary to conduct

contemporary studies for knowing whether these findings are valid in present times as well. Also, regional & ethnic variations demand that these studies should be done in all regions of India. For addressing this problem, the present study has been done on lower limb bone ossification pattern seen in western Maharashtra.

Aim : To assess the skeletal maturity in the lower limb for a known chronological age.

Objectives:

To compare the study of appearance and fusion of ossification centres in the lower limb.

To evaluate sex-related variation & its correlation with age.

To know variations of appearance & fusion of centres of ossification.

To suggest any additional radiological investigation to aid and reduce the range in determining age.

Materials and Method :

Study Design: Retrospective observational cross-sectional study

Study Area: Dr. D. Y. Patil medical college, hospital & research centre, Pimpri, Pune, Dr. D. Y. Patil vidyapeeth, Pune. 411018. (Maharashtra State)

Duration & Sample Size of Study: 429 radiographs of the lower limb of patients of the age group ranging from 1 month – 25 years reported from 1st April 2017 to 31st March 2020 treated at tertiary health care centre were studied for appearance & fusion of ossification centres.

Sampling technique: patient's radiograph data at radiology department Server MEDSYNAPSE PACS.

Inclusion criteria: Radiographs of Patients of the age group ranging from 1 month – 25 years reported from 1st April 2017 to 31st March 2020 at Dr. D.Y. Patil Medical College, Hospital and

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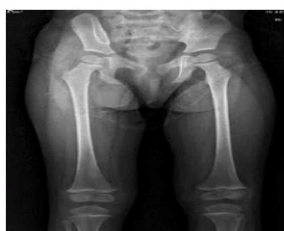


Figure 1: 2yr F; Appearance Head & distal end femur, proximal end tibia



Figure 2: 5yr F: Appearance GT



Figure 3: 3yr M Appearance Head femur & distal end



Figure 4: 13 M, LT Appeared but not fused



Figure 5: 16yr F, Iliac crest & ischial tuberosity appeared, femur proximal end fused.



Figure 6: 17yr M, Proximal end femur Near fusion(F4), Iliac crest appeared, Ischial tuberosity not appeared.



Figure 7: 2yr F, Knee, Ankle Appearance proximal & distal Tibia



Figure 8: 3yr M, Ankle Appearance distal Tibia, Fibula, cuboid & Navicular

Fig. 1-4 Ossification Centre's appearance Hip & Knee joint; Fig. 5-6 Fusion Ossification Centre's Hip joint; Fig. 7-8 Ossification Centre's appearance Ankle joint



Figure 9: 16yr F, Knee Near complete fusion(F4)



Figure 10: 17yr M, Knee Near complete fusion(F4)



Figure 11: 18yr F, Knee complete fusion(F5)



Figure 12: 19yr F, Knee complete fusion(F5)



Figure 13: 15yr M, Knee Incomplete stage (F3) fusion



Figure 14: 13yr M, Knee Incomplete stage (F2) fusion



Figure 15: 9yr F, Calcaneum secondary centre (A)



Figure 16: 13yr F, Calcaneum secondary centre Fused



Figure 17: 15yr M, Distal Tibia incomplete (F2) fusion, Calcaneum secondary centre near fusion



Figure 18: 17yr M, Distal tibia & fibula complete fusion (F5)

Fig. 9-14 Ossification Centre's fusion Knee joint; Fig. 15-18 Fusion Ossification Centre's Ankle joint

Research Centre, Pune.

Exclusion criteria: Patients of the age group less than 1 month and more than 25 years were excluded from the study. Nutrition and socioeconomic status were not assessed.

Permission of institutional ethics committee taken vide letter no. DYPV/EC/ 501/ 2020 dated 4/06/2020.

Methodology:

The epiphysis of lower limbs was observed for appearance (A) and non-appearance (NA) of ossification centres and different phases of fusion will be graded according to Dr. William Sangma et al and Mckern and Stewart 5 stages as follows:

Stage 1 (F1) : Non-union

Stage 2 (F2) : Commence of union (1/4th united)

Stage 3 (F3) : Incomplete union (1/2 united)

Stage 4 (F4) : Complete union (3/4 united)

Stage 5 (F5) : Complete union – with the absence of epiphyseal scar.

Skeletal maturity will be evaluated radiologically, studying the various centres of ossification and the results compared with the previous known standard studies.

Observation & Results :

Out of 429 patients, 236 were male and 193 females. Study of ossification around hip, knee & ankle done in 133, 162 & 134 cases respectively. The appearance of ossification centres was studied in patients aged 1-14.9yr for hip (75) and 1-11.9yr for knee (76) & ankle joints (57). Fusion of ossification centres was studied in the age group 15-22yr for hip (58) and 12-22yr for knee (86) & ankle (77) joints.

Hip: Appearance

The appearance of ossification centres of the hip along with tri-radiate was studied in 75 patients (Table 1) of which 39 were males & 36 females in the age group 1 to 15 years. The head of the femur appeared in all cases from 1 year onwards. Greater trochanter appeared in females- 40% cases in 3rd year, 50% in 4th year & 100% cases in 5th year above, whereas in males- 33% in 3rd year, 50% in 4th year & 100% cases in 5th year above.

Lesser trochanter appeared in females- 50% in 12th & 13th year each & 100% 14th year above; whereas in males- 33% in 12th year & 100% in 13th year above.

Lesser trochanter fusion was observed in females- 50% cases 14th year & 100% 15th year above; while in males- 100% cases 14th year above.

Iliac crest appeared in all females 14th year above, whereas in males- 50% cases in 14th year & 100% cases 15th year above.

Tri-radiate cartilage completely fused in females- 50% cases 14th year & 100% cases 15th year above, while in males- all cases 15th year above the shown fusion.

Table 1

SECONDARY OSSIFICATION CENTERS AROUND HIP JOINT: APPEARANCE AGE 1-14 YEARS								
Age Range (years)	Sex	Total number of cases	Head 1yr	GT 4yr	Iliac crest	LT		Tri - radiate
						A 12 - 14yr	F 14 16yr	
1 -1.99	F	3	3					
	M	2	2					
2 -2.99	F	2	2					
	M	3	3					
3 -3.99	F	5	5	2				
	M	3	3	1				
4 -4.99	F	2	2	1				
	M	2	2	1				
5 -5.99	F	4	4	4				
	M	2	2	2				
6 -6.99	F	3	3	3				
	M	3	3	3				
7 -7.99	F	2	2	2				
	M	3	3	3				
8 -8.99	F	2	2	2				
	M	4	4	4				
9 -9.99	F	3	3	3				
	M	3	3	3				
10 -10.99	F	1	1	1				
	M	3	3	3				
11 - 11.99	F	3	3	3				
	M	2	2	2				
12 - 12.99	F	2	2	2		1		
	M	3	3	3		1		
13 - 13.99	F	2	2	2		1		
	M	3	3	3		3		
14-14.99	F	2	2	2	2	2	1	1
	M	3	3	3	1	3	3	

Table 2

SECONDARY OSSIFICATION CENTERS AROUND HIP JOINT: FUSION														Trirad. Cart. 13- 15 yr	
AGE 15-22 YEARS															
Age Range (years)	Sex	Total num ber of case s	Stage of Fusion of Conjoint Epiphysis to shaft 17-18yr					Isc hial Tu ber osit y A 16y r	Isc hial Tu ber osit y F 20y r	Stage of fusion of Iliac crest 16-21yrs					
			F1	F2	F3	F4	F5			F1	F2	F3	F4	F5	
15 - 15.99	F	2			2							2			2
	M	4		2	2						2	2			4
16 - 16.99	F	5			2	3		3				2	3		5
	M	6			4	2		3				4	2		6
17 - 17.99	F	4				1	3	4				3	1		4
	M	5				3	2	2			2	3			5
18 - 18.99	F	3					3	3					2	1	3
	M	6				1	5	6				2	4		6
19 - 19.99	F	4					4	4	1				4		4
	M	5					5	5	2			2	3		5
20 - 20.99	F	3					3	3	3				1	2	3
	M	3					3	3	3				2	1	3
21 - 21.99	F	2					2	2	2					2	2
	M	2					2	2	2					2	2
22 - 22.99	F	1					1	1	1					1	1
	M	3					3	3	3					3	3

Fusion :

Fusion of ossification centres around hip joints studied in 58 cases (Table 2) of which 34 were male & 24 females of age 16- 22 years. Femur conjoint epiphysis to shaft showed near fusion in both male & females F4/F5 stage in 17th year & complete fusion F5 stage in males 19 years onwards & females 18 years onwards.

Iliac crest in both males & females near fusion F4/F5 stage observed 20th year & complete fusion F5 stage 21 year onwards.

Ischial tuberosity appeared in females- 60% cases 16th year, & 100% 17th year onwards, whereas in males- 50% cases in 16th year, 40% 17th year & 100% 18th year above.

Ischial tuberosity complete fusion observed in females- 25% cases in 19th year & 100% 20th year onwards, while in males- 40% cases in 19th year & 100% 20th year above.

Knee: Appearance

The appearance of ossification centres around knee joints studied in 76 cases (Table 3) of which 40 were males & 36 females of age 1 to 12 years

Ossification centres for distal end femur & proximal end Tibia appeared in all cases 1st year onwards. proximal end Fibula appeared in females- 50% cases in the 3rd year, 60% 4 & 5th years

& 100% cases 6th year above; whereas in males- 14% in the 3rd year, 50% 4th year, 60% 5th year & 100% 6th year onwards.

Fusion

Fusion of ossification centres around Knee Joints was studied in 86 cases (Table 4) of which 47 were male & 39 females in the age group 13 to 22 years. Distal end Femur & proximal end tibia/fibula fused with their respective shafts as follows: Females showed near fusion F4/F5 stage 16 year onwards & complete fusion F5 stage 17 year onwards; whereas in males near fusion F4/F5 stage seen in 17 to 19 years & complete fusion F5 stage saw 20 years onwards.

Ankle: Appearance

The appearance of ossification centres & tarsals at the ankle joint was studied in 57 cases (Table 5) of which 32 were males & 25 females from 1 to 12 years of age. Calcaneum 10 centre, talus, cuboid (intrauterine development) & lateral cuneiform centres appeared in all cases in 1st year.

Calcaneum secondary centre appeared in females 50% cases 5th year, 66% 6 years, 50% 7 years & 100% cases 8th year onwards, while in males: 33% cases 5th & 6th year, 50% 7th year, 100% cases 8th year onwards. Navicular appeared in females- 60% cases 4th year, 100% cases 5th year onwards & in males- 50% 4th year, 50%

Table 3

SECONDARY OSSIFICATION CENTERS AROUND KNEE JOINT: APPEARANCE AGE 1 - 12 YEARS					
Age Range (years)	Sex	Total number of cases	Distal end Femur Birth	Proximal end Tibia Birth	Proximal end Fibula 4yr
1 - 1.99	F	4	4	4	
	M	2	2	2	
2 - 2.99	F	3	3	3	
	M	2	2	2	
3 - 3.99	F	2	2	2	1
	M	7	7	7	1
4 - 4.99	F	3	3	3	2
	M	6	6	6	3
5 - 5.99	F	3	3	3	2
	M	5	5	5	3
6 - 6.99	F	3	3	3	3
	M	2	2	2	2
7 - 7.99	F	4	4	4	4
	M	3	3	3	3
8 - 8.99	F	5	5	5	5
	M	4	4	4	4
9 - 9.99	F	2	2	2	2
	M	2	2	2	2
10 - 10.99	F	4	4	4	4
	M	5	5	5	5
11 - 11.99	F	3	3	3	3
	M	2	2	2	2

5th year, 66% 6th year & 100% cases 7th year onwards.

Medial cuneiform appeared in females- all cases 2nd year onwards; males: 50% 2nd year, 50% 3rd year & 100% 4th year onwards

Middle cuneiform appeared in females- all cases 3rd year onwards & males: 50% cases in 3rd year, 50% 4th year, 50% 5th year & 100% cases 6th year onwards.

Ossification centres for 1st/2nd/3rd metatarsals appeared in females: 50% cases 3rd year, 66% 4th year & 100% cases 5th year onwards, whereas in males: 50% cases in 4th year, variable appearance 5-6

Table 4

SECONDARY OSSIFICATION CENTERS AROUND KNEE JOINT: FUSION AGE 12 - 22 YEARS							
Age Range (years)	Sex	Total number of cases	Distal end Femur & Proximal end Tibia - Fibula				
			F1	F2	F3	F4	F5
12 - 12.99	F	4	2	2			
	M	5	3	2			
13 - 13.99	F	5		3	2		
	M	5	1	2	2		
14 - 14.99	F	2	0	0	2		
	M	4		2	2		
15 - 15.99	F	3		0	1	2	
	M	4			2	2	
16 - 16.99	F	3			0	1	2
	M	5			1	3	1
17 - 17.99	F	4				0	4
	M	5				4	1
18 - 18.99	F	8					8
	M	5				2	3
19 - 19.99	F	3					3
	M	4				1	3
20 - 20.99	F	3					3
	M	4					4
21 - 21.99	F	2					2
	M	3					3
22 - 22.99	F	2					2
	M	3					3

year & 100% cases 7th year onwards. Centres for 4th & 5th metatarsal- appeared in all cases 7th year onwards.

Ossification centre of distal end tibia and fibula appeared in 1st year onwards in both males & females for all cases.

Fusion :

Fusion of ossification centres around ankle joints was studied in 77 cases (Table 6) of which 42 were male & 35 females 12- 22 years of age. Secondary centre of calcaneum fused with the body in females in 60% cases at 13 years & 100% at 14 years onwards, while in males: 50% cases at 1 year, 25% 14 years, 75% 15 years & 100% cases 16 years onwards.

Table 5

PRIMARY/ SECONDARY OSSIFICATION CENTERS AROUND ANKLE JOINT: APPEARANCE AGE 1-12 YEARS																	
Age Range (years)	Sex	Total number of cases	Tarsals								Metatarsals 3 -4yr					Distal end Tibia 1yr	Distal end Fibula 1yr
			A	F	C / T	C U 1	N 3	L C 1	M I C 3	M C 2	1	2	3	4	5		
1 - 1.99	F	2			2	2		2							2	2	
	M	2			2	2		2							2	2	
2 - 2.99	F	2			2	2		2		2					2	2	
	M	2			2	2		2		1					2	2	
3 - 3.99	F	2			2	2		2	2	2	1	1	1		2	2	
	M	4			4	4		4	2	2					4	4	
4 - 4.99	F	3			3	3	2	3	3	3	2	2	2		3	3	
	M	2			2	2	1	2	1	2	2	1	1		2	2	
5 - 5.99	F	2	1		2	2	2	2	2	2	2	2	2	1	2	2	
	M	6	2		6	6	3	6	3	6	6	6	4	2	6	6	
6 - 6.99	F	3	2		3	3	3	3	3	3	3	3	2	2	3	3	
	M	3	1		3	3	2	3	1	3	3	3	2	1	3	3	
7 - 7.99	F	2	1		2	2	2	2	2	2	2	2	2	2	2	2	
	M	2	1		2	2	2	2	2	2	2	2	2	2	2	2	
8 - 8.99	F	2	2		2	2	2	2	2	2	2	2	2	2	2	2	
	M	3	3		3	3	3	3	3	3	3	3	3	3	3	3	
9 - 9.99	F	3	3		3	3	3	3	3	3	3	3	3	3	3	3	
	M	2	2		2	2	2	2	2	2	2	2	2	2	2	2	
10 - 10.99	F	2	2		2	2	2	2	2	2	2	2	2	2	2	2	
	M	3	3		3	3	3	3	3	3	3	3	3	3	3	3	
11 - 11.99	F	2	2		2	2	2	2	2	2	2	2	2	2	2	2	
	M	3	3		3	3	3	3	3	3	3	3	3	3	3	3	

Table 6

SECONDARY OSSIFICATION CENTERS AROUND ANKLE JOINT: FUSION AGE 12 -22 YEARS																		
Age Range (years)	Sex	Total number of cases	Stage of Fusion of Metatarsals Epiphysis to shaft 17 -18yr					Stage of Fusion distal end of Tibia to shaft 16 -17yr					Stage of Fusion distal end of Fibula to shaft 16 -17yr					Calcaneum Secondary centre 12 -14yr
			F 1	F 2	F 3	F 4	F 5	F 1	F 2	F 3	F 4	F 5	F 1	F 2	F 3	F 4	F 5	
12 - 12.99	F	3	2	1				2	1				2	1				
	M	5	5					5					5					
13 - 13.99	F	5	2	1	2			1	2	2			1	2	2			3
	M	6	4	2				3	1	2			3	1	2			2
14 - 14.99	F	3		1	2				1	2				1	2			3
	M	5		1	4				1	4				1	4			1
15 - 15.99	F	4		1	2	1				2	2				2	2		4
	M	4	1	2	1			2	1	1			2	1	1			3
16 - 16.99	F	5			2	3				2	3				2	2	1	5
	M	3			2	1				1	2					1	2	3
17 - 17.99	F	3					3					3					3	3
	M	6				2	4				1	5				1	5	6
18 - 18.99	F	4					4					4					4	4
	M	5					5					5					5	5
19 - 19.99	F	3					3					3					3	3
	M	1					1					1					1	1
20 - 20.99	F	2					2					2					2	2
	M	2					2					2					2	2
21 - 21.99	F	2					2					2					2	2
	M	2					2					2					2	2
22 - 22.99	F	1					1					1					1	1
	M	3					3					3					3	3

In females fusion of the distal end of the tibia & fibula to their shafts shows no variation with near fusion F4/F5 stage in 60% at 16 years & complete fusion F5 stage at 17 years onwards. Whereas in males near fusion of tibia F4/F5 stage in 66% at 16 years & 100% in 17 years; complete fusion F5 stage in all cases 18 years onwards. Near fusion of fibula lower end in males F4/F5 stage all cases at 16th & 17th year; while complete fusion F5 stage present 1 year onwards.

Fusion of secondary centres of metatarsals in females was observed in 25% of cases at 15 years, 60% at 16 years & 100% at 17 years onwards, whereas in males in 33% at 16 years & 100% at 1 year onwards.

Discussion :

Age determination by epiphyseal fusion is one of the most important scientific tools in Forensic Medicine. In the literature, there were many studies conducted on different parts of the body using various methods and modalities. In this study, the main emphasis has been given to the appearance of secondary ossification centres and the fusion of epiphysis with diaphysis.

Gaulstaun's study⁸ performed on the Bengali population extensively studied the appearance & fusion of ossification centres, findings of which are comparable to the present study. Appearance and fusion of ossification centres of the head of the femur (1 & 1-19yr), iliac crest (14 & 20-21yr) & ischial tuberosity (16 & 20yr) are similar to Gaulstan's chart with 1-2 years earlier in females.

Findings of ossification centres around the knee are similar to the study of Bhise SS⁹ in the Mumbai region that fusion of epiphysis of the distal end of the femur proximal end of tibia fusion occurs in most of the cases at 17 – 19 years for males and at 16 – 17 years for females. Majed O. A. and Osama R. E. in their study on the Saudi population concluded a long time taken for fusion (21-23yrs) which shows a regional variation.¹⁰

Gaulstaun's study of ankle & foot described the appearance of tarsals & secondary centres of metatarsals. Our study findings validate those earlier studies as well as make some additions like the secondary centre of calcaneum appears at 7 & 8yr and fuses at 14 & 16yr in females & males respectively. Fusion of distal end of tibia & fibula by 16-18 years showed no variation in males & females in our study which is in contrast to Bhise Ss¹¹ who concluded that in females' fusion occurs 2 years earlier than in males.

All studies were done until are on different populations in race, ethnicity, or residency, which had an influential but comparative effect on the epiphyseal union and on the results. Therefore, a comprehensive study was required in the Pune region to compare findings with earlier studies and to see the applicability of findings in medico-legal cases in Maharashtra.

Conclusion & Recommendations :

This research is an attempt to study the appearance & fusion of ossification centres of the lower limbs in a sample population of western Maharashtra. Results of the study show that most age of

appearances & fusion correlates with established reference ranges in Indian studies like Gaulstaun's on Bengali population & Bhise's on Mumbai population, but some variations observed underline the importance of conducting region-wise studies. Complete fusion of epiphysis is a more accurate indicator of age than the stage of fusion due to the complexity of interpretation of finding & borderline range of differentiation (Stage F1-F4). In general, females showed 1-2 years earlier appearance & fusion of ossification centres than males with some exceptions, which might be due to less sample size in some age groups.

We recommend more such studies to be region-wise undertaken with more sample size to make out variations in diverse populations like India. The use of Ultrasonography, MRI or other bone maturity assessment methods in age estimation should be explored whenever feasible & cost-effective.

Conflict of Interest: None

Source of Funding: Self

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ORIGINAL ARTICLE

Analysis of Questionnaire-based Response of Indian Medical Students about the Distinguishing Features of Relevant Toxic Plants, their Systemic Effects and Legal Provisions under Narcotic Drugs and Psychotropic Substance Act, 1985

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Abstract :

Drug abuse is a great social evil. It affects all aspects of life. The young generation of impressionable age easily falls into the trap and ruins their Physical, mental, social and financial health for the rest of their life. To control the situation, it is essential to know the level of awareness about the toxic plant, their systemic effects and various legal provisions under the NDPS Act 1985 so that a suitable strategy could be planned to fight Narcotic Drug abuse. A cross-sectional study was conducted between December 2020 and January 2021 among Phase 3 MBBS students in a medical college at Barabanki with the objective to estimate the level of awareness about the identification of plants, their systemic effects and legal provisions under the NDPS Act 1985. A total of 163 students (86 males and 77 females) participated in the study. 63.8% of students were well versed with the legal provisions of the NDPS Act 1985. 60.7% of students could recollect and correlate the morphological features of the plants covered under the NDPS Act 1985. Knowledge of the systemic effects of these toxic plants was not adequate. The knowledge of phase-3 MBBS students about toxic plant identification, their systemic effect and legal provisions under the NDPS Act 1985 is Moderate.

Keywords : Drug abuse; Phase-3 Medical students; Toxic plants; NDPS Act 1985.

Introduction :

Drug abuse is a great social evil. It is prevalent throughout the globe, covering all castes, creeds, cultures and religions. The young generation of impressionable age easily fall prey and ruins their physical, mental and social life. It ruins their finances and families.

According to India national crime record bureau (NCRB), 72799 cases under NDPS Act were registered in 2019 alone, mainly from Punjab (11536) and Uttar Pradesh (10198). To control the situation government has promulgated NDPS Act 1985. To succeed in the drug control awareness among medical personnel and the public about toxic plants, their systemic effect and various legal provisions under NDPS Act 1985 is essential so that a suitable strategy could be planned.

This study is to estimate the level of awareness among medical graduates who will have to play important role in the control of Narcotic drug abuse.

Aims and Objectives :

1. To Estimate the level of awareness among Phase-3 medical students about the identification of relevant toxic plants and their systemic effects.
2. To assess the prevailing Knowledge about various legal provisions under NDPS Act 1985 among medical students.

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Methodology: A cross-sectional study was conducted from 1st December 2020 to 31st January 2021 among Phase-3 MBBS students in a medical college at Barabanki. A pretested and validated questionnaire was used. Only volunteer participants after informed consent participated in the study. The questionnaire was divided into 3 parts with equal weightage. Each part had a maximum score of 5 and the cut-off score was set as ≥ 3 for the correct response for each part thus the maximum score was 15 having cut off ≥ 8 for 100% correct response.

Ethical Approval: Prior clearance and approval was taken.

Data Analysis:

Data were entered into a Microsoft excel sheet and analysed using SPSS version 15. Data were summarized in tabular form using percentages with a confidence interval of 95%.

Result :

A total of 163 Phase-3 MBBS students participated in the survey, out of which 86 were male students and 77 were female students. Responses are summarized in three parts (Domains).

Discussion:

131 (80.4%) Participants were aware of plants involved in the NDPS act, 1985 i.e. Cannabis, Coca and Poppy plants out of which 69 (80.2%) were male students and 62 (80.5%) were female students. General awareness regarding the toxicity of various seeds is not adequate as only 39.3% of the respondents have correctly responded toxicity of the poppy seeds. 64.4% of the respondent have correct knowledge of cocaine extraction from the leaves of the coca plants. As we have seen from the above table about morphological features of plants, 60.7% have correctly answered showing adequate knowledge of plants

Table 1: Knowledge Domain, regarding distinguishing features of Toxic Plants under NDPS Act 1985 (n=163)

Question	Response	Total n (%)	Male n (%)	Female n (%)
Knowledge of Relevant plants under NDPS Act 1985	Correct	131(80.4)	69(80.2)	62(80.5)
	Incorrect	32(19.6)	17(19.8)	15(19.5)
Features of the cannabis plant	Correct	87(53.4)	45(52.3)	42(54.5)
	Incorrect	76(46.6)	41(47.7)	35(45.5)
Which seeds are Non-Toxic	Correct	64(39.3)	33(38.4)	31(40.3)
	Incorrect	99(60.7)	53(61.6)	46(59.7)
Cocaine is extracted from	Correct	105(64.4)	55(64.0)	50(64.9)
	Incorrect	58(35.6)	31(36.0)	27(35.1)
Opium year period	Correct	75(46.0)	39(45.3)	36(46.8)
	Incorrect	88(54.0)	47(54.7)	41(53.2)

Table 2: Knowledge Domain, regarding systemic effects of Toxic Plants under NDPS Act 1985 (n=163)

Question	Response	Total n (%)	Male n (%)	Female n (%)
Most commonly used illicit drug of abuse in India	Correct	70(42.9)	36(41.9)	34(44.2)
	Incorrect	93(57.1)	50(58.1)	43(55.8)
Most concentrated form of cannabis	Correct	88(54.0)	51(59.3)	37(48.1)
	Incorrect	75(46.0)	35(40.7)	40(51.9)
Characteristic features of Chronic Cocaine poisoning	Correct	126(77.3)	64(74.4)	62(80.5)
	Incorrect	37(22.7)	22(25.6)	15(19.5)
Features of Opium poisoning	Correct	86(52.8)	36(41.9)	50(64.9)
	Incorrect	77(47.2)	50(58.1)	27(35.1)
Run Amok is seen in	Correct	124(76.1)	62(72.1)	62(80.5)
	Incorrect	39(23.9)	24(27.9)	15(19.5)

relevant to the NDPS act 1985. Out of these 61.6% were male and 59.7% were female showing no significant difference in male and female respondents.

The knowledge regarding the most commonly used illicit drug of abuse in India was known to 42.9% of students only, out of which 41.9% were male and 44.2% were female. Similar results were obtained in the rapid situation assessments (RSA) study by UNODC in 2002, 4648 drug users showed that cannabis (40%), alcohol (33%) and Opioids (15%) were the major substance of abuse⁴. The next question regarding the most concentrated form of cannabis is hash oil-88 (54%) students provided the correct answers. Hash oil is a concentrated extract from the cannabis plant. The concentration of THC in hash oil may be upto 90%⁵. Regarding the systemic effects of chronic cocaine poisoning, - 126 (77.3%) respondents had chosen the correct answer i.e. crawling insects under the skin, Black teeth, nasal septum

Table 3: Knowledge domain, regarding legal provisions under NDPS Act 1985 (n=163)

Question	Response	Total n (%)	Male n (%)	Female n (%)
NDPS Act 1985 renders following Acts obsolete	Correct	43(26.4)	21(24.4)	22(28.6)
	Incorrect	120(73.6)	65(75.6)	55(71.4)
which of following is not illegal to consume?	Correct	128(78.5)	70(81.4)	58(75.3)
	Incorrect	35(21.5)	16(18.6)	19(24.7)
licensed cultivation of Opium is done in which states?	Correct	112(68.7)	61(70.9)	51(66.2)
	Incorrect	51(31.3)	25(29.1)	26(33.8)
Death penalty under NDPS Act can be given for which offence.	Correct	97(59.5)	53(61.6)	44(57.1)
	Incorrect	66(40.5)	33(38.4)	33(42.9)
Punishment for possession of a small quantity of Ganja for self-consumption	Correct	89(54.6)	45(52.3)	44(57.1)
	Incorrect	74(45.4)	41(47.7)	33(42.9)

perforation showing adequate knowledge of chronic cocaine poisoning. Features of acute opium poisoning correctly identified by 86 (52.8%) students as they were taught in forensic medicine classes in 2nd year; The triad of coma, pinpoint pupils and respiratory depression is said to be almost pathognomonic for opium poisoning⁶. 76.1% of respondents correctly identified Run Amok as an occasional acute reaction of chronic cannabis consumption.⁷ As we have seen from the knowledge of systemic effects of toxic plants and their responses 50.9% have correctly answered showing fair knowledge of systemic effects of toxic plants under the NDPS Act 1985. Out of these 50.0% were male and 51.9% were female showing no significant difference in male and female responses.

NDPS Act 1985 renders the Opium Act 1857 obsolete -120 (73.6%) students did not know about it showing poor knowledge of the Opium Act 1857. Bhang is not illegal to consume in India - 128 (78.5%) of students provided the correct response. Bhang does not fall within the definition of cannabis (hemp) as defined under Section 2 (iii) of the NDPS Act, 1985. This issue has been discussed at length in various judgments of various courts.^{8,9,10} Licensed cultivation of opium is done in Madhya Pradesh,

Table 3: Knowledge domain, regarding legal provisions under NDPS Act 1985 (n=163)

Domain	Cut-off	Total n (%)	Male n (%)	Female n (%)
Distinguishing features of toxic plants (max. score=5)	Score ≥	399(60.7)	53(61.6)	46(59.7)
Systemic effects of Toxic Plants (max. score=5)	Score ≥	383(50.9)	43(50.0)	40(51.9)
Legal provisions under NDPS Act 1985 (max. score=5)	Score ≥	3104(63.8)	57(66.3)	47(61.0)
Overall score (max. score=15)	Score ≥	892(56.4)	52(60.5)	40(51.9)

Rajasthan and Uttar Pradesh – 112 (68.7%) correctly knew about the states. In India NDPS Act empowers the central government to permit and regulate the cultivation of poppies for medical and scientific purposes. Death penalty under NDPS Act can be given for repeat convictions under 31 A of NDPS Act 1985. 97(59.5%) of respondents knew about this fact, showing adequate knowledge of various provisions of the NDPS Act, 1985.¹¹ Punishment for possession of a small quantity of ganja for self-consumption is imprisonment for six months or a fine or both, 89 (54.6%) of participants knew about it.

Conclusion :

Out of the total 163 participants, 60.7% had satisfactory knowledge regarding distinguishing features of toxic plants. In responses regarding systemic effects, 50.9% of participants gave correct answers. Of the total 163 participants, 63.8% gave satisfactory responses regarding legal provisions under NDPS

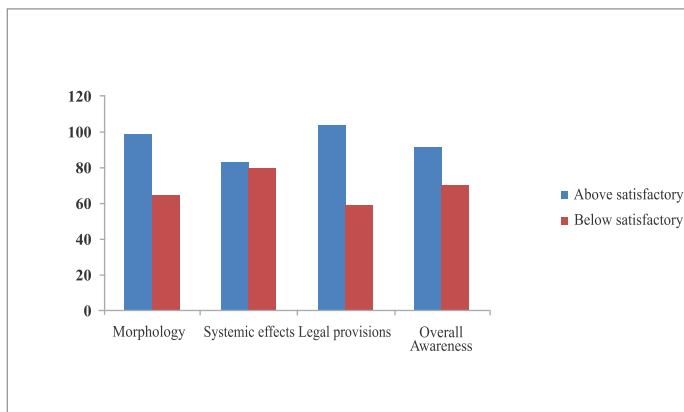


Figure 1. Participants' awareness level in respect of each and overall.

Act 1985. There was no significant difference in the % of correct responses and knowledge regarding distinguishing features of toxic plants and their systemic effect in male and female respondents 61.6% versus 59.7% and 50% versus 51.9%. However awareness of legal provisions under NDPS Act 1985 is significantly more in male than female. Overall maximum score =15 of all the three parameters, 56.4% gave the correct response in which 60.5% were male and 51.9% were female.

From the study conducted, it is evident that there is a need to further enhance the knowledge of the students at the level of the MBBS undergraduate curriculum so that students can contribute to society by controlling and guiding people in narcotics control efforts.

It should be noted that study subjects are students who have been taught an older version of the curriculum for MBBS students. It is hoped that with the introduction of a competency-based curriculum and newer teaching-learning methodology situation should improve.

Limitation of the study: The study was conducted on Phase-3 MBBS students who have preliminary knowledge and exposure

during their MBBS course and were in a better position as compared to the general population who are the main victims of narcotic abuse.

Source of funding : self.

Conflict of interest : None to declare.

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CASE REPORT

Scientific Interpretation of Unusual Injuries Observed in a Death caused by Firing from an Unlicensed Rifled Firearm

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Abstract :

Homicide is the act of killing one person by another. However, for convicting the accused various factors like motive, pre-planning, and circumstantial evidence are taken into consideration. There are various ways by which homicide can be accomplished. The method of using a firearm to kill a person is still less common in India as compared to western countries due to the stringent regulations to have a licensed firearm. However, people get unlicensed firearms (rifled or shotgun) from the black market. These are improvised firearms and lead to injuries which are not matching with the descriptions as per the prevailing conventional literature. This makes the interpretation of injuries by autopsy surgeons difficult to corroborate with circumstantial findings. Here we report a case where a middle-aged male is the victim of a gunshot by unknown individuals who had followed him knowing that he had withdrawn money from the bank. The gunshot is from an unlicensed rifled firearm which produced unusual injuries in multiple places. The authors had tried to deliberate the possible scientific explanation behind the causation of such an atypical pattern of injuries.

Keywords : Forensic ballistics; Homicide; Unlicensed rifledfirearm; Secondary cavity; Pressure waves; Hydrostatic shock.

Introduction :

The national crime records bureau (NCRB) reports that 12.2% of all 33,727 murder victims died due to firearms in the year 2008 in India.¹ On comparing the deaths during a decade, there has been an increase in death by 5,465.² It is shocking to note, that Delhi heads the list of total deaths due to firearms, with 1015 deaths. The main reason behind this surge is the availability of illegal unlicensed firearms from nearby states. Here we report a case of a firearm death caused by one such illegal unlicensed rifled firearm. These firearms are improvised during manufacturing thereby producing injuries which are not matching with a description of firearm wounds in prevailing conventional literature. The autopsy surgeons and investigators also face difficulties in the interpretation of such atypical injuries in correlation with the circumstantial findings. The novelty and aim of this case report were to discuss the atypical pattern the autopsy surgeon may face in such cases. The authors have deliberated the possible scientific mechanism of atypical findings observed in this case.

Case Report :

A middle-aged man is the victim of a fatal firearm injury by unknown individuals. He was received dead at All India Institute of Medical Sciences (AIIMS), New Delhi. The medicolegal autopsy was conducted as per the relevant provisions of CrPC and IPC. The body was subjected to radiological examination. A discontinuity was observed along the body of the mandible on the left side (Figure 1a). The chest X-ray showed haziness in the left lung fields and a loculated effusion along with the mediastinal

shift to the right side was present in the left hemothorax. (Figure 1b). Blood stains were present at multiple places along the front and back of the shirt and underlying inner garments correspondingly worn by the deceased. The upper three buttons of the shirt were missing suggestive of the struggle prior to the death. A localized red-colored contusion was present on the right parietal eminence with an underlying peri-cranial hemorrhage. A bullet entry wound surrounded by an oval-shaped muzzle imprint with burning, singeing surrounded by dried blood stains was present over the front of the left lower aspect of the face below the left zygoma region. The wound track was directed downwards, backward, and outwards with an exit wound over the lower aspect of the left side of the neck (Figure2). The track was found piercing the muscles of the face, with comminuted fracture of the underlying body of the mandible along with the middle one-third. On dissection, a diffuse hematoma was present over the left neck muscles (Figure 3a). At ear on the left internal jugular vein was present underlying hematoma with associated soft tissue contusion. After careful stripping of the dura, multiple air bubbles were found inside the brain vessels suggestive of air embolism (Figure 3b). The peritoneal cavity contained 1 liter of liquid blood mixed with blood clots. Multiple horizontal intimal tears and a single complete tear were present in the abdominal aorta along with the hemorrhagic staining of the outer walls (Figure4). The cause of death is given as Hemorrhagic shock due to firearm injury sustained to the head and neck.

The police investigations revealed that the deceased came after withdrawing money from ATM and was followed by some unknown individuals. At one point, the individuals blocked the vehicle in which the deceased came and tried to take away the bag containing the money. In this struggle, the victim got injured by a firearm. After sustaining firearm injury, the deceased walked for about 6 steps, fell down, and eventually succumbed to death. The above-mentioned scenario was confirmed after viewing the CCTV footage retrieved by the police. The missing three buttons

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in the shirt examination, sub-scalp contusion, and peri-cranial hemorrhage are correlated with the help of CCTV footage.

Discussion :

The reported case highlights the presence of unusual atypical injuries at places far away from the firearm tract. The exit wound is found on the left side closer to the floor of the mouth. The tear in the internal jugular vein lies away from the exit wound. The anatomical landmark of the internal jugular vein is adjacent to the cervical vertebra along with the carotid artery in the carotid sheath.³ The abdominal aorta, on the other hand, lies further downwards away from the exit wound and the firearm tract. There were multiple intimal tears and a single entire thickness tear present transversely placed involving the inner walls of the abdomen aorta along with hemorrhagic stains.

These injuries could be explained by the concept of the hydraulic reaction of bullets in the tissues and the formation of temporary cavity formation. The bullet transferred the energy to the medium in which it had traveled i.e., the soft tissues of the neck and the internal jugular vein causing the rupture. This accelerated the medium surrounding the path of the bullet away from it radially and created a hollow space in the form of a vacuum behind the bullet. Because of inertia, the cavity reaches its maximum diameter at any given point when the bullet has already passed that point leading to the formation of a temporary cavity. Thus, the temporary cavity formed by the motion of the tip of the bullet caused the radial displacement of tissue. This led to the generation of pressure waves that propagated through the tissue. This mechanism is called hydrostatic shock or hydraulic reaction of the bullets.⁴⁻⁹ In this case, the pressure waves generated had propagated by displacing the blood in the blood vessel which caused the remote effects like tear in the internal jugular vein and the abdominal aortic tears.¹⁰

The incapacitation of the deceased observed in the CCTV footage was due to traumatic brain injury i.e., brain parenchyma contusion under sub-scalp contusion in summation to the blood loss from the sustained vascular injuries. These distant injuries

Flow chart of the sequence of events:

The bullet entered the body through an entry wound on the face and exited via the floor of mouth.



The velocity of the bullet is reduced due to the retarding force applied to the bullet by the tissue and bone.



The fracture of the mandible is due to the disruptive effects of the temporary cavity.



The pressure wave generated as a result of bullet has led to remote vascular injuries



Thus, the hydrostatic theory or hydraulic reaction of the bullet is the scientific reason behind the causation

were caused by the pressure waves of the bullet when it passes through the tissues. There are many studies that conclude mild to moderate traumatic brain injury may occur following gunshot wounds, if not detected early may lead to long-term neurological sequelae.¹¹⁻¹³ Due to the ballistic pressure waves, changes had



Figure 1: (a) Fracture of the body of the mandible on the left side. (b) Haziness of the left side pleural cavity with a loculated effusion suggestive of left pneumo-hemothorax along with the mediastinal shift to the right side.



Figure 2: (a) A bullet entry wound surrounded by dried blood stains. (b) Muzzle imprint. (c) Bullet entry and exit wound depicting the wound track externally (Red arrow).

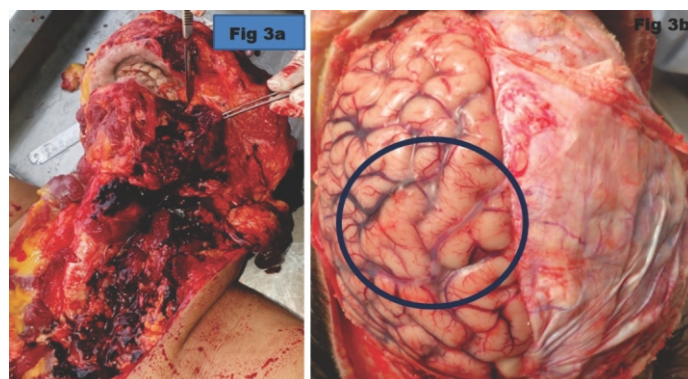


Figure 3: (a) Diffuse hematoma present over the left neck muscles. (b) Multiple air columns inside the cerebral vessels suggestive of air embolism.

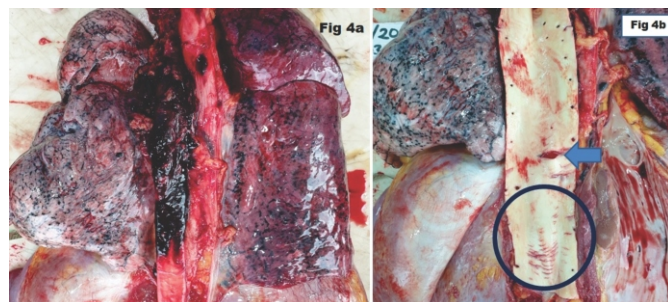


Figure 4 : (a) Hemorrhagic staining of outer walls of the thoracic aorta. (b) Multiple intimal tears and a single complete tear present in the inner wall of the abdominal aorta.

been observed in the hypothalamus and hippocampal regions of animals, when missile impact was given to the extremity.¹⁴ Hence, the injuries observed outside and distant to the wound track can be correlated by the above-explained concept of hydrostatic shock.¹⁰

Conclusion :

The chief role of the autopsy surgeon while dissecting the firearm cases is to correlate the injuries observed in best possible the scientific manner with the circumstantial and investigative findings. Even though correlating the entry wound with the exit wound through the wound track is the main objective in any firearm case, hypothesizing the other injuries with the observed firearm injuries is essential not only for a medico-legal purpose but also much needed for academic purposes.

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CASE REPORT**Facial Reconstruction during Postmortem Examination: Autopsy Case Reports****Rakesh K Gorea***Professor & Head Dept. of Forensic Medicine; Gian Sagar Medical College; Ram Nagar, Punjab, India.***Abstract :**

Dead bodies are brought to the mortuary with injuries. These injuries may cause mutilation of the dead body. In addition to the injuries by weapons, mutilation may be caused by other means too. Whenever there is mutilation to the face it becomes very painful for the family members and the friends to look at the face especially when it is the dead body. When a postmortem examination is conducted on the dead bodies in addition to serving other objectives of the autopsy one of the objectives is to give back the body in a presentable form so that relatives and friends can grieve over the dead body in a humanitarian and peaceful way. This objective will involve the reconstruction of the mutilated body, especially the face. This can be done in a variety of ways. Two such cases are being presented in this paper to highlight the importance of reconstruction of the face during postmortem examination.

Keywords : Reconstruction of the face; postmortem examination; mutilation of the face.

Introduction :

Mechanical trauma is one of the main causes of death in accidents and craniofacial trauma causes mutilation and may be responsible for missed identification of the unknown dead bodies, especially in the hit and run road traffic accident cases.^{1,2}

Mutilation of the faces by branding is done as a punishment for adultery, and sexual assaults on the female. It was also done in cases of treason.³

Facial mutilation by chemicals is a well-known phenomenon during marital discords.⁴ Involvement of the face is common (93%) when acid is thrown on the person.⁵ In one of the studies, facial injuries were found in 5% of the assault cases.⁶ Mutilation of the dead body may be intentional to render it unidentifiable. Mutilation can be a manmade or natural disaster. Mutilation presents a problem of identification.⁷ Mutilation may be done on small children usually after sexual assaults.⁸ Mutilation is common in homicides. Offensive mutilation was seen in Sweden in 30% of cases in one of the studies and injuries were caused by sharp-edged weapons.⁹ Sometimes the mutilation may be done after the death of the person. A case is reported where the son after killing the father removed the skin of the face. All this was done to take revenge.¹⁰ mutilations are done in homicides mainly to dispose of the body.⁹

If death occurs in such cases, all these cases will be brought to the mortuary. If there is facial mutilation then the face should be reconstructed to make the body presentable to the relatives.

Case Reports :**Case 1**

A male was brought for postmortem examination which had several injuries with a sword. There were big cuts on the face and

other parts of the body (Fig.1-3). The injuries had mutilated the face. Postmortem examination was done routinely. There was mutilation of the face due to several incised and chopped wounds on the face. Clotted blood and many injuries made the face look horrible.

After the completion of the routine postmortem examination, facial reconstruction was tried in this case to teach the students the best practices of a post-mortem examination. A plastic surgeon was involved in this case to do the suturing of the facial wounds (Fig. 4-5). The body was cleaned and dressed as per the culture of the deceased person (Fig. 6).

Case 2

A dead body of a female was brought to the mortuary with many chopped wounds on the body. Chopped wounds on the face mutilated the face and even it was becoming difficult to identify the body from the look of the face. There were fractures of the facial bones (Fig 7).

After the routine postmortem examination for finding out the cause of death and other queries of the investigation team, facial reconstruction was tried in this case.

Stitching was done initially but still, the face was not presentable (Fig.8). Then packing was done with cotton to give contours to the face (Fig. 9). There were also fractures of the facial bones with the loss of teeth. Fragments of bones and artificial teeth were placed and packed in the mouth to give the best contours to the face (Fig.9).

Even after this, there were gaps in the tissue due to skin loss, where we put the melted wax to make the contours of the face smooth (Fig.10-11)

All these efforts ultimately made the face presentable (Fig. 12).

Discussion :

We should take care of the rights of the dead body. The dead should be treated in a dignified manner. To give dignity to the dead facial reconstruction should always be tried if it is mutilated. We should use all the facilities available in our institutions to give the best results. We can involve other specialists in the hospital to increase the efficacy of our efforts. A plastic surgeon was

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Fig.1. Look at the face on arrival in the mortuary



Fig.2. Mutilation of the face seen after cleaning



Fig.3. Mutilation of the face seen after cleaning



Fig. 4. Face after stitching (front and right side)



Fig. 5. Face after stitching (left side view)



Fig. 6. The person dressed as per the culture and religion of the person



Fig. 7. Look at the face on arrival in the mortuary involved to stitch the facial wounds.

Offensive mutilation was done with sharp-edged weapons in these cases as was also seen in a study in Sweden.⁹

The above-mentioned two cases highlight how the reconstruction of the faces can be done during the postmortem examination. We should strive for the best possible outcomes by involving other



Fig.8. Face after stitching and packing close look



Fig.9. Face after stitching, packing, and artificial dentures



Fig. 10. Wax treatment of the wounds



Fig.11. Face after wax treatment of the face



Fig. 12. Look at the face while being presented

specialists.

We should clean the bodies and if possible, we should dress the dead bodies according to the cultural values to provide the best socio-cultural services.

Conclusion :

Whenever there is a mutilation of the body reconstruction of the body should be done as far as possible when we are conducting the postmortem examination. This is especially applicable to the face. All the possible methods should be used to make the body and face best presentable to the relatives. This will give a lot of solace to all those who will view the body and face for the last time. This work is usually highly appreciated by relatives and friends. This is the social responsibility of forensic pathologists that should not be forgotten.

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Conflict of Interest- The authors declare that there is no conflict of interest.

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CASE REPORT

Dyadic Deaths - Repercussion of COVID-19 Pandemic

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Abstract :

Of late we are going through the COVID-19 pandemic resulting in a lot of stress not only on health care workers but also on the general population. Social isolation and loss of jobs contributing to financial and mental crisis because of COVID-19 pandemic have been well proven by recent studies. This is known to be associated with distress, anxiety, and fear of contagion amongst the general population. The most extreme consequence of mental instability can result in suicidal thoughts, suicide attempts, and actual suicide. Dyadic death is the simultaneous deaths of two people, either as part of a pact, or desire to accompany the death of the first person without any agreement or as part of a homicide-suicide without the consent of the victim. Here we present two cases of dyadic deaths during the period of lockdown of COVID-19. In 1st case, the mother and her daughter were found in a hanging position resulting from the financial crisis and domestic disharmony, while 2nd case was amongst a family of four consisting of husband, wife, and their two kids who were also found hanged position following financial crisis brought by the lockdown. This explains the extent of the impact of the COVID-19 pandemic on the development of mental instability. The existing health care facilities are primarily focussing and prioritizing on treating the physical ailments whereas the psychological effects on the general population have mostly remained untouched barring a few exceptions. To prevent such type of tragic incidents timely, appropriate and relevant public health care measures should be adopted.

Keywords : COVID-19 Pandemic; Dyadic Death; Hanging.

Introduction :

COVID-19 pandemic and consequent lockdown had a tremendous psychological impact on the health of the general population across the globe resulting in depression. This in turn leads people to think of attempting suicide or committing actual suicide.

Dyadic deaths comprise homicide-suicide and suicide pacts.¹ Suicide pact is the simultaneous suicide of two or more individuals of a close relationship with a similar motive.^{2,3} They represent less than 1% of all suicides, and are carefully and secretly planned generally with the consent of two or more persons.⁴ There are no signs of violence or coercion on autopsy. Homicide-suicide is a homicide committed by a person who subsequently commits suicide within a few hours to one week of the homicide. The interval of one week between homicide and suicide is of utmost importance to distinguish the group in which suicide appears to be linked with a prior homicide from a group of violent persons with a history of assaults and murders who eventually commit suicide. Close temporal proximity which most of the time is between a few minutes to a few hours between committing homicide followed by suicide demonstrates that neither act is incidental to the other.⁵ Men usually kill their partner (Spousal/Consortia) and women their children (Filicide-Suicide).⁵ The mother perceives her infant as an extension of herself and both deaths represent an "extended" suicide.⁵

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Many personal aspects have been affected by the pandemic including physical health, and societal and financial well-being which have a direct link to mental suffering among some individuals.^{6,7,8} Here we are presenting two cases of dyadic deaths related to mental instability developed during COVID-19 Pandemic-lockdown leading to the adoption of such extreme measures.

Case Report :

Dyadic Death 1- Hanging :

The bodies of the mother, aged 32 years, and daughter, aged 18 months were found in their bedroom in a hanging position from a ceiling fan. No suicide note was observed at the scene of the crime. After the complete autopsy, the cause of death was established as hanging in both, however, the manner of death for the mother was suicide and homicide for the daughter. The underlying reasons are the loss of job of earning member of the family in lockdown leading to financial crisis and also domestic disharmony between the couple. (Fig. 1)

Dyadic Death 2- Hanging :

The bodies of 33 years old husband and 32 years old wife, a married couple along with their two kids, a son aged 6 years and a daughter aged 3 years were discovered in their bed room in a hanging position from a single ceiling hook. Before committing suicide, the husband wrote on the wall that he lost his job and was impossible to survive. Also poor interfamilial relationships due to inter-caste marriage prevented them to take help from relatives. In all the cases, the cause of death was hanging and the manner of death was suicide for husband and wife whereas homicide for both kids. (Fig. 2)

Discussion :

"Dyadic death" describes the simultaneous deaths of two people,

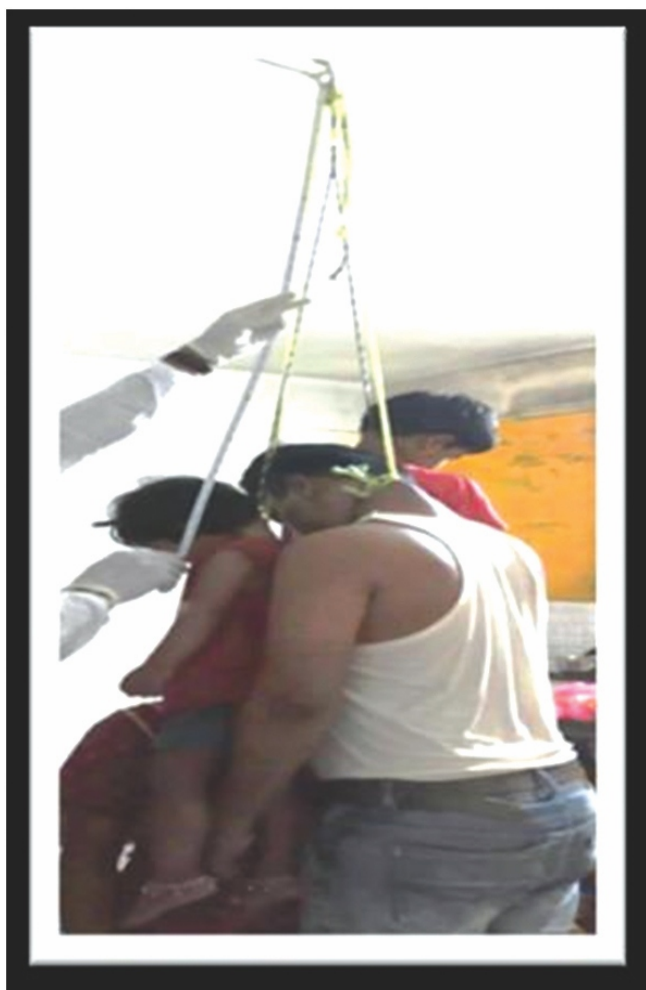


Figure 1 : Dyadic death 1- Hanging

either as part of a pact, or desire to accompany the death of the first person without any agreement or as part of a homicide-suicide without the consent of the victim.³ Dyadic deaths are usually observed in situations where the thought process of the head of the family is extremely disturbed due to the ongoing circumstances making him feel helpless and miserable. He either kills all the family members and then kills himself or all the family members commit suicide. Hemphill and Thornley have discussed the theory of an “encapsulated unit,” serving as a substitute for society; if the survival of the unit is threatened, each member of the unit will want to commit suicide as a way of maintaining it.⁹ The elements taken into consideration while choosing the method of suicide are generally infallible, ensuring that the other party doesn't survive by adopting a highly lethal method.³

Familicide-suicide is when the perpetrator is the father, who is depressed and paranoid and kills every member of his family including his spouse, children, other relatives, and sometimes even pets.⁵ Female assailants most frequently kill their children and rarely adults.⁵

The different motives behind such pacts are social isolation, fear



Figure 2 : Dyadic Death 2- Hanging

of contagion, financial difficulties COVID-19 work-related stress, unable to return home because of lockdown, unavailability of substances of abuse during the lockdown, psychological disorders-depression, health problems, infertility, pre-marriage relationship complexities.^{10,11,12,13,14}

Social crisis, loss of job contributing to financial loss, and mental instability resulting from COVID-19 pandemic have been well proven by recent studies.⁸ This is known to be associated with distress, anxiety, depression, and fear of contagion in the general population. In such situations, the mental instability and helplessness lead to extreme steps in the form of dyadic deaths. Griffith and Mamun reported six suicide pacts amongst couples during COVID-19 pandemic through reasons being variable, the prominent factor behind suicide pacts was mental instability.²

Both cases occurred during COVID-19 Lockdown. In our first case, the mother adopted hanging as a method of suicide after hanging her daughter. In our second case, the husband and wife chose to hang as a method of homicide-suicide for their kids and themselves. The sole earning family member was under financial stress which led to the adoption of such extreme measures.

Conclusion :

The psychological effects of COVID-19 are of great concern. The existing health care facilities have prioritized treatment of

COVID19-related ailments which left psychological disorders unattended. Social boycotting of patients and suspects lead to extreme distress and anxiety.

In order to prevent such incidents in the future, some relaxation should be allowed during lockdown to a selected group of population which include patients in need of mental health aids. Free telephonic psychological counseling should be provided by circulating contact numbers via print and electronic media. Programs to promote recreational activities to be broadcasted via visual media. Family and friendly relations must be maintained to solve problems in time.

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CASE REPORT

Sudden Death due to Glioblastoma NOS: A Rare Medicolegal Autopsy Case Report in Indian Scenario

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Abstract :

Even though the era has grown up into tremendous technological advances in health care, diagnosis of sudden death is still challenging.¹ The definition of sudden death predominantly depends upon the duration and onset of symptoms.² According to the World Health Organization (WHO) and International Classification of Diseases, version 10 (ICD-10) sudden death is non-violent and not otherwise explained, occurring less than 24 hours from the onset of symptoms.³ There are several studies across the world that give ideas about patterns and profiles of cases of sudden death in relation to different age groups.⁴⁻¹⁰ As mentioned in one of the studies, sudden deaths due to an undiagnosed primary intracranial neoplasm are exceptionally rare ones, with reported frequencies in the range of 0.02% to 2.1% in medico-legal autopsy series. Out of which, only 12% of all cases of sudden, unexpected death due to primary intracranial tumors are due to Glioblastomas.¹¹ The present case report describes the autopsy diagnosis of Glioblastoma NOS (Not Other wise Specified) in a case of sudden and unexplained death of a 40-year-old apparently healthy male.

A complete methodological forensic approach by means of autopsy, histological and immuno-histo-chemical examinations is important to label it a case of glioblastoma and relative complication with the rapid increase of intracranial pressure as the cause of death. Although modern diagnostic imaging techniques have revolutionized the diagnosis of brain tumors, the autopsy, careful gross examination, and section of the fixed brain (with coronal section) are still the final word in determining exact location, topography, mass effects, histology, and secondary damage of brain tumor and contributed the elucidation of the cause of death.

Keywords : Autopsy; Glioblastoma; Histopathology; Sudden death.

Background :

The National Cancer Institute, SEER, Bethesda estimated 23,820 new cases diagnosed with brain and other nervous system cancer in 2019, comprise of 1.4% of all new cancer cases. Out of these diagnoses, 17760 resulted in death which comprises 2.9% of all cancers death.¹²

Matschkee elaborated on the distribution of intracranial neoplasms as the cause of sudden death from the literature review, like that, astrocytoma (20%), glioblastoma (14%), meningioma (14%), and anaplastic astrocytoma (11%) were leading causes.¹³ He described the patho-physiological mechanism of sudden death as a result of intracranial neoplasms. The main reason established was the mass effect of the neoplasms which is responsible for any rapid increase in intracranial pressure, be it as a result of acute decompensation of chronic obstructive hydrocephalus resulting from a small brainstem tumor invading or compressing the aqueduct, or fatal bleeding into a hitherto clinically silent glioblastoma to ependymoma.¹³ Compensatory

mechanisms inevitably become exhausted at some point because any sudden, even tiny increase in intracranial pressure leads to terminal failure of the respiratory centers located in the lower brainstem owing to the herniation phenomenon.¹³

Glioblastoma NOS has an incidence of 2-3 per 100,000 adults per year and accounts for 52% of all primary brain tumors annually. Overall, glioblastoma NOS accounts for about 17% of all tumors of the brain (primary and metastatic). These tumors tend to occur in adults between the ages of 45 and 70. Between 2005 and 2009, the median age for death from cancer of the brain and other areas of the central nervous system was age 64.¹⁴

Glioblastoma is a primary brain neoplasm comprised of about 12-20% of all intracranial tumors and 50-60% of all astrocytic neoplasms.¹⁵ The World Health Organization (WHO) 2016 classified Glioblastoma: Glioblastoma, IDH wild type, Giant cell glioblastoma, Epithelioid glioblastoma, Glioblastoma IDH mutant, Glioblastoma, NOS.¹⁵ Many researchers shared cases explaining sudden death due to intracranial neoplasms like glioblastoma, oligodendroglioma, medulloblastoma, etc. in various age groups.¹⁶⁻²¹

Case presentation :

A 40-year-old apparently healthy man with clinical history has been unremarkable so far and there were no symptoms or complaints suddenly fell down at his home. Relatives identified

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him unconscious and brought him to Shree Krishna Hospital, Karamsad. The attended doctor found him dead as he was not having a recordable pulse and blood pressure, ECG was also showing flat lines. The patient was declared dead and a medicolegal autopsy was advised. On autopsy examination, the deceased had a moderate build, rigor mortis was in the developing stage and postmortem lividity was faint and not fixed. The cyanosis was present overall on the finger and toe nails. There was no external injury all over the body. No injury was evident on internal examination also. On internal examination of the brain, a growth of 3 x 2.5 x 1.2 cm size was identified on the left side of the cerebral region. On the cut section, the present growth was leathery hard in consistency and showed evidence of hemorrhages at places. The Brain weighed 1450g and showed edema. On examination of the lungs, moderate pulmonary edema was noticed. On examination of other organs, features of polyvisceral stasis were observed.

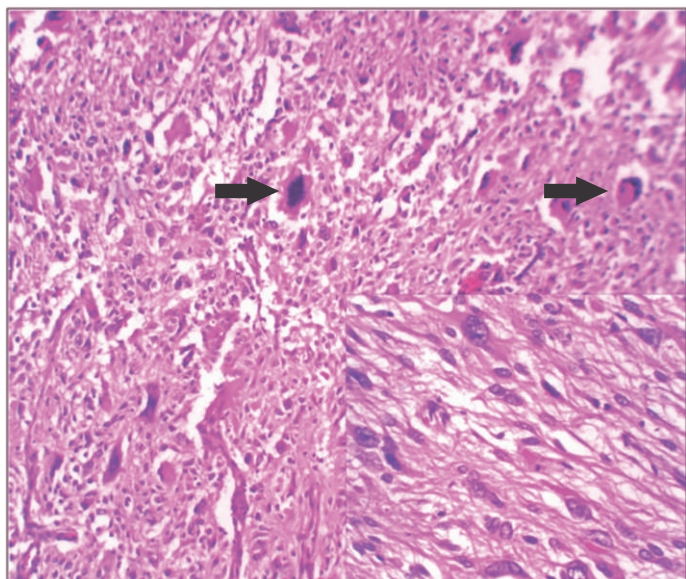


Figure 1: The microphotograph shows presence of highly pleomorphic tumour cells in a fibrillary background (dotted arrows). (H & E stain, 100x) The inset shows the oval to spindled vesicular nuclei with prominent nucleoli, which are severely pleomorphic (solid arrows). (H & E stain, 400X)

Histopathology :

Gross examination revealed a variegated appearance, brownish blackish and greyish white hard necrotic areas. Microscopic sections revealed a tumor with anaplastic astrocytes. The tumor cells were highly pleomorphic, having oval to spindle hyperchromatic nuclei and abundant eosinophilic cytoplasm. Bizarre tumor cells and multinucleated giant cells were reported. Microvascular proliferation and congested blood vessels were noticed. Extensive necrosis and psammomatous calcification were also found. It was concluded as Glioblastoma NOS [WHO grade IV] [Figure 1 & 2].

Immuno histochemical examination :

Tumor cells express GFAP and ATRX expression is retained. Ki67 proliferation is 20%. Immunohistochemical features were

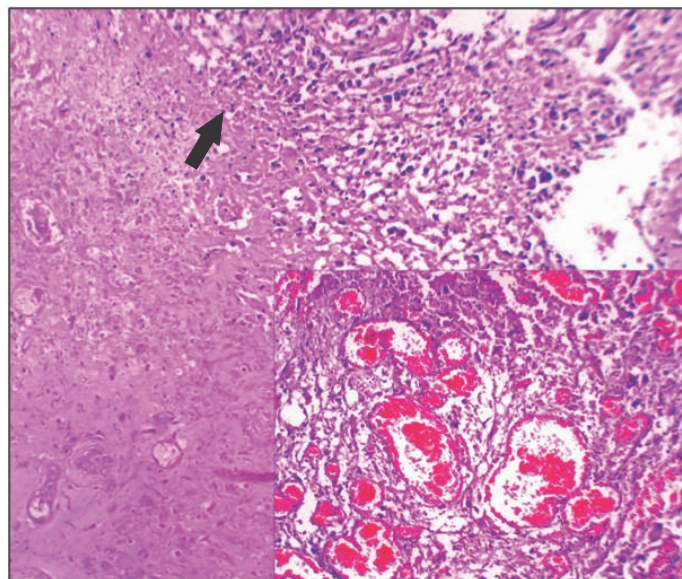


Figure 2: Microphotograph showing areas of necrosis interfacing with viable tumour cells on the right side (H & E stain, 100x).

suggestive of glioblastoma NOS.

Based on the autopsy features, histopathological and immuno-histochemical observations, it was concluded a case of Glioblastoma NOS, in final opinion about the cause of death. This was the first such case detected at the center with regards to medico-legal autopsies.

Conclusion :

Glioblastoma is a highly malignant brain tumor. Autopsy cases of sudden death due to Glioblastoma NOS are a handful in the literature. Autopsy findings if supported with histology may be helpful in lineating opinion about the cause of death. This case report is unique for the center and may be useful to build a better understanding of Glioblastoma NOS, especially in autopsy cases [Medicolegal and Pathological].

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REVIEW ARTICLE

Lead Poisoning: An updated Review of Literature

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Abstract :

Lead poisoning has silently crept into the purview of current global public health concerns. Many health-related problems in children and adults are the result of direct and indirect exposure to a toxic environment. This paper examines lead poisoning imposed related disorders through a sustained review of available literature on the subject. Studies on a multi-dimensional approach related to lead exposure and its relationship with effects on health were consulted to present a short review that highlights the noxious effect of this toxic element on the brain, heart, kidneys, and reproductive organs. Studies postulated a positive association of lead exposure with criminal behaviour, recidivism, delinquency, aggression, and low IQ. It is highly recommended to educate people regarding the deleterious effects of lead.

Keywords : Lead poisoning; Toxicity; Exposure; Mental health; Brain development; Criminal behaviour.

Introduction and Background :

Lead is a bluish-grey heavy metal found naturally under the earth's crust in the form of ores including galena.¹ While it has been in use for over 6000 years; its toxicity was first recorded in 2000 BC. The Romans used lead for making utensils and for preserving juice.² It has a major impact on health because it expresses its presence even years after exposure. It has a marked presence in the environment due to industrial emissions, mining, smelting, leaded gasoline, paint, ammunition, pipes, etc. The other sources of Lead exposure include traditional medicines, toys, jewellery,³ soil, and dust.^{4,5} Research revealed that the impact of lead on humans has increased by 500 to 1000 times than their pre-industrial counterparts.⁶

Lead enters the human body as a trace element and tends to interfere with the overall process of growth and development of the human brain. Environmental toxicity has a profound impact on immature, developing brains largely because the mature brain is protected by the boundary of cells that prevent the neurotoxins from the blood to enter the brain. A report by WHO 2009,⁷ states that lead poisoning alone contributes to 0.6% of overall child neurological disorders. Researchers agree that neurological damage during the early years of life is responsible for cognitive and behavioural problems,⁸ violence, IQ deficit,⁹ criminal activity,^{10,11} anti-social behaviour, aggression, delinquency as well as attention deficit hyperactivity disorder (ADHD) among children.^{12,13,14} According to a report by conduct problems prevention research Group (CPPRG, 1992),¹⁵ antisocial behaviour among children and adolescents was observed as a common problem with an estimated prevalence of 4 to 10 % of children across the world.¹⁶ Most health problems were

associated with medical issues like preterm birth, injury, or tumour of the brain. However, factors like the exposure of children to pesticides and neurotoxic elements were observed to be responsible for the low IQ levels of children.¹⁷

Within the body, more than a dozen chemicals exist as neurotoxins that may be defined as essential elements but produce changes in the biological system if present in a specific chemical form and in high concentration.^{18,19} Examples include Mercury (Hg), Arsenic (As), Aluminum (Al), Lead (Pb), and Cadmium (Cd). All these elements affect the brain particularly the architecture and neural connections that get developed during early childhood.

Lead toxicity interferes with the myelination processes that inhibit signal transmissions in brain cells. Lead exposure results in poor learning and school performance; behavioural problems leading to violence,²⁰ attention deficit at even low concentrations of 50µg/l in the blood of children.^{21,22,23,24} According to earlier published data, concentrations of 70µg/dl of blood lead were considered to be safe for humans. Later minute examination of the nature and toxicity of lead, the Centre for Disease Control (CDC) reduced its optimum exposure limit to 10µg/dl.²⁵ Recent research on morbidity rates due to Lead toxicity optimum has put the pressure on CDC, to declare its safe level in the blood to be 2µg/dl.^{26,27}

Currently, even minimal exposure to lead is not safe for humans or animals.^{24,28} Sustained low-level exposure to lead can result in a deficiency in cognitive abilities of children rather than higher doses of lead toxicity.²⁸ High doses of lead can result in permanent damage to the brain and may even cause death. The biological fallouts of lead toxicity have been confirmed on vital organs including the gastrointestinal tract, kidneys, and the reproductive and cardiovascular organ systems but primarily are known to impair the central nervous system. The process of toxicity of Lead is explained by its ability to bind at the site of the - SH group of proteins of different enzymes to displace other metal ions. This results in the dysfunction of different enzyme systems of the human body.

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Lead exposure assessment is done either through biomarkers like urine, hair, nails (finger and toe), and blood or the sources of lead in the environment including soil, food, and water. The selection of biomarkers is important for assessing exposure to particular essential yet toxic elements. The reliability of any biomarker is determined by intrinsic factors like specificity towards a particular pollutant or element, reproducibility, the relationship between exposure biomarker with other variables, and analytical procedures that can alter the results due to collection timings and contamination of the sample. The standardization of analytical procedures is another important aspect of the validity of biomarkers used to assess any toxicant in a population.^{29,30} The selection of biomarkers is significant to reduce the error rate in the measurement of exposure and calculate the risk of occurrence of disease in epidemiological studies.^{29,31}

Material and Methodology :

The material for this review was collected from PubMed, Google Scholar, Scopus, and Hinari using the keywords lead and diseases Lead and its effects on the human population, lead poisoning, lead exposure, criminal behaviour, cognition, and lead toxicity. Complete papers written only in the english language were included for the present review. The papers where only abstract was available were excluded. The important findings of the relevant articles published between 1990-till date were compiled.

Toxicokinetics of Lead :

Toxicokinetics is the study of absorption, distribution, metabolism, and excretion of a toxicant or xenobiotic substance with time. Despite enormous research, the exact mechanism of Pb toxicokinetic and thermodynamics is not clear.^{32,33} However, various models have been developed to elucidate the toxicokinetic of lead in the human body, a few named the Radulescu & Lundgren, (2019),²⁶ Legget (1993)³⁴ and O'Flaherty Model (1993).³⁵ These models explained the distribution of absorbed lead into compartments, its rate of exchange, retention, and distribution in various body tissues. After circulation throughout the body, Lead gets attached to red blood cells. Only 1% to 5% of Lead remains in plasma. About 5% to 15% of the absorbed Lead is retained in adult humans whereas; in children 30% to 40% of the Lead is retained. The difference in absorption levels can be attributed to the differences in physiology, body surface area, and body weight of adults and children. The absorption is observed to be much more in children than in adults making such toxic elements potentially more dangerous to children than adults.³⁶

Conditions like fasting, anaemia, and calcium deficiency tend to increase the absorption of Lead.³⁷ Therefore, the Centers for Disease Control and Prevention (CDC) urged parents to ensure proper nutrition and check the dietary intake of calcium, phosphate, and iron so that the absorption capacity of Lead can be minimized.^{38,39} Various research conducted on children has shown an inverse correlation between levels of calcium in the body and levels of Lead in the blood.^{40,41} The presence of food also influences the absorption of Lead in the gastrointestinal tract.⁴²

Lead is absorbed through ingestion, inhaling, and skin exposure.

It is taken up by the blood from the lungs and the gut and is transported to different parts of the body like kidneys, brain, lungs, bone, and teeth through blood plasma.^{43,44} The concentration of absorbed Lead is higher in the kidney and liver as compared to the brain. In adults, about 90% of the lead is stored in the trabecular and cortical bone as lead Phosphate. The absorbed lead within different body compartments (blood, soft and mineralized tissues) has a different half-life. In blood, lead has a half-life of about 36 days, in soft tissues (kidney, liver, lungs, etc.) have 40 days and bone has a half-life of 30-40 years. Lead stored in bones is the major source of endogenous lead. In the case of pregnancy, it is transferred from mother to fetus via the placenta during fetal skeletal formation. The transfer of lead from the mother's blood to the fetus is about 80% to 100% and starts as early as 12 weeks of gestation and continues throughout the development till the birth of the child.^{45,46} In conditions of metabolism, alteration during lactation, osteoporosis, and ageing; lead may be released from the bloodstream.

The principal route of exposure to inorganic lead is through ingestion of food, intake of water, and polluted air.⁴⁷ The second pathway of exposure is through the respiratory system. The magnitude depends on factors like particulate size, the respiratory volume based on the capacity of the lungs, and the tendency of mucociliary muscles to clear the inhaled lead. Toddlers can be exposed to the habit of constantly taking their hands to their mouths while playing with toys or on dusty floors. Dermal and inhaled exposure is possible through occupational circumstances.

Approximately 20% to 70% of ingested lead is absorbed by the body while complete absorption of lead is through respiration in contaminated environments.⁴⁸ Besides inorganic lead exposure, humans are susceptible to organic lead exposure via the dermal route. Industries dealing with lead or related products present the risk of organic lead exposure. Inorganic lead that is not metabolized and absorbed in the body passes through the gastrointestinal tract and gets eliminated as faeces or gets excreted through the kidneys.⁴⁹ Minor proportions of lead get excreted via sweat, breast milk, fallen hair, and nail clippings.^{50,51}

Significance of Biomarkers :

Health risk assessment in epidemiological studies is done on the basis of current and past human exposure to a particular chemical. It can be calculated qualitatively by analyzing behavioural changes in humans and quantitatively through examination of different tissues for chemical accumulation.

Analysis of body tissues and fluids for the presence of chemicals and metabolites shows the interaction of chemicals with human biological systems. The measurement of these chemicals in body tissues or fluids is termed human biomarkers or biomonitoring. This approach is applied for exposure assessment to help epidemiologists to calculate the risk involved in chemical exposure on the basis of trace elements present in body fluids. While accessing the dose of chemical actually absorbed internally by various fluids or tissues, it does not give information on sources of exposure.⁵² Comparison of biomarkers is done on characteristics like reliability, reproducibility, and accuracy on

different occasions. Moreover, they should be inexpensive and moderately invasive in nature.⁵³ The study of biomarkers is important because they provide quantitative data on the outcome interaction of chemicals with total body burden and help in the assessment of risk to an individual, a group, or a population.

Impact of Lead toxicity on Human Health :

As per, the WHO report, around 0.6% of the total disease burden among children is due to lead poisoning.⁷ Lead exposure during childhood can re-program genes, resulting in alteration of actual gene expression and increasing chances of getting the disease during adulthood.^{54,55} Lead interrupts the transduction of electrical and hormonal signals that leads to neurotoxicity and cardiovascular impairment.⁵⁶ It increases the chances of osteoporosis and dental caries among adults.

Effect of Lead toxicity on different organs of the human body:

Brain: Lead is a potent neurotoxicant, and can cause irreversible damage to the brain.⁵⁷ Research by agencies like the national toxicology programme and the American academy of pediatrics stated that Lead causes adverse effects among children and adults at a concentration of as low as 5 micrograms per deciliter in blood.⁵⁸ Lead toxicity can cause problems in sensory organs, hypertension^{5,9} and neuro-degenerative diseases like Alzheimer's, Parkinson's, and impaired cognitive function.⁶⁰

Kidneys: Studies suggested an association between the levels of lead in blood and renal dysfunction with advancing age.^{61,62} The WHO states that a blood lead concentration of 40 micrograms per decilitre causes renal dysfunction and lead nephropathy.⁶

Cardiovascular diseases (CVDs): Researchers suggest a causal positive correlation between lead exposure at a low level and elevated arterial pressure.^{59,63,64}

Carcinogenic effects of Lead: Exposure to inorganic lead at chronic and low levels are believed to be causative of cancers in the brain, kidneys, breast, stomach, and lungs.^{65,66,67} The carcinogenic effects occur through involvement in oxidative stress, inhibition of synthesis and repair of DNA, altered cell-signalling pathways, and binding at DNA-binding protein sites^{66,68,69}

Reproductive system: Lead exposure threatens the reproductive health of men and women. Among men, lead exposure can reduce the production of sperms and their motility, abnormality in chromosomes, prostate function, and changes in testosterone levels. Women showed signs of delayed growth and pubertal development;^{70,71} infertility; hypertension during pregnancy; and miscarriage and premature deliveries.^{72,73,74}

Bones: Accumulated lead in the bones of women can pass through the placenta and interrupt the growth and development of the fetus's brain by crossing the blood-brain barrier. The occurrence of osteoporosis is seen among lead exposed individuals.

Association of lead exposure and crime :

Crime is a complex problem to define. It can only be defined with the help of multiple factors including social, biological, economic, and environmental. Many authors have suggested a

strong association between prenatal and postal lead exposure and neurological defects, and criminal activities during adolescence and adulthood.^{14,75,76} It can be explained on the basis of the ability of lead to mimic calcium and some other divalent ions. It results in the disruption of many enzyme systems and brain disorders which leads to behavioural problems, attention deficit, violence, anti-social behaviour, low IQ, and criminal activities.^{77,78,79} Exposure to Lead has also been associated with the increase in homicide rates.⁸⁰ However, a study conducted by Beckley and others did not find a dose-response association between lead exposure and criminal activity.⁸¹ It is imperative to consider factors like socioeconomic status, level of education, and childhood environment⁷⁵ while studying the criminal behaviour of an individual. Further, it is pertinent to mention that we did not find any published data in the Indian context.

Conclusions :

Lead poisoning has ill effects on every system of the human body and most severely the central nervous system. Various body tissues like blood, bone, hair, tooth, nails, urine, etc. have been used as biomarkers in several studies. Children and women are a particularly vulnerable group. In children, low to high levels of lead poisoning are associated with brain damage, intellectual disability, behavioural problems, antisocial behaviour, violence, and sustained juvenile delinquency.

The effects of lead exposure carry on from childhood to adulthood. Currently, it is one of the most important areas of public health concern worldwide. There is an urgent need to evaluate lead toxicity among vulnerable groups and increase awareness of the general public about this potent danger.

Recommendations: Lead has adverse impacts on human health even at very low concentrations. On the recommendations of research and health agencies, most countries succeeded in regulating the levels of lead in the environment by formulating or amending their existing laws.

Even after the complete prohibition of leaded gasoline and paints, the impacts of lead exposure are still prevalent. Governments should start awareness programs where people should be taught how calcium and iron inhibit the absorption of lead in the human body. Government should ensure the proper implementation of the guidelines of the World Health Organization for the prevention and management of lead poisoning.

Public health departments should organize screening camps to check blood lead levels, especially among people living in occupational exposure conditions, pregnant women, and children. Further, the identification and elimination of the sources responsible for lead poisoning should be properly dealt with. Government should allocate special funds for effective research in this direction.

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