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The Journal covers all technical, medico-legal and clinical aspects including the ethical and social issues related to the subject specialty of Forensic Medicine and Toxicology and allied specialities. The journal promotes dissemination of original research findings.

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# Journal of Indian Academy of Forensic Medicine

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**From Editor's Desk**

**Dear All,**

Rains pouring all around, so are articles from our learned authors. The agreement has been signed between editorial board, governing council and SAGE publication Pvt Ltd. Moving a step forward we are in process of transferring the articles to SAGE and working on website. For improving the number of citation from JIAFM and somehow increase the impact factor, we have been regularly requesting the authors to cite the articles of JIAFM in the references of their article for which they are getting an upper hand in publication and many authors have started doing it.

The journal has demonstrated a marked improvement in its ranking, moving from Q4 in 2023 to **Q3 in 2024.** This advancement highlights the journal's growing influence in the academic and research communities, particularly in the field of forensic medicine. Over 150 manuscripts were submitted for the Jan-Mar 2024 issue. Acceptance Rate: 75%. Publication timeline is decreasing from more than a year to almost 8 to 9 months for peer review and final publication. This decrease in time line was possible by releasing supplementary issues, which will be done further too. Key topics in the issues were - Advances in forensic toxicology; Legal frameworks in forensic investigations; Ethical challenges in clinical forensic medicine. A few featured articles in this issue include: Forensic DNA Technology: New Frontiers in Crime Investigation; Discussing advancements in DNA profiling techniques and their impact on complex criminal investigations; Ethical Dilemmas in Forensic Medicine: Case Studies; Highlighting real-world ethical challenges faced by forensic professionals.

The journal follows a double-blind peer review process, ensuring unbiased evaluation of manuscripts by experts in the fields of forensic medicine and related disciplines. The journal is indexed and abstracted in major databases, ensuring broader visibility and access: Scopus (improved to Q3 ranking in 2024); PubMed (In process); Google Scholar; IndMED (In process); DOAJ (In process).

Citation Metrics: With its improved Q3 ranking, the journal has seen a significant increase in its citation metrics, making it a prominent source for forensic research. The recent citations per article have shown a growth of approximately 15%, signifying higher engagement from the academic community.

I thank my editorial team specially **Dr. Narendra Patel; Dr. Vishal Seán Baveja; Dr. Vaibhav Agarwal** and **Mr. Chain Singh Lodhi,** who are tirelessly devoting day and night to release this issue on time. I also thank **Dr. Siddhartha Das** as **Joint Editor** and **Dr. Mandar Sane,** who had been helping me in this endeavour of publishing the journal since 2022.

We responded to all the queries of the authors in our official email ID of the editorial team. I am thankful to all the **authors** for keeping their patience and feel sorry, as sometimes I may not have responded to your calls or messages due to varied reasons, but the editorial team had been very vigilant and serious in responding to all the emails received. I need to especially thank our **reviewers,** without whom we would not have come up with a quality issue as was desired.

Best wishes!

Sincerely

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EDITORIAL

# Medical Education, Professionalism and the need for Collaborative Research on Indian Perspectives

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Collaborative scholarship between medical education and healthcare professionals (HCP) is required to advance new insight regarding quality medical education and health practices. Excellent medical education improves the skills of Indian Medical Graduates (IMG), so exploring good practices of HCP that foster the sufferers' quality of life. So, continuous and combined research in this field is a must to initiate a rationale to evaluate the new strategies. This editorial depicts background and pragmatic evidence to prove the relationship between medical education, practices of HCP and research for defining the implementation of programs and policies crucial for excellent public health interventions.

**Keywords:** Medical education; practices; healthcare professional; quality of life

It has become quite a challenge for the new-age medical teacher to adopt a student-friendly approach while teaching a massive number of students during the undergraduate program. The teaching-learning methods used during medical education can significantly impact the learning process among medical students.[1]

Competency-based medical education (CBME) has been in full swing nationwide since 2019. The National Medical Commission (NMC) of India has illustrated the essential competencies mandatory for an IMG in their competency-based module. There is a paradigm shift in the current approach to medical education, and the usefulness and limitations of the newer concept in the Indian context are yet to be demonstrated as the best teaching-learning method.

Medical education is directly related to producing competent IMGs who will be the future HCPs. Comprehensive medical practice needs knowledge, clinical skills, intelligence, good communication skills, attitude, and inter-professional behaviour, the most vital core issues for building an accepted doctor-patient relationship.

**Challenges ahead:**

Education techniques have changed from the traditional "chalk and talk" methodology to modern, innovative classroom techniques with all the latest features. Notably, the best teaching-learning method can only be determined based on a better understanding and appreciation of the methods used by the students.[1]

In addition to the teaching-learning methodology, the two other components, curricular design and assessment methodology, also need introspection. Considering existing infrastructural deficiencies, there is a need to reflect upon the feasibility of implementing the CBME curriculum. The teaching learning and assessment methodologies in CBME, which are based mainly on global medical systems, may not be totally appropriate in the Indian context. There is a need to innovate and adapt to the same in the Indian context based on scientific evidence.

One of its objectives is to improve access to quality and affordable medical education for nearly 1,18,316 medical graduates and 30,000 postgraduates yearly from 706 medical colleges nationwide.[2] It is a massive task to teach such a vast number of students, while teaching staff and infrastructures are inadequate to fit the requirements, and there are many other invaluable deficiencies.

Plenty of challenges are ahead to implementing the new CBME modules. The lack of infrastructure, low student-teacher ratio, inadequate faculty training, reluctance to join medical colleges by IMG and failure to uniformly implement the CBME curriculum in every medical institution of the country is to be studied scientifically even after five years of implementation of CBME.

**Role of research:**

Evidence-based practice is believed to be ideal in all healthcare aspects, with medical education and healthcare practices being no exception. The concept of medical education and health research is developed and linked to its outcome in the professional field. There is a need to encourage research in medical education to improve vital inquiry into educational matters and upgrade knowledge about the subject.

Earlier, behavioural scientists who did not necessarily have a medical background performed medical research in classical experimental psychology and cognitive science. During the last few decades, medical research has observed gross changes regarding topics and investigators of medical backgrounds. Research in medical education benefits from a congregation of perspectives and close collaboration among medical educators and behavioural scientists.[3,4] Research in medical education has changed continuously from descriptive studies to justification comparison studies on the curriculum.[5] Investigative research is also becoming commoner. Observing how researchers change the topics and what society has gained from it becomes interesting.

The primary variables may include educational expertise, gained skills, essential gained subject knowledge, logical ability,

empathic self-regulation, teaching-learning methods, and interactional abilities with a good provision for feedback, which are critical components to make an IMG competent.

Furthermore, medical education is an essential social determinant of health. Programs that remove differences in health outcomes between economically weaker sections and racial and ethnic groups need to be studied to promote health equity. Every point influencing learning and gaining skills by IMG must be studied scientifically and persistently.

**Conclusion:**

Health policymakers, educators, and researchers should invest more time in deep-rooted research to find systematic evidence for further amendments to public health benefits, as medical education has deep-rooted consequences concerning the foundation of skilled health professionals accomplished taking up the onus and accountability, guaranteeing the discharge of excellent healthcare.

This will go a long way in enabling our future HCPs to discharge excellent healthcare.

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ORIGINAL ARTICLE

# Incidence of Different Type of Lip Lines among Medical Students at Prayagraj

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**Abstract:**

Despite other available methods of identification studies of lip lines is emerging as a reliable tool of personal identification. The lip surface contains numerous fine grooves distributed vertically and horizontally at different inclinations to give rise to different types of lip lines. Study of lip print is called Cheiloscopy. Present study has been done to observe incidence of types of lip lines in different quadrants of lips on 200 undergraduate medical students at Moti Lal Nehru Medical College, Prayagraj. Digital images of lip lines were taken with the help of a DSLR Camera and observed using Tsuchihashi classification system. Type 1 (complete vertical) was the most common variety of lip line observed followed by Type 1'> 4 >2>5 > 3 in males and Type 1' > 4 > 5 > 2 > 3 among female subjects in order of incidence. Type 1 and Type 1' lip lines were found commonly on lower lip quadrants (LL > LR) while Type 4 and Type 5 lines on upper lip quadrants (UL > UR) in most of male and female subjects. Order of incidence of different lip lines in upper quadrants (UR and UL) was Type 4> 5>2>3> 1'> 1among male and Type 4 >5>2>1' > 3>1 among female subjects while on lower lip it was Type 1> 1'>2>3 >4>5 in male and Type 1>1' >2>5 >3>4 in female subjects.

**Keywords:** Lip lines; Identification; Cheiloscopy.

## Introduction:

'Vermilion zone' is a less keratinized muco-cutaneous area of the lips, bounded between delicate oral mucosa and keratinized skin. Fischer in 1902 was the first anthropologist to describe that lip surface contains numerous fine grooves distributed vertically at different inclinations.[1] Varied orientation of these lines gives rise to different patterns of lip lines which are classified by different researcher with little variation. Lip prints are as unique as fingerprints and do not change during the life of a person. In 1967, Santos was the first person to classify lip grooves.[2] He divided them into four types namely: Straight line, Curved line, Angled line, Sine-shaped curve. Later in the year 1970, Suzuki and Tsuchihashi classified the lip prints into following popular classes: -[3,4]

Type 1 (Complete vertical groove),

Type 1' (Incomplete vertical groove),

Type 2 (Branched groove),

Type 3 (Intersected groove),

Type 4 (Reticular pattern groove)

Type 5 (Irregular groove)

Study of lip prints is called Cheiloscopy. Many methods have been adopted to develop and characterize lip lines in the form of prints among which digital Cheiloscopy is gaining popularity due to its precise interpretation.[5] Since 1950, it has been presumed that such patterns on lips may be individual specific and can help towards identification specially in criminal investigation. Materials and object like cigarette buds, wine glasses etc. are frequently used to recover such lip marks. Incidence of different types of lip lines give rise to a wide horizon for researcher who claimed beyond individual identification to have race, ethnic group, blood group and sex discriminating potential.[6] So for it appears essential to record, observe and report the pattern of different types of lip lines and their incidence for each group of population.

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## Materials and methodology:

Study has been conducted on equal number of male and female subjects to obtain a sum of 200 total subjects. Digital images of gently swabbed lips with distilled water have been taken with the help of a DSLR Camera and observed for different types of lip lines in a clockwise manner from upper right (UR), upper left (UL), lower left (LL) to lower right (LR) quadrant of lips.[7] This method is hygienic, contactless and convenient to observe than application of lip gloss or lipstick or placement of glass slide as previously used and suggested by others, which can be quite laborious and may be unhygienic due to direct or indirect contact among subjects. Data of presence of different types of lip lines have been recorded and evaluated for their incidence in different quadrants of lips. Variable incidence of such lines, in percentage for each quadrant among subjects of different sexes has been tabulated for reporting purpose.

Present study is a prospective observational cross sectional study conducted on 200 undergraduate medical students of Moti Lal Nehru Medical College, Prayagraj. Youngest was of age 20 years

while oldest 25 years. After ensuring consent, equal number of male and female medical students had been chosen to obtain desired number of subjects. The digital camera produces precise and magnified lip images which are easy to observe and interpret than an old traditional method like Lipstick method and cellophane tape, white chart paper, magnifying lens, charcoal powder and brushes etc. DSLRs are digital cameras that capture images using a prism (i.e. a reflex mirror) that helps in reflecting and swiveling the light from different angles. It combines the optics and the working of a single-lens reflex (SLR) camera using an image sensor. DSLR functions give the photographer the freedom to choose any mode depending on the need. Digital images of a DSLR Camera (NIKON D 70 DX Format 6.1 effective megapixel CCD sensor, Optical Zoom 10x) mounted on a height-adjustable tripod placed parallel to the lip height in front of each subject. Images have been observed for different types of lip lines present on right and left halves of upper and lower lips with the help of a laptop/desktop[8]. This method is relatively easier and involved no direct or indirect physical contact with the participants.

Exclusion Criteria: Those subjects were excluded whose native residence is outside state of Uttar Pradesh and lip abnormalities like surgical scars, deformity or any other anatomical alteration in lip structure.

Ethical Clearance: Necessary approval from institutional ethical committee has been obtained before commencement of present research work (Annexure).

**Results:**

In this study lip lines were examined with the help of digital images and labeled according to Suzuki & Tsuchihashi-1970 classification system in four quadrants of lips in a clockwise manner starting from upper right to lower right quadrants among male and female subjects. Observations are presented in tabulated forms using actual number of observations and percentage with respect to equal number of male and female subjects to make total number of subjects 200.

The order of incidence of different type of lip lines was observed as 1>1'>2> 3> 4>5 among males and 1>1'> 2> 5> 3> 4 among females on both quadrant of lower lip. All types of lip line except Type 1' were observed in more number of males than females. On lower lip, Type 1 Lip lines were present in maximum number of subjects, male (52%) > female (44%), the incidence varies slightly among quadrants (LL > LR) in both male and female subjects. Similarly, Type 1' lip lines were present more in LL than LR quadrant in both male and female subjects. Type 2 lines were found more in LL than LR in males but order is reversed in females where Type 2 lines were more in right quadrant of lower lip than left. Type 3, Type 4 and Type 5 lip lines has greater incidence toward right quadrant in males but towards left quadrant in females.

**Table 1. Incidence of different type of lip line on quadrants of lower lip.**

| | Type of Line | Lower Left (LL) | LR | Total |
|---|---|---|---|---|
| Male | Type 1 | Type 1 (47%) | Type 1 (46%) | (52%) |
| | Type 1' | Type 1' (29%) | Type 1' (18%) | (33%) |
| | Type 2 | Type 2 (18%) | Type 2 (17%) | (20%) |
| | Type 3 | Type 3 (14%) | Type 3 (17%) | (19%) |
| | Type 4 | Type 4 (10%) | Type 4 (12%) | (13%) |
| | Type 5 | Type 5 (08%) | Type 5 (12%) | (12%) |
| Female | Type 1 | Type 1 (40%) | Type 1 (39%) | (44%) |
| | Type 1' | Type 1' (35%) | Type 1' (31%) | (36%) |
| | Type 2 | Type 2 (13%) | Type 2 (16%) | (18%) |
| | Type 3 | Type 5 (12%) | Type 5 (10%) | (13%) |
| | Type 4 | Type 3 (8%) | Type 3 (7%) | (08%) |
| | Type 5 | Type 4 (6%) | Type 4 (6%) | (07%) |

As for as upper lip is concerned, the incidence of lip lines have varied order from that of lower lip. Order of incidence was found to be Type 4>5>2>3>1'>1 among males and Type 4 >5>2>1>1'>3 among females on quadrants of upper lip, the upper right (UR) and upper left (UL). Type 5,Type 2and Type 3 lip lines were observed in more number of males than females while Type 4, Type 1 and Type1' lines has higher incidence among females. On upper lip Type 4 lip lines were present in maximum number of subjects, male 33% and female 34%, the incidence varies among quadrants, upper left (UL) > upper right (UR), in both male and female subjects. Similarly, Type 5 lines were present more in UL than UR quadrant while Type 1and Type 1' lines were present more in UR than UL in both male and female subjects. Type 2 lines have equal incidence on both UR than UL quadrant in both male and female subjects. Type 3 line have reverse order of incidence among both the sex as these lines are more common in UL quadrant in male and UR quadrant in females.

Considering all the four quadrants together, the order of incidence was found to be LL (47%) > LR (46%) > UR (12%) > UL (07%) for Type 1 lip line, LL (29%) > LR (18%) > UR (16%) > UL (14%) for Type 1', UR =UL (23%)> LL (18%) > LR (17%) for Type 2, UL (20%) > UR = LR (17%) > LL (14%) for Type 3, UL (30%) > UR (25%) > LR (12%) > LL (10%) for Type 4 and UL (26%) > UR (23%) >LR (12%) > LL (08%) for Type 5 in male subjects.

The order of incidence was found to be LL (40%) > LR (39%) > UR (18%) > UL (17%) for Type 1, LL (35%) > LR (31%) > UR = UL (17%) for Type 1', UR =UL (18%) > LR (16%) > LL (13%) for Type 2, UR (17%) > UL (14%) >LL (12%) > LR (10%) for Type 3, UL (31%) > UR (30%) >LL (8%) > LR (7%) for Type 4 and UL (23%) > UR (20%) > LL = LR (06%) for Type 5 lip lines among females.

**Table 2. Incidence of different type of lip line on quadrants of upper lip.**

| | Type of Line | UR | UL | Total |
|---|---|---|---|---|
| Male | Type 4 | Type 4 (25%) | Type 4 (30%) | (33%) |
| | Type 5 | Type 5 (23%) | Type 5 (26%) | (30%) |
| | Type 2 | Type 2 (23%) | Type 2 (23%) | (25%) |
| | Type 3 | Type 3 (17%) | Type 3 (20%) | (22%) |
| | Type 1' | Type 1' (16%) | Type 1' (14%) | (17%) |
| | Type 1 | Type 1 (12%) | Type 1 (07%) | (12%) |
| Female | Type 4 | Type 4 (30%) | Type 4 (31%) | (34%) |
| | Type 5 | Type 5 (20%) | Type 5 (23%) | (26%) |
| | Type 2 | Type 2 (18%) | Type 2 (18%) | (21%) |
| | Type 1 | Type 1 (18%) | Type 1 (17%) | (19%) |
| | Type 1' | Type 1' (17%) | Type 1' (17%) | (18%) |
| | Type 3 | Type 3 (17%) | Type 3 (14%) | (18%) |

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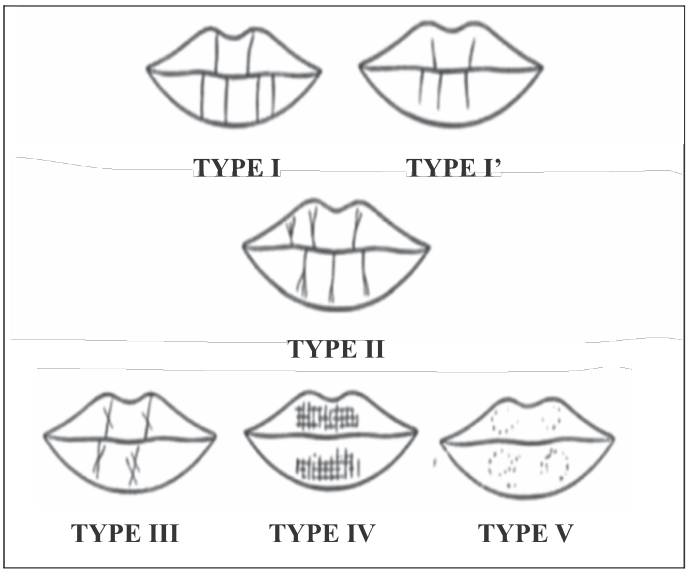


**Discussion:**

Personal identification is defined as the 'Establishment of the identity of an individual'. Identification techniques play a crucial role in the management of dead bodies in situations of natural calamities and disasters like earthquakes, tsunamis, air crashes, landslides, terrorist attacks etc. Nearly all criminal investigations need precise, reliable and admissible identification techniques to pinpoint criminals and terrorists for the administration of justice by quality prosecution. Lip lines manifest in intrauterine life (6th week) and remain constant during the lifetime of an individual.[9] Lip patterns recover even after trauma, inflammation and the diseases like herpes which can be recognized without difficulty.[4] Cheiloscopy i.e. study of lip prints have shown enormous potential towards personal identification.

Present study has adopted quadrant method for evaluation of lip print i.e. division of lip region into four quadrants which was also implicated by Gondivkar et al. (2009), Saraswathi et al.[10] (2009), Satyanarayana et al. (2011), Gupta et al. (2011), Venkatesh and David[11] (2011), Prabhu et al.[5] (2012), Koneru et al.[12] (2013) in India and Tsuchihashi[3,4] (1974), El Domiaty et al.[13] (2010), and some other researchers across the globe. Aditi et al. (2022), Vats Y et al. (2013), Hassan FZ et al. (1977) have opted for 6 quadrants division, Augustine J et al (2008) for 8 quadrants, Jagmeet Kaur et al. (2021) and Adamu LH et al.[14] (2013) for 10 quadrants division of lips.

Similar to our observation Type 1 i.e. vertical complete lines, are mentioned as most common observed lip lines in studies of Vijay Kautilya D et al. (2013), Koneru et al.[12] (2013), Vahanwala and Parekh,[15] (2000), Kapoor N et al.[16] (2015), Sanya et al. (2021), Priyanka Ghalaut et al. (2012) Pratibha et al.[17] (2020) in India and by Neo et al.[18] (2012) in Malaysia, Ragab et al. (2013) in Egypt and Ishaq et al. (2018) in Pakistan. The range of incidence of Type 1 lip lines varies from 30% to 64% in these studies which is also verified in present study as 52% male and 44% female have shown Type 1 line. On the contrary, Rao B et al. (2014), Kumar et al. (2016) reported Type 4, reported as the commonest lip line in India and Abdel Aziz et al. (2016) reported Type 3 as the most common variety observed in Malaysian and Egyptian population. We found all type of lines more common in males similar to what reported by Koneru et al. (2013), Kapoor et al.[12] (2015) and Saraswathi TR et al[17].(2009), on the contrary, reported that the incidence of Type 1 line in more among females. Aditi et al.,[18] (2013) also reported Type 5 as the most predominant line among male and female subjects.

Type 4 lines are seen in majority of subjects on the upper lip in present study which is in agreement with studies of Kumar et al. (2016) however K. Srinivasulu et al. (2020), Ghimire et al.[19] (2013) Nishi R. et al.,[20] (2018), reported Type 1line as the most common line on the upper lip followed by Type 2. Kapoor et al. (2015) reported Type 2 line as the most common line on the upper lip followed by Type 1.

Majority of researches i.e. Nishi R. et al.,[20] (2018), K. Srinivasulu et al. (2020) have reported that the order of incidence of different lip lines is almost identical for right and left quadrants including present study, indicating bilateral symmetry among both half of a single lip.

**Conclusion:**

Lip prints are present since birth and remain till life in unaltered form which can be used for identification like finger prints. Incidence of different types of lip lines varies among populations and can be a potential tool for determination of sex, ethnic group, race. The time has now arrived to explore the ways to reach out the destination in the form of a reliable human identification technique using lip lines. Further studies are needed with larger sample size to verify and to add further data. The identification data which can be useful for society should be prompt, precise and at the same time secured and computerized. Presently, biometric data of fingerprint and iris or face scan are serving the purpose but collection and preservation of biometric data have significant financial implications with it to arrange sophisticated scanning instruments, computers and manpower along with expensive servers for its storage.

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ORIGINAL ARTICLE

# A Cross Sectional study of Cephalic Index to Determine Sexual Variation in male and female MBBS and BDS Students of a Tertiary Care Teaching hospital in North East India

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**Abstract:**

Anthropometric characteristics have direct relationship with sex, shape and form of an individual and these factors are intimately linked with each other and are a manifestation of the internal structure and tissue components which in turn, are influenced by environmental and genetic factors. Cephalic Index is useful for identification of race. It is also used to determine sexual differences especially in individuals whose identities are unknown. A research study was conducted with an aim to determine cephalic index of MBBS and BDS students of a tertiary care teaching hospital in North East India and to compare sexual variation. A total of 480 MBBS and BDS students participated in the study with a ratio of 2:1. The mean age of the participants was 21 ± 2 years. Male participants were more in number than female with 2:1 ratio. Students belonging to all Northeastern States participated in the study with fewer from All India quota. The mean cephalic index was 82.07 ± 2.61 ranging from 72.43 to 84.21. The CI of female was more than male students and it was found to be statistically significant (p=0.02). The Brachycephalic type is the commonest cephalic index in both sexes (73.5% in male and 64.8% in female) respectively followed by Mesaticephalic (24.6% in male and 33.3% in female). Dolicocephalic is least common type of cephalic index. However, brachycephalic CI is higher in male participants and mesaticephalic CI is higher in female participants and this difference is found to be statistically significant.

**Keywords:** Cephalic index; Sexual dimorphism; North east india; Mesaticephalic; Dolicocephalic; Brachycephalic skull; MBBS students; BDS students; Tertiary care teaching hospital.

## Introduction:

Anthropometric data are believed to be objective and they allow the forensic examiner to go beyond subjective assessments such as ´similar' or ´different'. With measurement data, the examiner is able to quantify the degree of difference or similarity and state how much confidence can be placed in this interpretation.[1]

Cephalic index is a useful anthropometric parameter utilized in the determination of racial variations.[2] It is also called as Cranial Index or Index of breadth and was defined by Swedish professor of Anatomy Anders Retzius (1796–1860) as the ratio between maximum breadth of the skull to the maximum length of the skull. It was first used in physical anthropology to classify ancient human remains found in Europe.[3] It is one of the clinical anthropometric parameters recognized in the investigation of craniofacial skeletal deformities and brain development because of its validity and practicality. Cephalic indices also play a crucial role in comparison of cephalic morphometry between parents, offsprings and siblings and provide information on inheritance pattern.[4] Further, cephalic index is the most frequently investigated craniofacial parameter as it utilizes the length and breadth of the head which are useful indices in the study of secular trend.[5] It gives an idea of how genetic characters are transmitted between parents, offsprings, and siblings.[6] It is inherited in a unitary fashion. Isolated or syndromic-craniosynostosis, primary microcephaly, and hydrocephalus are pathological disorders which manifest with abnormal cephalic indices in addition to other features.[7]

Cephalic Index is divided into three categories: Dolicocephalic (long headed), Mesaticephalic (medium headed), Brachycephalic (short headed).[8,9] Cephalometric studies can also be carried out by various methods like photogrametry, ultrasound, computed tomographic scanning, magnetic imaging, optical surface scanning and cephalometry.[10]

The present study was carried out to measure cephalic index, the types of head shapes in MBBS and BDS students of a tertiary care teaching hospital in North East India in order to study the sexual variation. This will help in establishing a database regarding sexual variations in cephalic index of the study population. This study will also help in identification, especially in sex differentiation of unknown bodies, decomposed bodies and mutilated remains and in mass disasters.

## Materials and methods:

The present study is a Cross-sectional study and was carried out in a tertiary care teaching hospital, in North East India. This institute has yearly intake of 125 undergraduates medical students, 150 postgraduate medical students and 50 dental

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students. The study was done from January 2021 to October 2022. The study population comprised of MBBS and BDS students studying in the institute who were above 18 years of age and were willing to participate. Students with congenital craniofacial anomaly, trauma and those who have undergone reconstructive surgery were excluded.

The sample size was calculated as follows:

Taking sample size as (N)

Taking power of the study (U) at 80% = 0.84

Value at 95% confidence interval (V) = 1.96

Standard deviation (SD) of cephalic index for male($SD_1$)= 2.55 and for female($SD_2$) =2.79

Taking, mean (M) for cephalic index in male ($M_1$) = 77.08 and for female ($M_2$) = 79.02 (from the study done by Gujaria[21]), sample size was calculated using the formula:

$$N = \frac{(U+V)^2 \times (SD_1^2 + SD_2^2)}{(M_1 - M_2)^2}$$

$$\text{Therefore, } N = \frac{(0.84 + 1.96)^2 \times (2.55^2 + 2.79)^2}{(77.08 - 79.02)^2}$$

$$= 29.77$$

The calculated sample size was 29.77 for male and female each, which was rounded to 30 for male and female each. Therefore, total sample size calculated was 60. However, MBBS and BDS students in the institute are enrolled from seven northeastern states quota and central quota. So, 60 students from each seven state and central quota if considered, then sample size came around 480. Since the number of students were less than 60 for some states, all the students from that particular state were included in the study.

Sampling: In some states number of students were more than 60, therefore, simple random sampling was done. Participants were selected by lottery method.

Study variables: Independent Variables:

1.Age 2.Sex 3. Ethnic group

4. Breadth of the skull (cm) 5. Length of the skull (cm)

Dependent Variables: Cephalic Index

Study tools: Martin's Spreading Calipers

Data collection: Working definition:

Cephalic Index: The ratio between the maximum breadth of the skull to the maximum length of the skull multiplied by hundred.

Maximum breadth of the skull: The distance between the two parietal eminences of the skull.

Maximum length of the skull: The distance between the glabella and the external occipital protuberance of the skull.

Procedure: Students were called in batches during free time or after the classes to the department of Forensic Medicine and Toxicology and the measurements were done and recorded. All the measurements were done maintaining privacy in a room.

**Table 1. Distribution of the participants by state domicile (N=480).**

| State | Frequency | Percent |
|---|---|---|
| Arunachal Pradesh | 44 | 9.2 |
| Non Northeastern States | 36 | 7.5 |
| Manipur | 150 | 31.3 |
| Meghalaya | 52 | 10.8 |
| Mizoram | 43 | 9.0 |
| Nagaland | 51 | 10.6 |
| Sikkim | 36 | 7.5 |
| Tripura | 68 | 14.2 |

**Table 2. Distribution of the participants by their height and weight (N=480).**

| Anthropometric parameter | Measurement (Mean ± SD) |
|---|---|
| Height | 161 ± 9 cm |
| Weight | 58 ± 10 kgs |

**Table 3. Distribution of the participants by their skull breadth and length (N=480).**

| Skull | Measurement (Mean ± SD) |
|---|---|
| Breadth | 14.9 ± 0.7 cm |
| Length | 18.1 ± 0.6 cm |

**Table 4. Sex variation of cephalic index.**

| Sex variation | Cephalic index (Mean ± SD) | Mean difference | P value |
|---|---|---|---|
| Male | 81.85 ± 2.68 | 0.54 | 0.02 |
| Female | 82.39 ± 2.57 | | |

After getting due consent from the study subjects, these measurements were performed with subjects in a relaxed condition with head in the anatomical position using standard anatomical landmarks. A spreading caliper was used to measure the head measurements.

Statistical analysis: Data entry was using windows based statistical package for social sciences [SPSS] version 21.0 (Armonk NY: IBM Corp). Descriptive statistics like mean, standard deviation was used to summarize age and cephalic index. Frequency and proportion were used to determine sex and ethnic group. To compare between male and female cephalic index students test was used. A p-value of 0.05 or less was considered significant.

Ethical issues: Written informed consent was obtained from the students regarding the collection of data, and the approval from the Research Ethical Board (REB), of the institute was sought. The findings were recorded in proforma and the results were analyzed. Access to the data will be restricted to the investigator and the guides, and members of REB (Research Ethics Board) when they demand. The present study is a self-sponsored study and there is no conflict of interest.

**Results:**

A total of 480 students participated in the study. The mean age of the participant is 21 ± 2 years ranging from 18 years to 26 years including both sexes of MBBS and BDS students. Male subjects were 285 (59.4%) and females were 195 (40.6 %). (Figure 1). Majority belonged to MBBS – 326 (67.9%). BDS - 154 (32.1%). (Fig 2).

Majority of participants belonged to Manipur state domicile – 150 (31.3%), followed by Tripura (14.2%), Meghalaya (10.8%), Nagaland (10.6%), Arunachal Pradesh (9.2%), Mizoram (9.0%),

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**Table 5. Correlation between age of the participants and their cephalic index.**

| Correlation | | Age (year) | Cephalic Index |
|---|---|---|---|
| Age (year) | Pearson Correlation | 1 | 0.12 |
| | P value (significant) | | .009 |
| | N | 480 | 480 |

**Table 6. Sex wise comparison of different types of cephalic index (N=480).**

| | Male | | Female | | |
|---|---|---|---|---|---|
| Type of Cephalic Index | Frequency | Percent | Frequency | Percent | P value |
| Dolichocephalic | 9 | 1.9 | 9 | 1.9 | |
| Mesaticephalic | 118 | 24.6 | 160 | 33.3 | 0.02 |
| Brachycephalic | 353 | 73.5 | 311 | 64.8 | |

Sikkim (7.5%) and Non Northeastern States (7.5%) (Table 1 and Fig 3). Above table depicts that the height and weight of the participants where the mean height is 161 ± 9 cm and the mean weight of the participants is 58 ± 10 kgs (Table 2). Average measurement breadth and length of the skull of participants are 14.9 ± 0.7 cm and 18.1 ± 0.6 cm respectively where the measurement ranges from 13 to 16 cm and 16 to 19 cm respectively (Table 3). The mean cephalic index is 82.07 ± 2.61 ranging from 72.43 to 84.21 (Table 4). Above figure depicts the sexual variation of cephalic index where female's cephalic index is comparatively higher (82.39 ± 2.57) than male (81.85 ± 2.68) with mean difference of 0.54 and it is statistically significant with p value of 0.02 (Fig 4). Positive correlation is seen between age in years and cephalic index where with every unit increase in years of age, there is increase of cephalic index by 0.12 which is found to be statistically significant (p value 0.009) (Table 5).

Cephalic index classifications: for male - <75.9, 76 to 81 and > 81; for female - <75, 75.1 to 83.0 and > 83.

Above table 6 and figure 5 have shown that Brachycephalic type is the commonest Cephalic Index in both sexes (73.5% in male and 64.8% in female) respectively followed by Mesaticephalic (24.6% in male and 33.3% in female). Dolicocephalic is least common type of cephalic index. However, Bracycephalic CI is higher in male participants and Mesaticephalic CI is higher in female participants and this difference is found to be statistically significant with a p value of 0.02.

Fig 6 shows the gender distribution of the participants statewise where maximum number of participants belonged to Manipur. 82 males and 68 females participated form Manipur, 33 males and 35 females from Tripura, 35 males and 17 females from Meghalaya, 32 males and 19 females from Nagaland, 31 males and 13 females from Arunachal Pradesh, 25 males and 18 females from Mizoram, 24 males and 12 females from Sikkim and 23 males and 13 females from Non North Eastern states. Table 7 shows comparison of cephalic index between the course category i.e BDS and MBBS where CI in more among BDS students than MBBS with the mean difference of 0.81878 and it is found to be statistically significant with a p value of 0.002.

**Discussion:**

The present study was aimed at determining the sexual variation of cephalic index amongst MBBS and BDS students of a tertiary care teaching hospital where majority belongs to mongoloid origin.

The mean cephalic index was 82.07 ± 2.61 and ranged from 72.43 to 84.21 where male's cephalic index is 81.85 ± 2.68 and female's is 82.39 ± 2.57 with a mean difference of 0.54 which is statistically significant (p-value 0.02). The brachycephalic (large sized) type of cephalic index was the commonest type seen in both sexes (male - 73.5% and female - 64.8%) and this variation was found to be statistically significant with a p-value of 0.02. Mesaticephalic type of cephalic index is higher in female (33.3% vs 24.6%).

The mean cephalic index of this study finding is similar to the studies conducted in various parts of the country (Nepal, Central India, Nigeria, China and Malaysia) conducted by Timsina et al.,[17] Yagain et al.,[22] Eliakim et al.,[29] Raji et al.,[30] Thu et al.,[32] and Murniati et al.[34] where the study were focused on different ethnic group and found the mean cephalic index higher in comparison to the other race. Above mentioned studies also found that the cephalic index – brachycephalic type was majority.[17,22,29,30,32,34] But previously many studies were conducted in North, South and Central India, where the findings showed that the medium sized (mesaticephalic type of cephalic index) head/skull were common.[11-15,19,49-51] Majority of the studies show that the cephalic index of female was predominant and it was statistically significant.[15,17,19,22,25,29,33-36,52,53]

The present study also showed similar finding where female's cephalic index is higher (82.39 ± 2.57) and difference by 0.54 in average and this difference is found to be statistically significant.

In the present study, the mean cephalic index in females (82.39) [Brachycephalic] was higher than the studies of Yagainet al.,[22] (78.20); Patro et al.[19] (78.38); and Khair et al.[51] (75.22); which shows Mesatocephalic range in the above studies.

These findings are compared with the studies conducted by Kumaranet al.,[11] Shah et al.,[13] Timsina et al.,[17] Muhammed et al.,[33] Akhter et al.,[36] Ansari et al.,[38] and Thomas et al.,[49] where the researchers compared the cephalic index between different ethnic group and races and found that Mongoloid cephalic index is higher than other ethnic groups. The northeast Indian people are mainly of Mongoloid origin having higher cephalic index which is different from other parts of India.

In the present study the Mean Cephalic Index in overall study sample (82.07) was higher than the studies of Mishra et al.[16] (77.79); Patro et al.[19] (77.75); Salve et al.[23] (76.94); and Khair et al.[51] (78.48); which shows the mesaticephalic range in the above studies, whereas, it was similar in Nair et al.[52] (81.21); and Kanan et al.[53](81.00); which shows the brachycephalic range.

In our study, the dominant head shape type was brachycephalic (47.2%) followed by mesaticephalic (30.4%). Dominant head type in this study was similar to other studies in Nigeriaby Akinbami,[10] the study in central India by Yagain et al.[22] showed that there is a tendency towards brachycephalic. This was not similar to a study performed by Muhammad et al.[33] who found 58.5% of the Indian population was dolichocephalic.

Comparing the previous records of the CI with current work proves the tendency towards "brachycephalic," which is a confirmation of continuous growth of the brain more in the lateral direction. Also, in tropical zones, the form of the head is longer

(i.e., dolichocephalic), but in temperate zones, the head type is round (i.e., mesaticephalic or brachycephalic). Since India is in both temperate and tropical zones partly, the present classification depicts a tendency to be Brachycephalic from dolichocephalic. The average measurement of breadth and length of the skull of participants of both sexes are 14.9 ± 0.7 cm and 18.1 ± 0.6 cm, respectively, where the measurement ranges from 13 to 16 cm and 16 to 19 cm, respectively. The variations of head shape may be due to hereditary factors or environmental, which may act as a secondary effect. Vermaet al.[50] also found the head lengths (18.85 cm), which is slightly higher than the present study. The results of the present study validate that there is a variation in the Cephalic Index between males and females. Though both categories have Brachycephalic skulls, the value in the female sex is higher with a significant difference ($p = 0.02$), confirming sexual dimorphism of the Cephalic Index.

**Conclusion:**

In the present study, Cephalic Index has been calculated for the MBBS and BDS students of a tertiary care teaching hospital in North East India. It is found that the majority of the students (64.8%) have a Brachycephalic type of skull, and there is a significant ($p = 0.02$) sexual variation, i.e., sexual dimorphism between males and females. Though both males and females have a brachycephalic skull, the Cephalic Index is higher in females, and the difference is significant, with a p-value of 0.02. This confirms the Sexual Dimorphism of the Cephalic Index and hence can prove useful in the identification of skeletal remains in this part of the country.

**Ethical Clearance:** taken

**Conflict of Interest:** Nil

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ORIGINAL ARTICLE

# Determination of Multiplication Factor to know the Height using the Combined Length of Forearm and hand in Dead Bodies at Indore Central India

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**Abstract:**

Like other phenotypic traits, stature is ascertained through the integration of genetic, environmental, and demographic factors. It has been underscored that the associations between various bodily parameters manifest variances across populations due to dissimilarities in nutrition, levels of physical activity, and environmental influences, which serve as modulatory factors. Moreover, racial and ethnic disparities exert a noteworthy influence on genetic expressions. The intricate relationship between genetic potential and environment is multifaceted and is the fundamental determinant of stature. Stature exhibits sexual dimorphism and adheres to a relatively normal statistical distribution. Stature prediction occupies a central position in anthropological research and the identification procedures mandated by medical jurisprudence or necessitated by medico-legal experts. Hence, it assumes significance for both medico-legal and humanitarian purposes. The present study was conducted to know the multiplication factor for estimating stature. The anthropometric measurements of the combined length of the forearm plus hand and height were taken using “standard anthropometric measuring instruments” in centimetres'. The data were recorded carefully up to mm for accuracy and then analysed with associated factors, and appropriate tests were applied to test the statistical significance. The value of $<0.05$ was considered statistically significant to interpret the findings. In the present study, the M/F ratio was 1:1. The mean stature was $163.45 \pm 5.38$cm in male subjects, whereas, in female subjects, the mean stature was $142.27 \pm 5.34$ cm. The males were found to be taller than females, with the bisexual differences being statistically significant ($p<0.001$). This study helps to know the multiplication factor that may be used for stature estimation in the population of Indore. Definite proportion exists between all individuals' stature and the combined length of the forearm and hand. These multiplication factors are derived for males 3.58 and females 3.78. statistical analysis.

**Keywords:** Identification; Anthropometry; Stature; Forearm and hand; Multiplication factor.

## Introduction:

Estimation of stature from the incomplete skeletal remains or the mutilated or amputated limbs or parts of limbs or highly decomposed, fragmented human remains has obvious importance in personal identification of the individual in the events of murders, accidents or natural disasters considered as one of the most significant aspects of forensic science.[1] It is the single most portable, universally applicable inexpensive and non-invasive technique for measuring the length of the forearm and hand. Stature is one of the most essential and primary elements in formulating the biological profile during the process of personal identification of an individual. Stature is one of the key parameters established in the course of identification of unknown skeletal remains.[2] As all individuals differ in their measurable traits, therefore stature estimation by anthropometry is paramount for giving quantitative expression to variations of such traits. Ascertaining sex and estimating stature from incomplete skeletal remains and decomposing bodies is a recurring theme in physical anthropology and forensic science.[3,4] In most advanced countries, documented skeletal remains are available to forensic experts. In India, recorded skeletal remains are not available for establishing the norms of stature reconstruction. In the absence of documented skeletal material, the researchers have focused their attention towards living population groups of India and have taken relevant bone length over the skin and correlated them with the stature to find out the degree of relationship between them and subsequently formulated multiplication factor for long bones and their fragments for the reconstruction of stature.[5] Thus, the studies conducted by researchers.[5-8] in India pertains to the use of percutaneous measurement of long bones and their fragments for the reconstruction of stature. Some of the studies[6,9,10] have reported a significant difference in the proportion of the limb bone dimensions due to the population's environmental, hereditary and dietary factors, and have influenced a person's stature. In a vast country like India, the climatic condition and nutritional habits of different regions vary considerably, in

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**Table 1. Multiplication factor.**

| The ratio of height and average of combined length of forearm and hand | Male | Female |
|---|---|---|
| Minimum | 3.42 | 3.67 |
| Maximum | 3.73 | 3.77 |
| Average | 3.58 | 3.72 |

**Table 2. Study of comparison of multiplication factor of combined length of forearm and hand for both male and female with other studies.**

| S. No. | Authors | Multiplication factor male | Multiplication factor female |
|---|---|---|---|
| 1. | Kumar Amit et al. (2010) | 3.67 | 3.73 |
| 2. | Kumar Sushil et al. (2010) | 3.899 | -- |
| 3. | Choudhary et al. (2014) | 3.665 | 3.664 |
| 4. | Jain et al. (2015) | 3.68 | 3.73 |
| 5. | Banik et al. (2016) | 3.89 | 3.79 |
| 6. | Present study | 3.58 | 3.72 |

addition to the racial and ethical variation. It is opined that the study of residents of one state is not necessarily applicable to residents of another state.[11] Due to improved socioeconomic conditions, the population, especially in India, is getting taller, and the relationship between height and length of long bones is changed. Hence, fresh formulae are needed for generation.[12,13]

The lack of anthropometric data concerning the local population of Indore was felt as the city is prone to mass disasters like bomb blasts, and accident. Hence the present study was aimed at & concentrated on the Indian population of Indore of known stature, of which anthropometric measurements of the combined length of forearm and hand were calculated & correlated with stature to find the multiplication factor.

**Material and methods:**

The present Cross-Sectional study was carried out on a sample of 400 deceased individuals in the Department of Forensic Medicine mortuary, Mahatma Gandhi Memorial Medical College and M.Y. Hospital, Indore (M.P.). In the present study, a convenient sampling procedure was done. We examined 200 deceased males and 200 deceased females. The study included individuals who were 21 years of age or older. Exclusion criteria were skeletal abnormalities, deformities, amputated lower limbs, and mutilated and decomposed bodies. Written informed consent was taken before the research after giving detailed information to the relatives of the deceased regarding the study. Detailed individual demographic data, including the height, sex, age etc., were also recorded on the pre-structured proforma. Anthropometric measurements of the combined length of the forearm and hand on the left and right side of each consented individuallying down height were also recorded. All the measurements were taken in daylight. The measurements were taken twice for accuracy.

Stature is measured as the vertical distance between the vertex and the heel in the mid-sagittal plane, where the vertex is the highest point on the head when the head is held in Frankfurt Horizontal (FH) plane using Standard measuring tape.

The length of the Forearm and hand was measured between the tip of the olecranon process of the ulna and the tip of the middle finger of the hand of the subjects using a sliding calliper as well as a standard measuring tape. The measurements were taken where the pronated and forearm were placed on flat, hard, and horizontal surfaces with extended and abducted fingers but without any abduction adduction, flexion or extension of wrist joint so that the forearm was directly in longitudinal axis with the middle finger.

Multiplication factors were calculated to evaluate ratio of the average height of the individual and the average combined length of the forearm and hand.

**Observation & results:**

Distribution of anthropometric parameters for age, the mean age of the male and female subjects was 43.25 ± 13.85 years and 38.57 ± 14.70 years, respectively. The range of the age in male subjects was 21 to 80 years. The range of the age in female subjects was 21 to 90 years. The maximum sample came in the age group 21-30 years in females and 51-60 years in Males.

Furthermore, multiplication factor calculation and comparison with other studies were done in Table No. 01 and 02, respectively. These multiplication factors are derived for males 3.58 and females 3.78. statistical analysis is used to know the relation between height and the combined length of the forearm and hand.

**Discussion:**

The male subjects' mean height was 163.45 ± 5.38 cm, with the maximum reported height being 179.50 cm and the minimum reported height being 153.6 cm. Therefore, the height range for male subjects in this study was 153.6 to 179.5 cm. It is important to note that the study conducted by M.R. Shende population of Maharashtra state of India.[14] The height range for male subjects in that study was reported to be 153.4 to 189.2 cm, with a mean height of 170.12 cm and a standard deviation of 6.99 cm. The observed subjects in that study were between 18 and 22 years old. While the minimum reported height was the same in both studies, it is worth noting that the maximum reported height in the study conducted by M.R. Shende was approximately 10 cm greater. This difference could potentially be attributed to the narrower age range of subjects in the current study compared to the age range in the study conducted by M.R. Shende.[14]

Moving on to the female subjects, the mean height observed in this study was 142.27 ± 5.34 cm. The range in height for the female subjects was reported to be from 145.0 to 167.3 cm. Comparatively, in the study conducted in Maharashtra, Indian female subjects had a height range of 140.8 to 174.0 cm, with a mean height of 156.15 cm and a standard deviation of 11.10 cm, which were higher than the findings in our study.[14] Furthermore, another study conducted in Jammu, India, found slightly higher heights for both males and females, with observed heights of 169.76 ± 6.23 cm for males and 155.21 ± 5.32 cm for females.[15] These findings suggest that there is height variation in different parts of India. It is worth noting that males were found to be, on average, 21.18 ± 5.38 cm taller and had more extended hands than females. These differences between sexes were statistically significant ($p < 0.001$)(14–17).Various studies have consistently shown that males tend to be taller than females.

In the present study, the mean age of male subjects was 43.25 years, while the mean age of female subjects was 38.57 years.

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Thus, the mean age of males was higher than that of females. The multiplication factor, which represents the stature ratio to the combined length of the forearm and hand, has been calculated and observed in males and females. In males, the range of the multiplication factor was found to be between 3.42 and 3.73, with an average of 3.58. In females, the range was between 3.67 and 3.77, with an average of 3.72. The multiplication factor serves as a convenient tool, particularly in situations where forensic investigators may not be well-versed in complex mathematical equations or when dealing with many cases, such as mass disasters or incidents involving victims of terrorist attacks. The table reveals that previous studies conducted by Kumar Amit et al. (2010),[16] Jain et al. (2014),[18] and Choudhary et al. (2014)[15] have reported similar multiplication factors of 3.67, 3.68, and 3.66, respectively, in males. However, Kumar Sushil et al. (2010)[16] and Banik et al. (2016)[19] found a higher multiplication factor (3.89) in males, which contrasts with the findings of the present study. Regarding females, our study demonstrated a similar multiplication factor (3.72) for the combined length of the forearm and hand compared to other studies, such as Kumar Amit et al. (2010).[16] Jain et al (2015),[18] Banik et al (2016)[18] (Table-02).

Full form of mnemonic used in study-

HT- Height.

RCLF & H– Right combined length of forearm and hand.

LCLF & H– Left combined length of forearm and hand.

Avg CLF & H –Average combined length of forearm and hand.

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**Conflict of interest:** None declared.

**Ethical approval:** The study was approved by the Institutional Ethics Committee

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ORIGINAL ARTICLE

# A Profile on Medico-legal Cases Reported at a Tertiary Care Centre in the Coastal Town of South Karnataka

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**Abstract:**

The National Medical Council of India has officially renamed Casualty as Emergency Department and as the name suggests it is equipped to handle any incoming trauma into a hospital. Some cases unlike others have a legal aspect to it apart from it being a medical emergency. A retrospective cross-sectional of medico-legal cases recorded from 1st January 2020 to 31st December 2021 was conducted at Kasturba Medical College and Hospital, Manipal. Through this study, such cases labeled medico-legal are evaluated based on Age, Gender, and Type of Cases. Consequently, aim to reduce the frequency of such cases reported, by understanding the risk factors at the helm and thus aid in spreading awareness among the general public to curtail the causative factors so responsible.

**Keywords:** Medico-legal; Tertiary Care; Road Traffic Accidents; Assault.

**Introduction:**

A center which is specialized to provide the highest level of care and is equipped to handle any incoming trauma is designated as a tertiary care center.[1] The cases that arrive through the emergency department have varying characteristics. It can be purely a medical emergency or it can also have a legal implication to it.

The protocol dictates that if the doctor decides after obtaining a history and physical examination that a case should be labeled as medico-legal, then the police should be intimated accordingly, for further investigation into the incident.[2,3] The following process is by not just the treatment protocol, but also the reports and samples collected in correspondence with evidence collection formalities.[4] There also exists a possibility that any such documentation obtained may be called into question before the Court of Law and the doctor thus becomes an expert witness under section 45 of the Indian Evidence Act (IEA).[5]

It is intended that this study will form the framework of the current orientation of the categorization of Medico-legal cases reported in such demography. Statistics regarding the frequency of such cases along with factors such as gender, age, etc. play a vital role in creating a blueprint of the existing scenarios in a population. Factors such as circumstance do play a role, however, if a pattern can be identified from the population, then efforts could be made to prevent such recurrent happenings. Studies, in turn over a geographical area, over a period can directly or indirectly be used to map the conditions existing in a country. This consecutively helps public administrators, other Non-Governmental Agencies, and welfare workers to implement policies for the betterment of the community.

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**Material and methods:**

This is a retrospective, cross-sectional study pertaining to the medico-legal cases reported at Kasturba Hospital, Manipal, Karnataka over a span of 2 years, commencing from 1st January 2020 to 31st December 2021.

The procedure followed included:

i. Details collected from existing records such as the Accident Registers, Police intimation reports, and the patient's case files.

ii. The details so collected are entered in a predetermined proforma consisting of variables required for analysis.

Inclusion criteria included all medico-legal cases reported during the interval under consideration, while all non-medicolegal cases of the same duration were excluded. The data has been analyzed statistically and the results are represented in the form of frequency tables, graphs, and charts Statistical analysis of data was done and presented as results and observations in tabular form, graphs, and charts.

Institutional Ethical Clearance has been obtained from the concerned authorities. The data acquired through this study has been anonymized and is not shared with anyone outside the study team to maintain confidentiality.

**Results:**

During the two years, a total of 8475 cases were recorded under the medico-legal label, reported at Kasturba Hospital Manipal. They were analyzed in terms of Gender (Figure 1), Age groups (Figure 2), and the type of cases (Figures 3 and Table 1-2). As per the results obtained, there is not much difference in the number of cases reported during either year, but a small difference of 2.4%

**Table 1. Distribution of cases based on gender.**

| Type of Case | Cases Reported (in Number) | | |
|---|---|---|---|
| | Male | Female | Others |
| Burns | 103 | 60 | 0 |
| Physical Assault | 107 | 24 | 0 |
| Sexual Assault | 2 | 29 | 0 |
| Road Traffic Accidents | 3981 | 1057 | 2 |
| Poisoning | 368 | 255 | 0 |

**Table 2. Distribution of cases based on age.**

| Type of Case | Cases Reported in Number | | | |
|---|---|---|---|---|
| | <18 | 18-25 | 26-40 | 41 & above |
| Burns | 43 | 25 | 43 | 52 |
| Physical Assault | 5 | 29 | 54 | 43 |
| Sexual Assault | 23 | 7 | 1 | 0 |
| Road Traffic Accidents | 250 | 1363 | 1534 | 1893 |
| Poisoning | 87 | 159 | 190 | 187 |

**Table 3. Comparative study done by different authors with the present study.**

| Author | Number of Cases | Duration | Gender | Most Reported Type of Case | Risk-prone Age Group |
|---|---|---|---|---|---|
| Dr.Dake Rajesh et al.[6] | 1050 | 2 | M | Road Traffic Accidents | 21-40 |
| Ashwini Kumar and Rajiv Joshi[7] | 1850 | 1.5 | M | Road Traffic Accidents | 21-30 |
| Partha S. Bhattacharyy et al.[8] | 355 | 2 | M | Road Traffic Accidents | 26-50 |
| Nikhil Jagtap and Manoj B Patekar[9] | 2450 | 2 | M | Road Traffic Accidents | 21-30 |
| Dr. Manju et al.[10] | 8615 | 3 | M | Road Traffic Accidents | 20-30 |
| Bharath Kumar Guntheti and Uday Pal Singh[11] | 1312 | 1 | M | Road Traffic Accidents | 20-40 |
| Ajmad Iqbal Burq et al.[12] | 3105 | 1 | M | Road Traffic Accidents | 21-30 |
| Mohammed Sarwar Mir et al[13] | 2250 | 1 | M | Road Traffic Accidents | 21-30 |
| Santhosh Chandrappa Siddappa and Anupam Datta[14] | 4066 | 1 | M | Road Traffic Accidents | 21-30 |
| Dileep Kumar et al[15] | 173 | 1.5 | M | Road Traffic Accidents | 21-30 |
| Vishal Garg and Dr S.K. Verma[17] | 784 | 2 | M | Road Traffic Accidents | 21-30 |
| Present Study | 8475 | 2 | M | Road Traffic Accidents | 41 and above |

with 48.80% (4136) cases reported in 2020 followed by 51.20% (4339) cases in 2021. Among the categories under consideration, the category 'Others' with 2487 (29.35%) cases encompasses everything from different kinds of Bites (including snake bites, dog bites, and rat bites), Falls (slip and fall), industrial accidents, injuries while playing and unresponsive or brought dead cases.

In the comparison of the cases on a monthly basis, in the year 2020, the most cases reported were in the month of January with 584 cases, however in 2021 the most cases were reported in the month of March with 540 cases. The month with the least cases reported in 2020 was April with 182 cases and in the year 2021, May had the least number of reported cases with 181 cases. The outcome obtained from the study has been represented in the form of pictorial representations.

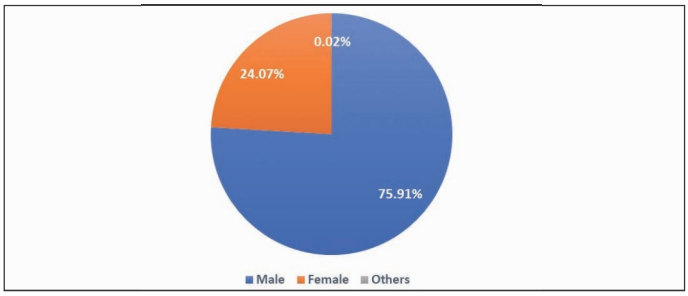


**Figure 1. Pie chart depicting gender-wise distribution of medico-legal cases.**

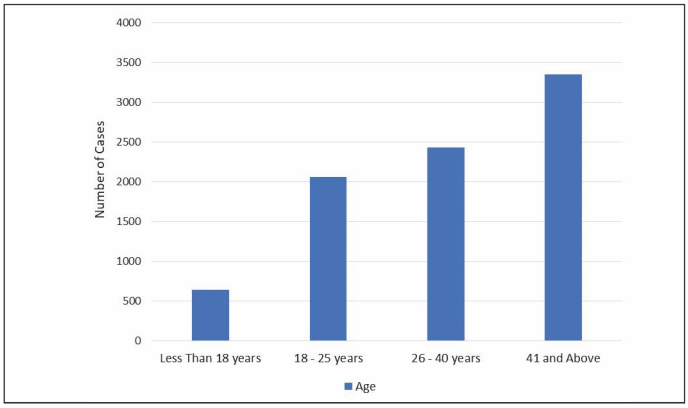


**Figure 2. Bar diagram depicting age-wise distribution.**

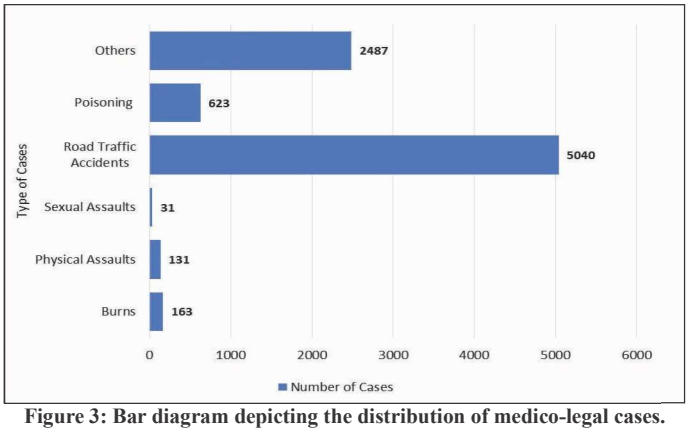


**Figure 3: Bar diagram depicting the distribution of medico-legal cases.**

## Discussion:

As per this study, the number of cases registered, male victim population was 6433 (75.91%) which is considerably higher than that of the female population (Figure 1). This conclusion is in accordance with the study done by multiple other authors such as Dr. Dake et al.,[6] Ashwini Kumar and Rajiv Joshi,[7] Partha S. Bhattacharyy et al.,[8] Nikhil Jagtap and Manoj B Patekar,[9] Dr. Manju, et al.,[10] Bharath Kumar Guntheti and Uday Pal Singh,[11] Ajmad Iqbal Burq, et al.,[12] Mohammed Sarwar Mir et al.,[13] Santhosh Chandrappa Siddappa and Anupam Datta,[14] Dileep Kumar et al.,[15] Abhishek Yadav and N.K. Singh[16] Vishal Garg and Dr S.K. Verma[17] etc.

This could be because of the male-to-female ratio or also because males are more predisposed to working outside, especially in India, hence increasing their chances of getting hurt. The most

risk-prone age as concluded from this study is 41 and above, which is extremely different from any of the information existing (Figure 2). Though this town primarily contains a student population, however, most of the cases reported in all the categories consistently remained much more in this age group as compared to others. The present study also depicts the fact that most of the cases are reported in the category of Road Traffic Accidents (Figure 3) which coincides with the result of the study conducted by Dr. Dake et al.,[6] Ashwini Kumar and Rajiv Joshi,[8] Partha S. Bhattacharyy et al.,[7] Nikhil Jagtap and Manoj B Patekar,[9] Dr. Manju, et al.,[10] Bharath Kumar Guntheti and Uday Pal Singh,[11] Ajmad Iqbal Burq, et al.,[12] Mohammed Sarwar Mir et al.,[13] Santhosh Chandrappa Siddappa and Anupam Datta,[14] Dileep Kumar, et al.,[15] Vishal Garg and Dr. S.K. Verma,[17] etc.

In studies reported by Dr. Tanuja Brahmankar et al.,[18] Ashwini Kumar, and Rajiv Joshi,[8] Physical Assault occupies the majority of cases reported, however as per his current study Physical Assault accounts for only 1.55% of total cases that has been reported. One of the reasons responsible for such an increase in road traffic accidents is because more vehicles are used by people and the non-adherence to traffic rules and regulations which can indicate a lapse in law enforced by law enforcement officials. Sexual Assault cases unlike the other cases show a greater incidence rate in the female population (93.55%) (Table 1) as per the present study which is congruent with studies carried out by S Saravanan et al. (62.6%)[19] Umar Nadeem et al.[20] also puts the female victim population at a higher risk.

The monthly distribution of cases varies, hence prediction of the number of cases each month cannot be done. However, the month with the maximum number of cases reported during the study period was January 2020 with 584 cases and the lowest to be reported was May 2021 with 181 cases. Though seasonal variation does not have a pivotal role in the number of cases registered unlike the flu during flu season, monsoon tends to show an increased occurrence of skid and fall accidents. However, the climate of the region under study generally has very frequent rains throughout the year, hence seasonal variation cannot be considered as a factor for increased or decreased cases reported.

**Conclusion:**

The emergency department of any hospital is a place that a multitude of people visit on a day-to-day basis. The primary duty of the physicians is to treat the incoming trauma. However, some of those cases will have legal implications that require further scrutinization by law enforcement agencies to delve deeper into the incidence under question. In terms of the records being used by the public administrative department, different variables can be ascertained from the said records and can further be used as a blueprint to analyze the type of cases that is generally reported at such tertiary centers. This in turn helps them to evaluate current levels of safety in the city, identify loopholes, and find solutions to address those. Moreover, these studies can also indicate the extent to which the proposed plans such as new traffic rules, anti-drug abuse campaigns, etc. are working. Also, in terms of the age and gender associated with these analysis helps the non-governmental organizations and the district administration working for this cause find exactly where the problem lies, and solve those instead of putting up newer generalized policies for the public.

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ORIGINAL ARTICLE

# A Questionnaire-based Study on Awareness and Knowledge of 'Medical Records' among Interns in a Tertiary care Hospital in Northern Karnataka

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**Abstract:**

In the near past, doctors are considered God by the patients but, in this era, Doctors are threatened by patients by increasing trends of complaints & litigations against doctors. The doctors should have optimum knowledge in delivering safe health care in an unbiased standardized way. Hence it is necessary to evaluate awareness and knowledge of 'Medical Records among budding Doctors. The present study was conducted to assess the awareness and knowledge of Medical Records among the Interns. This was a questionnaire based study carried out at Jawaharlal Nehru Medical College, KAHER. A predesigned self-structured multiple-choice questionnaire containing 20 questions was framed based on awareness and knowledge and was prepared in Google forms and sent to 123 Interns who were posted in various departments after obtaining informed consent. The results obtained in the study showed that the interns had enough awareness and knowledge about medical records and their purpose but they lagged in knowledge in maintaining MLC records and also lagged in awareness of charges for getting photocopies of medical records. Overall awareness and knowledge of medical records among our interns are better compared to peers but need to be enhanced to promote knowledge of electronic health data and their importance in their future practice.

**Keywords:** Interns; Awareness; Knowledge; Medical records; Electronic health records.

## Introduction:

Medical records are the systematic documentation of the patient's personal and social data, history of his or her ailment, clinical findings, investigations, diagnosis, treatment given, an account of following up, and outcome.[1] The medical records are the core of the Health Information system in the hospital.[2] The Medical Records Department (MRD) plays multiple roles in every hospital, which provides services to the patients, and hospitals and also plays a key role in health promotion and patient care quality. Therefore, evaluation of the services provided in this department is critical.[3] Doctors should have reasonable knowledge of medical records in delivering safe health care in an unbiased standardized way. Forensic Medicine subject is usually dealing with the teaching of medical law and ethics in Indian medical education set up.[4] Medical record plays a vital role in all cases, especially Medicolegal cases. For example, when a victim passed away in a road traffic accident, to claim insurance, MRD provides details of the concerned victim when asked by relatives. Nowadays everything had made easy using an electronic health record system. Taking into consideration the benefits and importance of medical records, the present study is aimed to assess the awareness and knowledge of intern doctors regarding medical records.

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## Materials and methods:

This Questionnaire study was carried out at Jawaharlal Nehru Medical College, KAHER after obtaining Institutional ethical clearance. A predesigned self-structured multiple-choice Questionnaire containing 20 questions was framed about the awareness and knowledge regarding medical records and was prepared in Google forms and sent to all the interns who were posted in various departments, among which 123 volunteering Interns were included in the study after obtaining informed consent. Responses were collected and analyzed and percentages were calculated.

## Results:

It was observed from table.1, that 89.4% of the Interns were aware of Medical Record Department and only 10.6% of Interns were unaware. Totally 87.8% of the Interns were aware of the abbreviation for MRD and only 12.2 % of interns were unaware of it. Most of the interns around 84.6% were aware of the purpose of MRD and only 15.4% of the Interns were unaware of it. Almost 95.9% of the interns were aware that the maintenance of patient records is the legal duty of the hospital and only 4.1% of the interns were unaware. A total of 82.9% of the interns were aware that the patient's records are the property of the patient, whereas only 17.1% of interns were unaware of it. Most of the interns, around 60.2% were aware of the duration of the preservation of hospital records, whereas 39.8% of the interns were unaware of it. Only 40.7% of the interns were aware of the charges for getting photocopies of medical records, whereas the remaining 59.3% of

them were unaware of it. Most of the interns, around 61.8% were aware of how to issue medical records when required by the patients, and the remaining 38.2% of interns were unaware of it. Totally 78.9% of the interns were aware that failure to provide medical records when asked by the patient is punishable and the remaining 21.1% of interns were not aware of it. Similarly, 72.4% of interns were aware of Electronic Health Records and only 27.6% of interns were not aware of Electronic Health Records.

It was observed from Table.2, that 100% of the Interns have enough knowledge of medical records. Almost 97.6% of the interns answered correctly that doctors are legally bound to maintain records in India and only 2.4% of them answered incorrectly. Only 45.5% of the interns answered correctly that the non-MLC records should be stored for 3 years and the remaining 54.5% of the interns answered incorrectly. Almost 64.2% of the interns know how to maintain medical records and only 35.8% of the interns don't have knowledge about it. Only 45.5% of the interns answered correctly that the MLC records should be stored for lifelong and the remaining 54.5% of the interns answered incorrectly. Totally 81.3% of interns know the maintenance of professional secrecy in the case of HIV, whereas 18.7% of them do not have enough knowledge about it. A total of 83.7% of the interns know about storing death certificates in MRD and only 16.3% of the intern do not have knowledge about it. Almost 94.3% of the interns know about the storage of MLC copies in MRD and only 5.7% of them do not know about it. Only 16.3% of the interns answered correctly that the punishment for issuing a false certificate is 7 years and the remaining 83.7% of them answered incorrectly. Almost 94.3% of the interns know that diagnostic aids will be useful for antemortem records and only 5.7% of them do not know about it.

**Table 1. Percentage of interns having awareness regarding medical records.**

| Sl. No | Questions | Correct Response |
|---|---|---|
| 1 | Are you aware of MRD? | Yes (89.4%) |
| 2 | Are you aware of the abbreviation for MRD? | Yes (87.8%) |
| 3 | Are you aware of the purpose of MRD? | Yes (84.6%) |
| 4 | Are you aware that the maintenance of patient records is the legal duty of the hospital? | Yes (95.9%) |
| 5 | Are you aware that the Patient's records are the property of the patient? | Yes (82.9%) |
| 6 | Are you aware of the duration of the preservation of hospital records? | Yes (60.2%) |
| 7 | Are you aware of the charges for getting photocopies of medical records? | Yes (40.7%) |
| 8 | Are you aware of how to issue medical records when required by the patients? | Yes (61.8%) |
| 9 | Are you aware that failure to provide medical records when asked by the patient is punishable? | Yes (78.9%) |
| 10 | Are you aware of Electronic Health Records? | Yes (72.4%) |

**Table 2. Percentage of interns having knowledge on medical records.**

| Sl. No | Questions | Correct Response |
|---|---|---|
| 11 | Is medical record medico-legally important? | 100% |
| 12 | Are Doctors legally bound to maintain records in India? | 97.6% |
| 13 | How long the non-MLC records should be stored? | 45.5% |
| 14 | Do you know how to maintain medical records? | 64.2% |
| 15 | How long the MLC records should be stored? | 45.5% |
| 16 | Will you report HIV positive case to his relatives under requisition without his knowledge? | 81.3% |
| 17 | Will the death certificate be available in MRD? | 83.7% |
| 18 | Will an MLC copy be available in MRD? | 94.3% |
| 19 | What is the punishment for issuing a false certificate? | 16.3% |
| 20 | Can reports of diagnostic aids be useful as an antemortem record? | 94.3% |

**Annexure:**

| Sl. No | Questions | Response |
|---|---|---|
| Awareness based Questions | | |
| 1 | Are you aware of MRD? | Yes/No |
| 2 | Are you aware of the abbreviation for MRD? | Yes/No |
| 3 | Are you aware of the purpose of MRD? | Yes/No |
| 4 | Are you aware that the maintenance of patient records is the legal duty of the hospital? | Yes/No |
| 5 | Are you aware that the Patient's records are the property of the patient? | Yes/No |
| 6 | Are you aware of the duration of the preservation of hospital records? | Yes/No |
| 7 | Are you aware of the charges for getting photocopies of medical records? | Yes/No |
| 8 | Are you aware of how to issue medical records when required by the patients? | Yes/No |
| 9 | Are you aware that failure to provide medical records when asked by the patient is punishable? | Yes/No |
| 10 | Are you aware of Electronic Health Records? | Yes/No |
| Knowledge-based Questions | | |
| 11 | Is medical record medico-legally important? | Yes/No |
| 12 | Are Doctors legally bound to maintain records in India? | Yes/No |
| 13 | How long the non-MLC records should be stored? | a)3 years b)5 years c)7 years d)lifelong |
| 14 | Do you know how to maintain medical records? | Yes/No |
| 15 | How long the MLC records should be stored? | a)3 years b)5 years c)7 years d)lifelong |
| 16 | Will you report HIV positive case to his relatives under requisition without his knowledge? | Yes/No |
| 17 | Will the death certificate be available in MRD? | Yes/No |
| 18 | Will an MLC copy be available in MRD? | Yes/No |
| 19 | What is the punishment for issuing a false certificate? | a) 5 years b) 7 years c) 10 years d) 3 years |
| 20 | Can reports of diagnostic aids be useful as an antemortem record? | Yes/No |

## Discussion:

The present study was carried out on 123 interns of Jawaharlal Nehru Medical College, KAHER who were posted in various departments after obtaining informed consent. The study showed that the interns had enough awareness and knowledge about medical records and their purpose but they lagged in some knowledge of maintaining MLC records and lagged awareness towards charges for getting photocopies of medical records.

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A similar study was conducted by Parmar P, et al in the year 2020, to assess awareness among Intern Doctors about Medical Records and Duty of Doctors in Tertiary Care Hospital, Valsad, they found that Intern doctors had no awareness regarding the duration of preservation of hospital records and were not sure of various aspects of medical records and duty of doctors. This study was in concordance with our study as our interns too lagged in knowledge regarding the preservation of medical records.[5]

A similar study was conducted by Behura SS et al in the year 2020, to assess the awareness and knowledge of dental records in Forensic Dentistry among Undergraduate dental students, found that 73.1% students were aware about legal maintenance of medical records and 67.4 % of them know the duration of preservation of medical records. This study findings were inconsistent with our study as our interns had lagged in knowledge regarding the preservation of medical records.[8]

**Conclusion:**

This present study was an endeavor to assess the awareness and knowledge regarding medical records among Interns. In this era, the public has enough awareness and knowledge about medical records using the internet and electronic media. Hence there are many suits and litigations against doctors, which is an immediate concern to the medical fraternity. So every doctor must acquaint themselves with laws and regulations that are concerned with medical records. This will result in the fulfilment of ethical, moral, and legal obligations in their duties.[7]

Keeping in view of the present study the interns had enough awareness and knowledge about medical records and their purpose but they lagged in some knowledge of maintaining MLC records and lagged awareness towards charges for getting photocopies of medical records. This implies that the curriculum has improved but also needs to be enhanced to promote knowledge of electronic health data and its importance in their future practice to create new educational opportunities.

**Recommendations:**

Based on the observations in our study, we recommend the following suggestions to enhance the knowledge and confidence in maintaining medical records.

- Students should be posted in casualty postings under forensic medicine department supervision periodically from MBBS professional year I which will enhance several fundamental skills for their future practice.
- The knowledge of medical records can also be increased by conducting periodic online zoom meetings by the Dept. of Forensic Medicine & Toxicology.
- Interns are encouraged to attend regular CMEs and workshops on Medical records to increase awareness and to update their knowledge of electronic health records in the medical practice.
- Interns will also acquire various skills in accessing medical records in their future practice. Interns' experience with EHRs is better compared to paper medical records.
- Providing read-only access restricts medical students' educational experience.
- Incorporating EHR access into the medical curriculum is essential as it will provide new educational opportunities that were not available before.[6]

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**Ethical Clearance:** The study was conducted after obtaining Institutional ethical clearance.

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ORIGINAL ARTICLE

# Fingerprint-Based Prediction of Gender: An Important tool in Criminal Investigation

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**Abstract:**

Fingerprinting is considered as the most reliable evidence of identification. The aim of this study is to determine fingerprint patterns and predict gender from them. This will serve as an important aid in forensic identification at the site of crime. This is a prospective study conducted on 298 medical students of Career Institute of Medical Sciences and Hospital, Lucknow. Fingerprints of all participating individuals were obtained in a predesigned proforma on an unglazed white bond paper and were analyzed for their relationship with gender. The most common fingerprint pattern was loops (39.6%), followed by whorls (33.7%), arches (25.2%) and composite (1.5%). Separately, in males, the most common fingerprints pattern was loops (39.6%), followed by whorls (37.4%), arches (22%) and composite (1%), but in females, though loops (39.7%) were the commonest fingerprint pattern, arches (31.2%) were more predominant than whorls (26.9%) followed by composite (2.2%). Incidences of individual fingerprint patterns were varied in different sexes. Frequency of loops, arches, and composite was found to be higher in females and whorls were higher in males. Males show predominance of loops, whorls and arches in left middle finger (6.9%), right ring finger (6.5%) and right thumb (4%) respectively. And composite was present in equal numbers in left thumb, left middle, and left little fingers (0.2% each). In females, maximum number of loops, whorls, arches and composite was found in left little finger (6.4%), right ring finger (5%), right little finger (5.2%) and right thumb (0.5%) respectively.

**Keywords:** Fingerprint; Gender prediction; Identification.

## Introduction:

Identification is an important part of criminal investigation, and includes identification of perpetrators in addition to identification of the victims. Dactylography (i.e. fingerprinting) is considered as the most important technique employed in the field of forensic science for the purpose of personal identification. Reason is that fingerprints (FPs) are never the same in two individuals even in identical twins. Hence, they are key evidence for crime scene investigators. Fingerprints are the contact impressions of the patterns formed by raised papillary or epidermal ridges of the skin of fingers. Epidermal ridges are formed during foetal period and do not change their course of alignment throughout the life of individual until destroyed by mutilation. Fingerprint is an individual characteristic. There is one chance in 64 billions of two persons having identical FPs.[1]

However, fingerprints are ubiquitous due to the use of hands to do all types of work. Fingerprints may be found on a variety of items, including window glasses, utensils, door handles, knifes, car steering, guns, sticks and even human skin itself. Unidentified fingerprints obtained from a crime scene can be used to identify a suspect and quickly solve a case. Biometric information, such as gender predicted using fingerprints, can also be effectively used to narrow down a list of suspects; such information is particularly useful when combined with other investigative information.

The aim of this study was to determine fingerprint patterns and predict gender from them. This will serve as an important aid in forensic identification at the site of crime.

## Material and methods:

The present study "Fingerprint-Based Prediction of Gender: An Important Tool In Criminal Investigation" is a prospective study conducted on 298 medical students of Career Institute of Medical Sciences and Hospital (CIMSH), Lucknow, Uttar Pradesh for a period of 6 months. Individuals from both genders and all age groups were included in the study. A predesigned proforma was used to collect the fingerprints. Ethical clearance for the present study was obtained from the institutional ethical committee, CIMSH, Lucknow. Persons having healthy hands were included in this study. Individuals with any congenital or acquired deformity or scars on fingers, suffering from any chronic skin disease, having worn fingerprints or extra or bandaged fingers were excluded.

Informed consents were obtained from the subjects before taking the samples. Each individual was asked to wash his/her hands thoroughly with soap and water to remove dirt and oil and dry them using tissue-paper. Individuals were then asked to press their fingertips on the ink pad of CAMLIN Company and roll it laterally on the ink slab and then placed on an unglazed white bond paper with one lateral edge and roll over in opposite direction. Bond papers were divided into 10 columns for each finger of the right and left hands. Fingerprints were taken into respective columns on the bond paper. Care was taken to avoid sliding of fingers to prevent smudging of the print. The primary

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fingerprint patterns were observed with the help of a magnifying lens and were identified as four patterns: loops, whorls, arches and composite. Confidentiality of the subjects was maintained. The fingerprint patterns in both hands of individuals and their relationship with gender was analyzed.

**Observations and results:**

We studied fingerprints of 298 students, out of which, 192 (64.5%) were males and 106 (35.5%) were females, with male to female ratio of 1.8:1. The most common fingerprint pattern among both males and females was loops (39.6%), followed by whorls (33.7%), arches (25.2%) and composite (1.5%) (Table 1).

It is observed that, in males (n=192), the most common fingerprint pattern was loops (39.6%), followed by whorls (37.4%), arches (22%) and composite (1%). Whereas, in females (n=106), commonest fingerprint pattern was loops (39.7%) followed by arches (31.2%), whorls (26.9%), and composite (2.2%). It is evident that the loops remain the most common and composite remains least common fingerprint pattern in both males and females, but the whorls are more common than arches in males and less common in females (Table 1).

Frequency of loops was found to be marginally higher in females (39.7%) as compared to males (39.6%). Whorls were found to be higher in males (37.4%) as compared to females (26.9%). Arches were more common in females (31.2%) as compared to males (22%). And composite pattern of fingerprint was more common in females (2.2%) than in males (1%).This suggests that loops, arches and composite were found in higher frequency in Females and whorls were found more frequently in males (Table 1).

**Table 1. Gender-wise distribution of fingerprint patterns.**

| Gender | Fingerprint patterns | | | |
|---|---|---|---|---|
| | Loop n (%) | Whorl n (%) | Arch n (%) | Composite n (%) |
| Male | 760 (39.6%) | 718 (37.4%) | 422 (22%) | 20 (1%) |
| Female | 420 (39.7%) | 285 (26.9%) | 331 (31.2%) | 24 (2.2%) |
| Total | 1180 (39.6%) | 1003 (33.7%) | 753 (25.2%) | 44 (1.5%) |

**Table 2: Fingerprint patterns in individual fingers of males.**

| Finger type | Fingerprint patterns | | | |
|---|---|---|---|---|
| | Loop n (%) | Whorl n (%) | Arch n (%) | Composite n (%) |
| Right Thumb | 62 (3.2%) | 56 (3.0%) | 74 (4.0%) | 1 (0.05%) |
| Right Index | 30 (1.6%) | 118 (6.1%) | 44 (2.3%) | 0 (0.0%) |
| Right Middle | 44 (2.2%) | 100 (5.2%) | 48 (2.5%) | 1 (0.05%) |
| Right Ring | 22 (1.1%) | 126 (6.5%) | 44 (2.3%) | 1 (0.05%) |
| Right Little | 74 (3.9%) | 92 (4.8%) | 22 (1.1%) | 3 (0.1%) |
| Left Thumb | 106 (5.6%) | 18 (1.0%) | 64 (3.3%) | 4 (0.2%) |
| Left Index | 102 (5.3%) | 60 (3.1%) | 30 (1.6%) | 0 (0.0%) |
| Left Middle | 132 (6.9%) | 30 (1.6%) | 26 (1.3%) | 4 (0.2%) |
| Left Ring | 88 (4.6%) | 74 (3.9%) | 26 (1.3%) | 2 (0.1%) |
| Left Little | 100 (5.2%) | 44 (2.2%) | 44 (2.3%) | 4 (0.2%) |
| Total | 760 (39.6%) | 718 (37.4%) | 422 (22%) | 20 (1.0%) |

**Table 3. Fingerprint patterns in individual fingers of females.**

| Finger type | Fingerprint patterns | | | |
|---|---|---|---|---|
| | Loop n (%) | Whorl n (%) | Arch n (%) | Composite n (%) |
| Right Thumb | 41 (3.9%) | 24 (2.2%) | 33 (3.1%) | 5 (0.5%) |
| Right Index | 30 (2.9%) | 30 (2.9%) | 41 (3.9%) | 2 (0.2%) |
| Right Middle | 51 (4.9%) | 16 (1.5%) | 35 (3.3%) | 4 (0.4%) |
| Right Ring | 20 (1.9%) | 53 (5.0%) | 29 (2.8%) | 2 (0.2%) |
| Right Little | 34 (3.2%) | 16 (1.5%) | 56 (5.2%) | 1 (0.1%) |
| Left Thumb | 56 (5.2%) | 16 (1.5%) | 31 (3.0%) | 4 (0.4%) |
| Left Index | 38 (3.5%) | 37 (3.4%) | 30 (2.9%) | 1 (0.1%) |
| Left Middle | 49 (4.7%) | 29 (2.8%) | 28 (2.6%) | 0 (0.0%) |
| Left Ring | 33 (3.1%) | 52 (5.0%) | 22 (2.0%) | 1 (0.1%) |
| Left Little | 68 (6.4%) | 12 (1.1%) | 26 (2.4%) | 2 (0.2%) |
| Total | 420 (39.7%) | 285 (26.9%) | 331 (31.2%) | 24 (2.2%) |

In males, loop was found to be the commonest pattern in left middle finger (6.9%). Whorl was more common in right ring finger (6.5%). Arch was more common in right thumb (4%). And composite was predominant in left thumb, left middle, and left Little fingers (0.2% each) (Table 2).

In females, maximum number of loops was found in left little finger (6.4%). Maximum numbers of whorls were seen in right ring finger (5%). Arches were found maximum in right little finger (5.2%). And composite was the commonest pattern in right thumb (0.5%) (Table 3).

**Discussion:**

In our study, loops (39.6%) were found to be the commonest fingerprint pattern among both males and females, followed by whorls (33.7%), arches (25.2%) and composite (1.5%). Similar pattern was found in the studies conducted by Bharadwaja et al.[2] (loops 51.87%, whorls 35.83% and arches 12.30%), Umraniya et al.[3] (loops 51.54%, whorls 35.79% and arches 12.67%), Gangadhar et al.[4] (loops 57.11%, whorls 27.89% and arches 15.00%), Bhavana D et al.[5] (loops 58.9%, whorls 29.6% and arches 11.5%), Deepa Deopa et al.[6] (loops 58.29%, whorls 37%, and arches 4.71%), and Prateek Rastogi et al.[7] (loops 60.95%, whorls 32.55%, arches 6.5%).

It is observed that, in males and females separately, there were some differences in the predominance of fingerprint patterns. In males, the most common fingerprints pattern was loops (39.6%), followed by whorls (37.4%), arches (22%) and composite (1%). In females, though loops (39.7%) were the commonest fingerprint pattern, arches (31.2%) were more predominant than whorls (26.9%) followed by composite (2.2%).

Incidences of individual fingerprint patterns were varied in different sexes. Frequency of loops was found to be marginally higher in females (39.7%) as compared to males (39.6%). Whorls were found to be higher in males (37.4%) as compared to females (26.9%). Arches were found to be more in females (31.2%) as compared to males (22%). And composite pattern of fingerprint was more common in females (2.2%) than in males (1%). This suggests that frequency of loops, arches and composite were higher in females, whereas, whorls were more frequent in males. Similar pattern was seen in a study conducted by Bhavana D et. al[5] in which the frequency of loops was found to be higher in females (620, 52.63%) and whorls were found to be higher in males (338, 57.09%). Arches were found more in females (119, 51.73%) compared to males (111, 48.26%). In another study conducted by Prateek Rastogi et al.,[7] frequency of loops was found to be higher in females (52.42%) than in males (47.58%) whereas whorls were more frequent in males (55.78%) as compared to females (44.22%). Arches were more common in females (55.38%) than in males (44.61%). So, the similar pattern

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found in various studies at different geographical locations suggests that there is an association between the fingerprint pattern and gender and thus prediction of gender of a person is possible based on his fingerprint pattern.

In our study, males show predominance of loops, whorls and arches in left middle finger (6.9%), right ring finger (6.5%) and right thumb (4%) respectively. Composite was present in equal numbers in left thumb, left middle, and left little fingers (0.2% each). In females, maximum number of loops, whorls, arches and composite was found in left little finger (6.4%), right ring finger (5%), right little finger (5.2%) and right thumb (0.5%) respectively. In a study conducted by Gopinath M et al.,[8] in both males and females, most loops were seen in left little finger (177), maximum whorls were seen in right ring (94), arches were seen maximum in left index (23) and composite was seen maximum in right thumb. In another study conducted by Sagun S et al.,[9] in males, percentage of loops was maximum in left little finger (81%). Percentage of whorls was maximum in right ring finger (66%) and arches in left index finger (18%). Whereas in females, percentage of loops was maximum in right little finger (88%). Whorls were found in equal numbers in right thumb, right ring and left ring finger (46% in each). Arches were maximum in left index finger (15%). In another study conducted by Amit A et al.,[10] it was observed that the majority of loops were present in middle and little finger of both males and females. Kanchan et al.[11] found in their study that arches were more in index finger of both male and females. Despite some similarities in the results of our study and the observations of other authors, we could not found any fixed pattern of predominance of fingerprint patterns in individual finger. More studies are required to be conducted to make the prediction for gender possible from the predominance of fingerprint patterns in individual finger.

**Conclusion:**

Fingerprints are the key evidence for crime scene investigators. Fingerprints obtained from crime scene play a key role in positive identification of the individuals. However, positive identification of fingerprint requires matching of the fingerprints obtained from the crime scene, with a known database or with the fingerprint of a suspect. But, in cases when suspects are many, prediction of the sex from fingerprint pattern can effectively help to narrow down the list of suspects. This can be of great help to law enforcement agencies involved in medico-legal processes, crime scene investigations and identification of victims of mass-disaster especially involving mutilated and fragmented remains.

With the result of our study, we could conclude that there is an association between the fingerprint pattern and gender and thus prediction of gender of a person is possible based on his fingerprint pattern. But we could not found any fixed pattern of predominance of each fingerprint pattern in individual fingers. And therefore further research on predominance of each fingerprint pattern in individual finger is required to make the prediction of gender possible from the predominance of fingerprint patterns in individual fingers. Based on these findings, we recommend combination of fingerprint with other identification data for the determination of sex.

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ORIGINAL ARTICLE

# A Retrospective Study of Postmortem Examinations at MGM Hospital, Warangal

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**Abstract:**

An autopsy (post mortem examination) or necropsy is a common, up-to-date medical technique in which the tissues and organs of a deceasedperson'sbodyarethoroughlyexaminedsurgicallywiththegoalofidentifyingthecauseofdeathandanycontributingfactors.Now a days poisoning and road traffic accidents cause most of the casualties, which lead to many deaths. To create a profile of fatalities brought on by unnatural sources that we can focus our efforts on reducing their frequency, we retrospectively studied the death cases brought for medico legal postmortem examination at the Mortuary, Department of Forensic Medicine and Toxicology at Kakatiya Medical College/MGM Hospital Warangal, Telangana, India, in the year 2019 to 2021. During this period, a total of 4657 autopsy cases were conducted. Themost autopsy cases [443(10%)] out of the total 4657 cases were performed in June. There were [3516(75.5%)] more male cases than female [1141(24.5%)] cases, which predominated. The largest percentage of cases [2868(62%)] belonged to the 25–54 age range. There were mostly 1644 (35%) cases of poisoning. Injury-related deaths, 988 (21%) and 557 (12%) were attributable to head injuries and multiple injuries respectively. 485 deaths by hanging (10%) and 253 deaths from thermal injury (5%) were reported. Poisoning was found to be the most common cause of mortality, and then followed by road-traffic accidents. Vehicle accidents involving head injuries were the leading cause of death.

**Keywords:** Unnatural deaths; Poisoning; Hanging; Head injury; Multiple injuries; Burns.

## Introduction:

An autopsy (postmortem examination) or necropsy is a common, up- to-date medical technique in which the tissues and organs of a deceased person's body are thoroughly examined surgically with the goal of identifying the cause of death and any contributing factors, such as tanatogenesis.[1] There have been several justifications for performing autopsy over the years ever since G.B.Morgagni first demonstrated their scientific worth.[2] The profiling of medico legal cases is necessary in order to prevent the preventable casualties in future and to study the genuine crime rate in the area. Mortality data are necessary to comprehend the underlying health of a population, in addition to advancing medical knowledge and providing assistance in an investigation.[3,4] To determine the main reasons for deaths in a population, mortality statistics might help health administrations. Additionally, it can offer proof that disease prevention measures should be prioritized.[5,6]

India is a developing country with increasing industrialization and urbanization. In our daily lives, we run into a variety of issues. While some people can handle life's stresses, others are unable to, and as a result, they pass away, making life unpleasant for their friends and family. The goal of this study is to create a profile of deaths that are caused by natural or unnatural causes so that we can make serious efforts to reduce their incidence. The number of medico-legal cases is rising as a result of the rapidly expanding population, rising unemployment rates, unforeseen COVID-19 pandemic, widening income gaps, substance addiction, increased vehicular traffic density, sparse infrastructure, and numerous sorts of morbidities. A special Mention about the deaths during lockdown in COVID-19 Pandemic is mentioned. Prior to a two month country wide lockdown, India's initial response to the pandemic included border closures and recommendations about social seclusion (25th Mar ch 2020-31st May 2020). Four different phases of the national lockdown were enforced, with the first (25 March–14 April) having the strictest limitations compared to phases two (15 April–3 May), three (4 May–17 May), and phase four (18 May–31 May), which coincided with a gradual lifting of constraints,[7] on April 20,certain restrictions would be lifted [conditional relaxation] enabling the opening of agricultural supply stores and enterprises related to dairy, aquaculture and plantations. Moreover, public works programmes were permitted to reopen with the direction to uphold social distance. There would be movement of cargo via trucks, railroads and aircraft. Also, banks and government facilities dispersing benefits would operate. However, none of the studies to date have examined how suicide rates may vary in India in 2020 compared to earlier years, or whether sex and geographic differences will affect these changes. This critical gap makes it more difficult to determine whether COVID-19 is still having an impact on suicide rates in India.

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**Table 1. Total autopsies.**

| Year | PME'S | % |
|---|---|---|
| 2019 | 1569 | 34% |
| 2020 | 1523 | 33% |
| 2021 | 1565 | 34% |
| Total | 4657 | 100% |

**Table 2. Sex wise figures.**

| Sex | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | Total | % | 2019% | 2021% | 2021% | Diff 2K19 VS 2020 |
| F | 398 | 375 | 368 | 1141 | 24.5% | 25.4% | 24.6% | 23.5% | -1.9% |
| M | 1171 | 1148 | 1197 | 3516 | 75.5% | 74.6% | 75.4% | 76.5% | 1.9% |
| Total | 1569 | 1523 | 1565 | 4657 | 100% | | | | |

Post mortem examination data are crucial because they help elucidate related pathology, treatment response, and disease evolution in addition to identifying the primary cause of death. Doctor scan correct, clarify, and confirm the ante mortem clinical diagnosis using autopsies, which helps them advance their understanding of medicine, hone their diagnostic skills, and put that knowledge to use in the future.[8] A subset of the total number of deaths reported in an area is determined via postmortem examination. In order to promote better and more accurate certification of the cause of death, this study intends to characterize the age and gender distribution as well as examine the causes of fatalities identified during postmortem investigations.

**Objectives:**

- To create a profile of fatalities brought on by unnatural sources so that we can focus our efforts on reducing their frequency.
- To determine the incidence of deaths in COVID-19 Pandemic in the year 2020.
- To compare the incidence of deaths in the year 2019, 2020 and 2021.

**Material and methods:**

All cases of deaths brought for autopsy at the Kakatiya Medical College mortuary in Hanumakonda, Warangal between January 1 and December 31, of 3 years i.e, 2019-2021 were included in this retrospective analysis.

The focus of this study has been on identifying the overall number of death cases, the sex of the persons, and the distribution by month. Age, sex, month of incidence, and cause of death at autopsy are among the cause of death characteristics that were examined. The frequency and proportion of these fatalities were calculated using the data, and the findings were expressed as percentages. This entry provides the distribution of the population according to age. Information is included by sex and age group as follows: 0-14 years (children), 15-24 years (early working age), 25-54 years (prime working age), 55-64 years (mature working age), 65 years and over (elderly).[9]

Inclusion Criteria: Unnatural deaths brought to the post-mortem examination at Kakatiya Medical College/MGM Hospital, Warangal.

Exclusion Criteria: • Bodies sent to the post mortem at the nearest medico-legal centre or Govt Hospitals on request of the deceased party.

• MLC cases converted to non MLC cases by the head of the institution.

**Results and Observations:**

The study of total number of autopsy conducted in Kakatiya Medical College /MGM Hospital are 4657 cases. There are 1569, 1523 and 1565 cases in 2019, 2020 and 2021 respectively [Table no1]. It is noted that the % of sex wise distribution is more in males [about 75%] and in females [about 25%], there is 3% of decrease in deaths in 2020 when compared with 2019 and 1.9% of female deaths decreased in 2021 compared to 2019 [Table No.2]. Age group distribution shows that 62% of the deaths are seen between 25-54 age group followed by 15-24 constituting 15% of cases. Over all trend shows when compared between years i.e, 2019 vs 2020 the results show that though there were low death cases in 2020, there is 22% increase in death cases of 15-24 age group followed by 21% increase in 0-14 age group, 13% rise in 25-54 age group and decrease in death cases of 55years and above age groups. Overall trend shows when compared between years i.e, 2020 vs 2021 the results show that there is 44% decrease in death cases of 0-14 age group followed by 9% decrease in 15- 24 age group, 953% rise in 55-64 age group. Overall trend shows when compared between years i.e, 2019 vs 2021 the results show that though there were low death cases in 2020 there is 33% decrease in death cases of 0-14 age group followed by15% decrease in 55 years and above age groups. In 2019, 45% of deaths cases were seen among males in 25-54 age group, followed by 55-64 age group comprising of 10% cases. Even in females 25-54 years age group showed more deaths [13%], followed by 15-24 and 65 & above age groups [4%]. In 2020, 52% of death cases are seen among males in 25-54 age group, followed by 15-24 age group comprising of 13%cases. Even in females 25- 54 years age group showed more deaths[15%], followed by15- 24 and 65& above age groups [4%]. In 2021, 48% of deaths cases were seen among males in 25-54 age group, followed by15-24 age group comprising of 16% cases. Even in females 25-54 years age group showed more deaths [11%], followed by15-24 [5%] cases [Table no.3]. There is a huge decrease in no. of cases in April 2020 due to COVID-19 pandemic lock down. Overall highest cases were seen in June followed by May and October, November and December with constituting10%, 09% and 09%. There is 3% of decrease in deaths in 2020 when compared with 2019 [Table no.4]. From the study it is observed that the most common cause of death is due to poisoning constituting of about 35% of total cases followed by

**Table 3. Age group wise distribution.**

| | Year | | | | | | | Year wise comparision | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | 2019 | | 2020 | | 2021 | | Total % | 19 vs 20 | 20 vs 21 | 19 vs 21 |
| | F | M | F | M | F | M | | | | |
| 0-14 | 18 | 34 | 26 | 37 | 15 | 20 | 3% | 21% | -44% | -33% |
| 15-24 | 63 | 147 | 63 | 193 | 80 | 171 | 15% | 22% | -2% | 20% |
| 25-54 | 204 | 701 | 229 | 798 | 178 | 758 | 62% | 13% | -9% | 3% |
| 55-64 | 47 | 163 | 1 | 16 | 42 | 137 | 9% | -92% | 953% | -15% |
| 65 & Above | 66 | 126 | 56 | 104 | 53 | 111 | 11% | -17% | 3% | -15% |
| Total | 398 | 1171 | 375 | 1148 | 368 | 1197 | 100% | -3% | 3% | 0% |
| Grand Total | 1569 | | 1523 | | 1565 | | 4657 | | | |

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**Table 4. Month wise disrtibution.**

| Month | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | Total | Total % | 19 vs 20 | 20 vs 21 | 19 vs 21 |
| January | 126 | 96 | 140 | 362 | 8% | -24% | 46% | 11% |
| February | 128 | 152 | 107 | 387 | 8% | 19% | -30% | -16% |
| March | 125 | 102 | 107 | 334 | 7% | -18% | 5% | -14% |
| April | 164 | 59 | 111 | 334 | 7% | -64% | 88% | -32% |
| May | 165 | 133 | 109 | 407 | 9% | -19% | -18% | -34% |
| June | 149 | 122 | 172 | 443 | 10% | -18% | 41% | 15% |
| July | 113 | 131 | 147 | 391 | 8% | 16% | 12% | 30% |
| August | 127 | 113 | 142 | 382 | 8% | -11% | 26% | 12% |
| September | 108 | 148 | 125 | 381 | 8% | 37% | -16% | 16% |
| October | 129 | 145 | 158 | 432 | 9% | 12% | 9% | 22% |
| November | 119 | 165 | 120 | 404 | 9% | 39% | -27% | 1% |
| December | 116 | 157 | 127 | 400 | 9% | 35% | -19% | 9% |
| Grand Total | 1569 | 1523 | 1565 | 4657 | 100% | -3% | 3% | 0% |

head injury constituting 21%, multiple injuries constituting 12% of total cases and hanging 10% of total cases. Overall trend, when compared between 2019 vs 2020 shows 49% decrease in burns cases, 11% decrease in hanging cases, 4% decrease in head injury due to road traffic accidents. Though there were less cases in year 2020, the over all trend shows 19% increase in deaths due to poisoning which might be due to easy availability and perhaps spurred on by lockdown. Overall trend, when compared between 2020 vs 2021 shows 33% decrease in burns cases, 10% increase in poisoning cases, 1% decrease in head injury due to road traffic accidents. 13% increase in deaths due to hanging. Overall trend, when compared between 2019 vs 2021 shows 65% decrease in burns cases, 1% increase in hanging cases, 5% decrease in head injury due to road traffic accidents. Though there were less cases in year 2020, the overall trend shows 31% increase in deaths due to poisoning which might be due to after effects of the unexpected COVID-19 pandemic. In 2019, the highest number of deaths were due to poisoning [31%], followed by head injury [22%], hanging [11%] and multiple injuries [11%] in males. In 2019, the highest number of deaths were due to poisoning [28%], followed by burns [20%], headinjury [17%], hanging [11%] in females. In 2020. In 2019, the highest number of deaths were due to poisoning [26%], followed by head injury [17%], multiple injuries [12%] and hanging [10%] in males. In 2019, the highest number of deaths were due to poisoning [11%], followed by burns [4%] and head injury [4%], hanging [4%] in females. In 2021, In 2019, the highest number of deaths were due to poisoning [29%], followed by head injury [17%], multiple injuries [11%] and hanging [7%] in males. In 2019, the highest number of deaths were due to poisoning [11%] followed by head injury [3%] and hanging [3%] in females [Table no.5].

**Table 5. Cause of death distribution.**

| Cod | 2019 | 2020 | 2021 | Total | Total % | 19 vs 20 | 20 vs 21 | 19 vs 21 |
|---|---|---|---|---|---|---|---|---|
| Asphyxia | 2 | 3 | 0 | 5 | 0% | 50% | -100% | -100% |
| Blunt injury-ab | 11 | 15 | 26 | 52 | 1% | 36% | 73% | 136% |
| Burns | 136 | 70 | 47 | 253 | 5% | -49% | -33% | -65% |
| Chop wounds | 0 | 0 | 1 | 1 | 0% | - | - | - |
| Cut throat | 2 | 4 | 6 | 12 | 0% | 100% | 50% | 200% |
| Dead born | 2 | 3 | 0 | 5 | 0% | 50% | -100% | -100% |
| Decapitation | 2 | 0 | 9 | 11 | 0% | -100% | - | 350% |
| Dog bite | 0 | 1 | 1 | 2 | 0% | - | 0% | - |
| Drowning | 40 | 71 | 56 | 167 | 4% | 78% | -21% | 40% |
| Electrocution | 42 | 26 | 31 | 99 | 2% | -38% | 19% | -26% |
| Hanging | 167 | 149 | 169 | 485 | 10% | -11% | 13% | 1% |
| Head injury | 339 | 326 | 323 | 988 | 21% | -4% | -1% | -5% |
| Honey bee bite | 0 | 0 | 1 | 1 | 0% | - | - | - |
| Hypovolemic shock | 13 | 8 | 1 | 22 | 0% | -38% | -88% | -92% |
| Lightening | 2 | 1 | 1 | 4 | 0% | -50% | 0% | -50% |
| Multiple injuries | 169 | 189 | 199 | 557 | 12% | 12% | 5% | 18% |
| Natural disease | 127 | 53 | 40 | 220 | 5% | -58% | -25% | -69% |
| Natural disease-covid19 | 0 | 1 | 0 | 1 | 0% | - | -100% | - |
| Poison | 470 | 560 | 614 | 1644 | 35% | 19% | 10% | 31% |
| Poison & drowning | 0 | 9 | 0 | 9 | 0% | - | -100% | - |
| Prematurity | 2 | 1 | 0 | 3 | 0% | -50% | -100% | -100% |
| Scalds | 3 | 0 | 2 | 5 | 0% | -100% | - | -33% |
| Scorpion bite | 1 | 1 | 0 | 2 | 0% | 0% | -100% | -100% |
| Septic shock | 13 | 10 | 11 | 34 | 1% | -23% | 10% | -15% |
| Smothering | 1 | 0 | 1 | 2 | 0% | -100% | - | 0% |
| Snake bite | 19 | 15 | 17 | 51 | 1% | -21% | 13% | -11% |
| Spinal cord injury | 2 | 3 | 3 | 8 | 0% | 50% | 0% | 50% |
| Stab injury | 2 | 2 | 6 | 10 | 0% | 0% | 200% | 200% |
| Throttling | 2 | 2 | 0 | 4 | 0% | 0% | -100% | -100% |
| Total | 1569 | 1523 | 1565 | 4657 | 100% | | | |

## Discussion:

The Department of Forensic Medicine and Toxicology at Kakatiya Medical College/MGM Hospital Warangal was where the current retrospective study was carried out. Males outnumbered females in post mortem cases in 1961 by a ratio of almost 3:1. This conclusion matched concurrently in the research of Radhakrishna et al.,[10] Sharma et al.,[11] Wasnik,[12] Shrivastava et al.,[13] Zine, et al.,[14] Qasim, et al.,[15] Afandi[16] and Patel JB, Chandegara PV, Patel UP, Parkhe SN, Govekar G.[17] Men often die earlier and from practically more diseases and illnesses than women. Men are more at risk than women in traditional social justice studies of health, however gender patterns in unnatural death mortality do not match this model.[18] Males are more vulnerable to accidents and violence because they are more exposed to the outside world. They are regarded as wage workers, with women typically restricted to the home and housework. Age groups between 25-54 years old [62%cases], including both sexes, were the most frequently engaged in all sorts of instances in our study are consistent with the results of the research by Radhakrishna et al.,[10] Wasnik,[12] Zine et al.,[14] Qasim et al.,[15] and Afandi[16] and Sharma et al.,[16] showed the most prevalent in the age range is 21-25 years and 26-30 years. Particularly in 2020, which is the 1st year of COVID-19 Pandemic, the 25-54 age group, who are the prime working age group,[9] when compared to females, we saw that males were significantly more affected by the rise in suicide rates. Male suicides in India have been linked to pressure to support the family and the traditional role of men as the" bread winners" of the house hold, which has been emphasized as a possible cause.[19] Although it hasn't been proven, it's probable that males suffered the economic effects of the pandemic more severely on average than females, including loss of employment and accompanying role stress and humiliation. June recorded the most cases (10%), followed by October, November and December (9%) in that order. The highest number of instances, 96 (9.83%), were noted in October, while September saw 93 (9.56%) cases according to Patel JB, Chandegara PV, Patel UP, Parkhe SN, Govekar G.[17] Study and 12.34% of deaths in the study

by Zine et al.[14] occurred in the month of October. Least number of cases were recorded in the month of April 2020 [59 cases] due to COVID-19 pandemic lockdown. The majority of the research on the COVID-19 pandemic's possible effects on suicide rates has been conducted in high income nations. According to research, with Japan and Hungary standing out as major outliers 20-22 suicide rates did not generally rise during the early months of the pandemic. From the study it is observed that the most common cause of death is due to poisoning constituting of about 35% of total cases followed by head injury constituting 21%, multiple injuries constituting 12% of total cases and hanging 10% of total cases.

Even during the pandemic, poisoning was the most common approach, other suicide methods included hanging, jumping from or into objects, burning, wrist or throat slicing, drowning, and injuries. A five-year research from one of India's major cities that included more than 5000 instances revealed that the victim's methods of suicide varied. They discovered that among men, poisoning was the most popular form of suicide, followed by head injuries, hanging, burns and drowning. For women, poisoning was the most popular method of suicide, followed by hanging, burns, drowning and head injuries.23Even death due to head injury is also observed to be increased during the initial months of the pandemic. Though the reasons were unclear but it is thought to be due to the conditional relaxation of the lock down.[14]

The most common cause of injury-related deaths, accounting for 21% of all fatalities, was head injury. This was followed by multiple injuries (12%), hanging (10%), burns (5%), electrocution and drowning (2%) and snake bite (1%). Burns made up 10.57% and electrocution 1.99% of all occurrences of thermal type injuries respectively. Burn-related deaths came in fifth place in this analysis, behind injury-related deaths and hanging deaths. It was the second most common cause death in Zine et al. study,[14] behind injury-related deaths. The findings of the research conducted by Wasnik[19] and Qasim et al.[15] were in agreement with those of our study.

1644 (35% of the total 4657 post mortem cases) cases of poisoning were discovered. Organophosphate was the cause in the most cases, then snake bite and soon. This result was almost identical to those of the research conducted by Radhakrishna et al.,[10] Sharma et al.,[11]and Wasnik.[12] This is because a large portion of the area was made up of rural residents who worked mostly in agriculture, making pesticide poisoning more common. In this investigation, incidents of OP poisoning were the most common cause of poisoning-related deaths. Since agriculture is the primary source of income for the vast majority of the state's citizens, it's possible that agricultural poisons will be easily accessible to the general public. The second most common cause of mortality from RTA is head injury and multiple injuries, both of which can be avoided. It is unfortunate to observe that the majority of death sare caused by this factor.

Right from the junior level, traffic norms and commonsense must be taught, and laws must be properly enforced. According to this report, hanging deaths were the third most common cause of fatalities and burn cases came in fifth.

**Conclusion:**

The aforementioned study analyses data on medico-legal cases submitted for autopsy at Kakatiya Medical College/MGM hospital,Warangal in aradical manner. Poisoning is found to be the most common cause of mortality and then followed by road traffic accidents. Vehicle accidents involving head injuries were the leading cause of death. An essential and necessary component of any investigation into a sudden suspicious death is a medical-legal autopsy. The abilities and knowledge of an autopsy surgeon help law enforcement organizations administer justice and hang the guilty. The information produced would help the Forensic expert gain a better understanding of the puzzling occurrence of a sudden suspicious death in their area of jurisdiction.

This study aids in the interpretation of the various medico-legal autopsy cases seen at the Kakatiya Medical College/MGM Hospital Mortuary, Warangal. Policy makers, law enforcers, and the community will gain knowledge from this that will help them examine the particulars of the cases and take appropriate action for the good of the neighborhood and the local populace. To reduce the number of casualties, health awareness campaigns regarding stress management and control as well as education campaigns to increase public understanding of traffic laws and driving regulations must be strengthened and repeated frequently.

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ORIGINAL RESEARCH

# A Study on Sexual Assault Victims and Associated Factors at a Tertiary Care Centre of a North-Eastern State of India: A Retrospective Study

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**Abstract:**

Sexual assault is a significant crime worldwide, irrespective of different cultures and religions. Most cases are unreported, yet it is a common, frequent and vital public health issue in developed and developing countries. Medico-legal examinations play an important role in determining the clinical and circumstantial evidence against this heinous crime, which helps appropriately present the incident before the courts of Law. This present paper aims to evaluate the socio-demographic profile of the alleged sexual assault victims and the medico-legal characteristics of the event and determine the factors affecting those incidents. A hospital record-based retrospective study was conducted on all the alleged sexual assault victims. Strict confidentiality was obtained in managing data extracted for the study from the hospital records. The ethical clearance was obtained. A gradual rise in the frequency of cases of sexual assault is noticed every year. Age-wise distribution showed that 69.1% of cases were in the age group of 11-20 years. Out of 835 victims, the majority, 89.8%, were Hindus, and 85.4% cases were unmarried. Accused relatives' houses were the most common place of the incident (31.1%). Most of the alleged victim girls (63.4%) reported having eloped with their boyfriends. Among the victims, 30% reported being force applied, while almost 2% said getting molested. Old hymenal tears were found in most cases (138/267). Sexual assault has lots of risk factors that affect the victim's physical and interpersonal relationships adversely. Hence, the associated influential factors should be considered to initiate preventive measures and control this sensitive public health issue.

**Keywords:** Sexual violence; Rape; Genital injury; Intimate partner violence; Eloping women.

## Introduction:

The World Health Organization (WHO) has defined sexual violence as any sexual act or attempt to obtain a sexual act or unwanted sexual comments or advances or acts to traffic or otherwise directed against a person's sexuality using coercion by any person regardless of their relationship to the victim, in any setting, including but not limited to home and work.[1] Sexual assault is a form of sexual violence, unwanted sexual contact. Here, a person intentionally sexually touches another person without consent or coerces or physically forces them to engage in a sexual act against their wish.[2] It includes child sexual abuse, groping; forced vaginal, anal, or oral penetration or drug-facilitated sexual assault; or the person's torture in a sexual manner.[2] Sexual violence occurs all over the world. In most countries, little research has been conducted on this sensitive issue. Among all other violent crimes, sexual assault remains the most underreported.[3] As per WHO, about 30% of women worldwide have been subjected to either physical or sexual violence by an intimate partner or non-partner sexual violence in their lifetime. African, Eastern Mediterranean and South-East Asia regions were reported to have the highest sexual or physical violence rates against women.[4] Studies suggest that one in three women might experience sexual violence with their close partner in different countries, including India.[5-7] According to The United Nations Children's Fund (UNICEF) reports, worldwide, almost 1 in 10 girls below 20 years have been forced to engage in sex or perform other sexual acts.[8] Many studies revealed that one in four adolescent girls account for their first sexual experience as forceful or against their will.[9-12] Sexual violence has a tremendous impact on the physical and mental health of the victim and causes bodily injury. It causes sexual and reproductive health problems at immediate and long-term costs.[11,13-16]

As per the latest report from the National Crime Records Bureau (NCRB) India, the total reported crime against women in India increased from 3 lakh 59 thousand in 2017 to 4 lakh in 2019, and Assam shared 7.4% of those crimes. Overall, 15.4% of the rape victims in India were also reported to be below 18 years.[17] Proper presentation of this type of crime before the courts of law is necessary for granting justice to rape survivors. Advancement of

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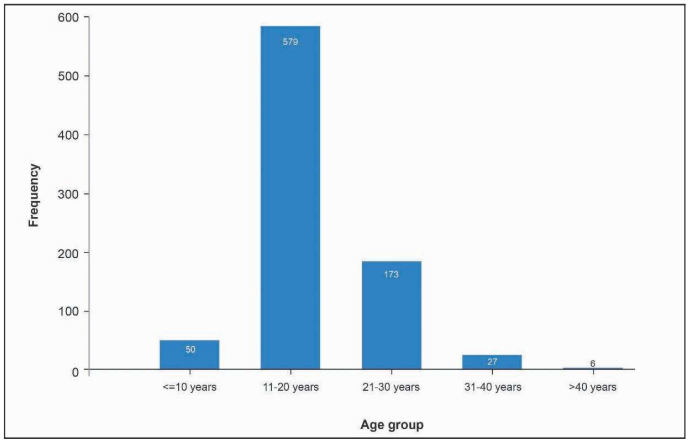


**Figure 1. Age-wise distribution of the cases.**

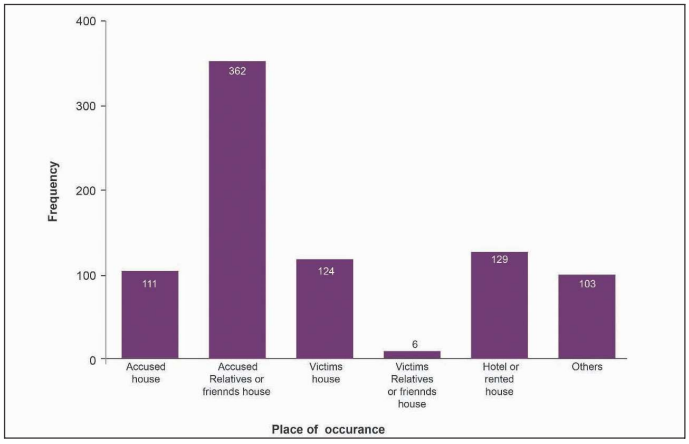


**Figure 2. Place of occurrence.**

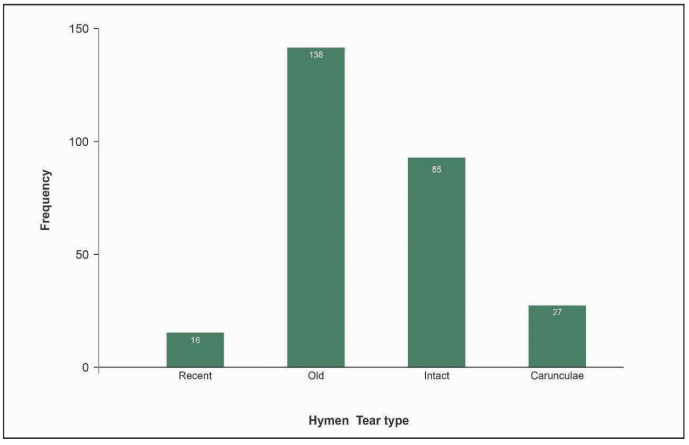


**Figure 3. Type of the hymenal tear.**

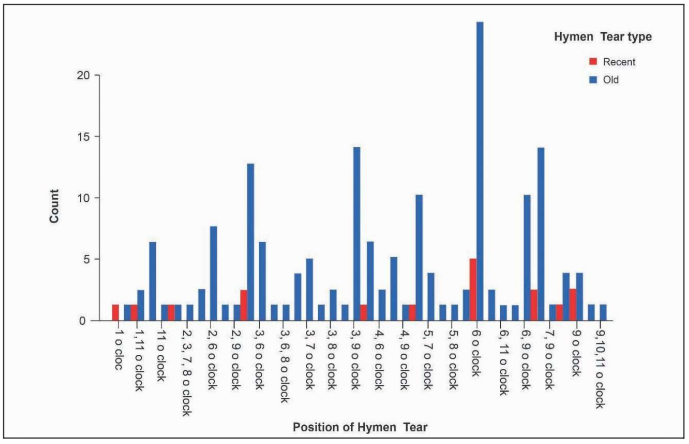


**Figure 4. Position of hymenal tear.**

medical and clinical examinations and adequate investigation of circumstantial evidence help determine essential clues about the incident. Medico-legal examinations play a vital role in this regard as healthcare workers are the first persons engaged in the assessment and documentation of the medical condition of the rape victims and sample collection.[18,19]

Sexual assault is under research worldwide.[20] Though, like in other parts of the country, cases are continuously rising in northeastern India. Not much data and studies are available about sexual assault victims in this part of India. Therefore, the present study is undertaken to evaluate the brief profile of alleged sexual assault victims brought for medico-legal examination in the referred hospital and determine the factors involved, which can be incorporated into future preventive planning.

## Materials and methods:

A hospital record-based retrospective study was conducted on all the alleged sexual assault victims who came to the Department of Forensic Medicine, Assam Medical College and Hospital, Dibrugarh (Assam), during the three years from 2017 to 2019. The study included all the sexual assault cases brought for medical examination from Dibrugarh and neighbouring districts. This study has included only the alleged victim of sexual assault, excluding the assailants. Ethical clearance was taken from the ethics committee (Human) of Assam Medical College and Hospital. The data for the present study were obtained retrospectively from the forensic examination records of sexual assault victims brought to the department. The records carry the various information related to the case history of the incident as disclosed by the victim and details of the medical examination done following existing guidelines. The medical examination comprised a general physical examination and a local genital examination. The victims were examined for injuries like abrasions, bruises, cuts, tears, bleeding, pregnancy, spermatozoa, stains on cloth, condition of the hymen, the position of the hymeneal tear, etc. The case details regarding age, sex, religion, occupation, marital status, place of occurrence, whether the perpetrators were known to the victim, whether the victim eloped with the accused, whether forced, intoxicated, or drugged, etc., obtained from the documented records.

The data extracted from the records were collected in a predesigned datasheet. As the data were related to medico-legal importance, strict confidentiality was maintained in management and data handling during the study. All personal identifiers were removed from the database before analysis. The statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software version 20. Descriptive statistical methods were computed. To test the significant association between various variables under study, Chi-square ($\chi 2$) tests were performed. A p-value<0.05 was considered to be substantial.

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**Table 1. Place of occurrence and age of the victim.**

| Place of Occurrence | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age group | Accused house (n=111) | Accused relatives or friends' house (n=362) | Victims house (n=124) | Victim relative or friend's house (n=6) | Hotel or rented house (n=129) | Others (n=103) | X2 (p-value) |
| <=10 years (n=50) | 17 (34.0%) | 0 | 20 (40.0%) | 1 (2.0%) | 0 | 12 (24.0%) | 218 (p<0.001) |
| 11-20 years (n=579) | 68 (11.7%) | 320 (55.3%) | 63 (10.9%) | 5 (0.9%) | 60 (10.4%) | 63 (10.9%) | |
| 21-30 years (n=173) | 25 (14.5%) | 40 (23.1%) | 28 (16.2%) | 0 | 54 (31.2%) | 26 (15.0%) | |
| 31-40 years (n=27) | 1 (3.7%) | 2 (7.4%) | 8 (29.6%) | 0 | 14 (51.9%) | 2 (7.4%) | |
| >40 years (n=6) | 0 | 0 | 5 (83.3%) | 0 | 1 (16.7%) | 0 | |

**Table 2. Place of occurrence and eloping.**

| Place of occurrence | Whether eloped with the accused | | $X^2$ (p-value) |
|---|---|---|---|
| | No (n=306) | Yes (n=529) | |
| Accused house (n=111) | 73 (23.9%) | 38 (7.2%) | 594.6 (p<0.0001) |
| Accused relatives or friends' house (n=362) | 6 (2.0%) | 356 (67.3%) | |
| Victims house (n=124) | 121 (39.5%) | 3 (0.6%) | |
| Victim relative or friend's house (n=6) | 4 (1.3%) | 2 (0.4%) | |
| Hotel or rented house (n=129) | 11 (3.6%) | 118 (22.3%) | |
| Other places (n=103) | 91 (29.7%) | 12 (2.3%) | |

## Results:

A total of 835 cases were included in the study, among which 67.3% reportedly refused medical examination. Among those, 254 (30.4%) cases were reported in 2017, 270 (32.3%) in 2018, and 311 (37.2%) cases in 2019. All the 835 cases were females.

Age-wise distribution of the cases: Most of the victims (69.3%) belonged to the age group 11-20 years. Out of 835 alleged victims, 50 (6.0%) were children aged ten years and below, as shown in Figure 1.

The religion and marital status of the cases: Out of 835 victims, the majority, 89.8% (750/835), were Hindus. Most victims (85.4%) were unmarried. Out of 835, only two victims were divorcees.

Place of incidence: Accused relatives' or their friends' houses were the most common place of the incidents for 43.4%, followed by hotel or rented dwellings in 15.4% of cases. Almost 14.9% of victims reported being assaulted in their own homes. Accused also preferred their own house (13.3%) for the alleged assault, as shown in Figure 2.

An in-depth study of the data showed a significant association between the victim's age and the incident's place (p-value<0.001). Most of the child abuse cases (age≤ 10 years) happened either at the victim's own house (40.0%) or the accused house (34.0%). While among the teenage girls (aged 11-20 years), the assault mainly happened at the accused relatives' or friends' houses (55.3%). Hotels and rented rooms are reported to be the most common places of assault of young and adult women, as shown in Table 1.

**Table 3. Other associated features with the victims.**

| Observations | Frequency | Percentage |
|---|---|---|
| Force applied: | | |
| No | 567 | 67.9 |
| Yes | 250 | 30.0 |
| Molestation | 15 | 1.8 |
| Medicine | 2 | 0.2 |
| Unpleasant Gest | 1 | 0.1 |
| Accused drinking | 11 | 1.3 |
| Findings at the examination: | | |
| Spermatozoa on vaginal slides | 5 | 0.6 |
| Stains on the clothes of the victims | 0 | 0 |
| Other simple injuries | 40 | 4.8 |
| Pregnancy at the time of examination | 48 | 5.7 |

**Table 4. Forceful assault among different age groups.**

| Age group | Type of force applied. | | | $X^2$ (p-value) |
|---|---|---|---|---|
| | No force applied (n=567) | Force applied (n=250) | Molestation, medicine or unpleasant gest (n=18) | |
| <=10 years (n=50) | 2 (4.0%) | 45 (90.0%) | 3 (6.0%) | 118 (p <0.001) |
| 11-20 years (n=579) | 414 (71.5%) | 151 (26.1%) | 14 (2.4%) | |
| 21-30 years (n=173) | 135 (78.0%) | 37 (21.4%) | 1 (0.6%) | |
| 31-40 years (n=27) | 15 (55.6%) | 12 (44.4%) | 0 (0.0%) | |
| >40 years (n=6) | 1 (16.7%) | 5 (83.3%) | 0 (0.0%) | |

**Table 5. Factors of sexual initiation among different age groups.**

| Factors of sexual initiation | | | | |
|---|---|---|---|---|
| Age group | Individual factor | Relationship factors | Community factors | Societal factors |
| <=10 years (n=6) | 0 (0.0%) | 6 (100.0%) | 0 (0.0%) | 0 (0.0%) |
| 11-20 years (n=59) | 1 (1.7%) | 24 (40.7%) | 22 (37.3%) | 12 (20.3%) |
| 21-30 years (n=51) | 1 (2.0%) | 9 (17.6%) | 2 (3.9%) | 39 (76.5%) |
| 31-40 years (n=12) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 12 (100.0%) |
| >40 years (n=2) | 0 (0.0%) | 1 (50.0%) | 0 | 1(50.0%) |
| Total (n=130) | 2 (1.5%) | 40 (30.8%) | 24 (18.5%) | 64 (49.2%) |

Most of the victim girls (63.4%) reported having eloped with their boyfriends, which resulted in the incident happening either at the accused relative or friend's house (67.3%) or hotel and other rented dwellings (22.3%) where they take shelter after eloping. The $\chi 2$ test revealed a significant association between eloping and the place of occurrence (p-value <0.001), as shown in Table 2. Two incidents were reported at the tea garden: one at school, one at the cinema hall, the accused shop, and one roaming.

Other associated features: 30% reported force applied, while almost 2% reported being molested. A total of 48 cases were reported to be pregnant at the time of examination, and 40 were detected with other injuries, as shown in Table 3.

Most of the child victims (45/50) reported force being applied for assault. Similarly, women of the higher age group reported being forced to use them. Molestation was primarily reported among teenage girls. The victim's age was a significant factor for violent sexual assault, as shown in Table 4.

Victim reporting sexual initiation: A total of 130 participants reported factors of sexual initiation. In most of the cases, the incident (6.3%) has resulted from extramarital affairs. At the same time, close relatives and kidnappings were the second most reported cause of the assault. Nine cases were gang-raped, and

twelve cases were the victim of domestic violence. While close relatives committed 4 out of the 50 assault cases among children below ten years, one each was committed by father and brother.

Among the alleged victims of the age group 11-20 years, kidnapping (21), close relatives (16) and gang rapes (6) were the commonly reported cases as compared to others. Extramarital affairs (37) were mainly reported among young women in the 21-30 years (37).

Age-wise distribution of the factors of sexual initiation revealed that all of the child victims were assaulted by their close relatives, including brothers and fathers. While most of the adolescent girls were primarily assaulted by their closed relationships (40.7%), community factors like kidnapping (37.3%) and societal factors like extramarital affairs and gang rapes etc. (20.3%) were also reported among them. Most of the women above >20 years of age assaulted at a societal level resulted from extramarital affairs, as shown in Table 5.

Genital injuries: Out of 266 victims who were visually inspected for genital injuries during the medical examination, 181 (68%) were found to have hymeneal tears. The genital injuries were mostly old hymeneal tears (51.9%) and carunculae hymnals (10.1%), as shown in Figure 3. Only 6% of victims reported having recent hymeneal tears. Hymen was intact in almost 32% of the victims.

The different positions on which the hymen was torn are shown in Figure 4. Six O'clock and three O'clock were the most typical hymenal tear sites in the case of both recent and old tears, implying sexual intercourse was the most probable cause of the hymenal tear at the six o'clock position.

**Discussion:**

The present study reflected a steady rise in the cases during the study period, agreeing with the National Crime Record Bureau of India (NCRB) report.[17,21] Studies conducted in different parts of India also showed a similar year-wise increase in the rate of sexual assault cases.[19,22-23] The yearly increase in cases signifies the increase in actual crime rate and the fact that the extensive media coverage and social media influences are helping create awareness against these types of crimes and seek justice by the victims.

The younger age group of 11 to 20 years was found to be at higher risk of sexual assault, which agrees with some studies.[23-27] A significant association between the victim's age and the incident's place of sexual assault was found in the present study. The commonplaces of occurrence for children aged <10 years in the current study were the accused and the victim's home, agreeing with some recent reviews.[28,29] This significant association is because the perpetrator is either a relative, neighbours, step-parents, etc.[30]

A more significant part of sexual violence with teenage girls aged 11 to 20 years occurred at the accused relative's house and friend's house. This may indicate the incidents resulting from the false assurance of marriage given by boyfriends to teenage girls, thus emotionally provoking them to engage in sexual intimacies.[23,25] A recent review also identified age as significant in the occurrence of anogenital injury. According to the current findings, women ≤ 19 years old had the highest risk.[30]

63.4% of women reported having eloped with their boyfriends, sheltered at accused relative or friend's houses (67.3%) or hotel and other rented dwellings (22.3%), showing a significant relationship with the place of occurrence. This intimate partner sexual violence is the most typical and one of the most critical risk factors for women concerning their susceptibility to sexual assault, according to the report of WHO.[1]

In 30% of cases, the force was applied, revealing that women's first sexual experience is usually unwanted and forced, as reported in various studies.[11,12] Forced sexual instigation and coercion during adolescence is in agreement with many studies.[12,32,33] Force application with 91.8% of the children <=10 years agree with the research outcome. 34 Women (83.3%) aged >40 also revealed the force application during the incident. A significant association between age and application of force ($p < 0.001$) was observed in the study. The present study indicates that children and older women were more vulnerable to violent sexual assaults as most of the incidents were non-consensual. At the same time, violent assaults were less prevalent among teenage or young women as they may fall prey to false hopes of marriage and a better future given by the assailant, particularly by boyfriends or love affairs. As children are too young to resist and do not even understand the act's consequences, they are forced to be involved in sexual activities during the assault. Whereas adolescent and adult alleged victims sometimes may complain of it as sexual assault even if the relationship was not forceful and relatively consensual due to breach of trust.[18]

The factors of sexual initiation revealed that all (100%) perpetrators of child sexual abuse are acquainted with the children, mostly their close relatives, including brother and father, which is in concurrence with a study.[35]

A majority of 67.3% of the sexual assault victims in the present study refused medical examination. This may be due to fear of social stigma, losing marriage chances, being considered uninhibited and responsible for the incident, and attendant humiliation and shame. The refusal of medical examination may also be due to the subsequent embarrassment caused by the appearances during cross-examination in court, media publicity, and the risk of losing love and affection from society, friends, and her husband, if married, agrees with some studies.[23,36]

Most women have not experienced a severe physical injury except for simple injuries in 40 (4.8%) cases. Similar studies in other parts of the country reported higher levels of physical injuries. Delayed reporting of cases for medical examination may be the reason for not having pieces of evidence of substance bruises or physical injuries.[19,23] The genital injury prevalence of 68% in the present study is relatively higher than various other studies where the investigator reported a lower prevalence in the range of 20% to 40%.[18,19,37,38] The majority of the victims of the current study had old hymenal tears, and only 6% of the victims had recent tears, concordant with another study.[19] The most common site of genital injury in the current study was the hymenal tear at 6 o'clock. The hymen is usually torn posteriorly at

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the 6 o'clock position following the first act of coitus, agree with a review.[39] Lack of injuries in most cases highlights the importance of all concern that injury is not the conclusive finding to give a final opinion of sexual violence, according to a recent study.[40]

Genital injuries have tremendous forensic significance from both legal and ethical points of view. It is also essential to know that the absence of genital injuries does not exclude sexual assault. The healthcare professional must be sensitive, understanding the legal formalities in forensic examination and its subsequent evaluations of the evidence to opine a case examined.

Children and young girls are more vulnerable to being sexually assaulted and most of the time at their own homes by close relatives. The introduction of early sex education in the curriculum, making children aware of their private parts, parents teaching their children about good and bad touch, and exposure to self-defence courses at an early age may help the children resist this kind of crime.

**Conclusion:**

Despite the advancement of education, awareness and amendments of stringent laws against heinous crimes, sexual assault cases are still rising continuously. Early reporting of the crime for medical examination helps accelerate the judicial process. The parents need to be more aware and protective towards the girl child as girls of lower age groups are more vulnerable to being assaulted at their own houses. Along with stringent laws against this type of heinous crime, proper education and awareness programmes regarding women's rights, health care facilities, and judiciary procedures may help women fight against this social evil. While defining preventive measures for better managing the issues, the law enforcement authority may consider the risk factors evaluated in this study.

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ORIGINAL ARTICLE

# Mortality Profile of Autopsied Geriatric Population: A Retrospective Study from Eastern India

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**Abstract:**

The elderly or geriatric age group is more vulnerable not only to natural diseases but also to accidents, suicides, and homicides in developing countries. To study the epidemiology, age, sex, cause and manner of elderly who were brought for medicolegal autopsy, this retrospective review analysed post-mortem reports of the elderly age group (60 years and above), who were referred for medicolegal autopsy at SCB Medical College & Hospital, Cuttack, Odisha between January 1, 2018, to December 31, 2019. The elderly individuals accounted for 12.6% of autopsies during the study period and most of them belonged to the 60-64 year age group and showed male predominance (72.2%). Overall, craniocerebral injuries (32.7%) were found to be the leading cause of death in the autopsied geriatric population, followed by poisoning (21%, n=160). Among natural causes, non-communicable diseases such as cerebrovascular accidents (3.4%) and cardiovascular diseases(2.6%) were the chief cause of death than communicable diseases such as tuberculosis (0.3%). Regarding manner, accidents were more frequently reported than suicides, natural deaths, and homicides. Of note, suicides were twice as common in elderly females (n=127) than in elderly males (n=63). The results of the study highlight that accidents represented significant deaths among the autopsied elderly age group than suicides, homicides, and natural diseases in India. Medicolegal autopsies play a paramount role not only in the determination of the cause and manner of such deaths but also in providing mortality statistics for effective policymaking.

**Keywords:** Geriatric deaths; Accidents; Gerontology; Medicolegal autopsy; Poisoning; Suicide.

## Introduction:

The elderly age group (≥ 60 years) is on the rise across the world. It has been estimated that the proportion of the elderly age group is increasing at a fast phase and is expected to contribute 16 % of the world population in 2050 against 10 % in 2022.[1] India, which become the world's most populous country in 2023, also faces the challenge of an unprecedented increase in the geriatric age group.[2] Various factors such as socio-economic status, lifestyle, availability of quality healthcare, increasing life expectancy, genetics, nutrition, and environment, etc. attributed to this ever-increasing population of the elderly.[3] The rising geriatric population pose a major public health challenge, especially in developing countries and their already constrained healthcare system because of their vulnerability to deaths from natural and unnatural causes. The knowledge of the mortality profile, which varies across countries and regions of a country, is imperative for any government and health care providers. Because the mortality data contributes to vital statistics, thus, in turn, exhibits the effectiveness of implemented programs and future policy making.[4] However, studies on elderly mortality are primarily devoted to natural deaths and their certification by physicians. There is a dearth of literature available on elderly mortality from medicolegal autopsies, which is crucial in determining the cause and manner of death in unnatural and suspicious deaths in the elderly, especially in India. Hence, the present study was carried out to investigate the mortality profile of the elderly or geriatric population (60 years and above) subjected to medicolegal autopsies at a tertiary health care centre in eastern India.

## Materials and methods:

This descriptive retrospective study was conducted to assess the geriatric age group mortality among cases brought for medicolegal autopsy at the mortuary of the Department of Forensic Medicine & Toxicology, SCB Medical College & Hospital, Cuttack, Odisha after obtaining due clearance from the institutional ethics committee. The post-mortem reports along with their annexures such as the inquest report and viscera report were referred to during the study period ranging from January 1, 2018, to December 31, 2019. For the present study, the elderly or geriatric age group or senior citizens are considered to be individuals aged 60 years and above.[5] Post-mortem reports of unknown, decomposed bodies, and deceased aged less than 60 years were excluded from the study. The cause of death and manner of death were determined based on the police

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**Table 1. Basic details of the studied population.**

| Year | 2018 | 2019 | Total |
|---|---|---|---|
| 1. Number of autopsies performed | | | |
| Total autopsies | 2682 | 3319 | 6001 |
| Elderly Age Group | 324 | 437 | 761 (12.6 %) |
| 2. Sex of the geriatric population | | | |
| Males | 239 | 311 | 550 (72.2 %) |
| Females | 85 | 126 | 211 (27.8 %) |
| 3. Age of the geriatric population | | | |
| 60-64 | 118 | 160 | 278 (36.5 %) |
| 65-69 | 62 | 107 | 169 (22.2 %) |
| 70-74 | 63 | 89 | 152 (20 %) |
| 75-79 | 45 | 39 | 84 (11.0 %) |
| 80 & above | 36 | 42 | 78 (10.3 %) |
| Total | | | 761 |

**Table 2. Cause of death in the geriatric population.**

| Cause of Death | | | | | | |
|---|---|---|---|---|---|---|
| Variable | Cranio cerebral injuries | Poison-ing & its compli-cations | Burns & its compli-cations | Haemo-rrhage & Shock | Others (Vertebrospinal Injuries, CVA, envenomation, electrocution, etc) | Total |
| Sex wise Cause of Death | | | | | | |
| Male | 204 | 111 | 25 | 59 | 151 | 550 (72.2 %) |
| Female | 45 | 49 | 58 | 14 | 45 | 211 (27.8 %) |
| Total | 249 (32.7%) | 160 (21%) | 83 (10.9%) | 73 (9.6%) | 196 (25.8%) | 761 |
| Age wise Cause of Death | | | | | | |
| 60-64 | 84 | 59 | 26 | 29 | 80 | 278 (36.5%) |
| 65-69 | 48 | 35 | 21 | 16 | 49 | 169 (22.3%) |
| 70-74 | 58 | 28 | 17 | 17 | 32 | 152 (20%) |
| 75-79 | 35 | 18 | 9 | 6 | 16 | 84 (11%) |
| 80 & above | 24 | 20 | 10 | 5 | 19 | 78 (10.2%) |
| Total | 249 (32.7%) | 160 (21%) | 83 (10.9%) | 73 (9.6%) | 196 (25.8%) | 761 |

or magistrate inquest report, the autopsy requisition, the post-mortem report, chemical, histopathological and other ancillary tests, and the crime scene investigation report (when available). The deceased aged 60 years and above, subjected to medicolegal autopsies were classified into the following categories: 60-64 years, 65-69 years, 70-74 years, 75-79 years, and > 80 years. The data were filled in structured proforma and entered into the MS Excel spreadsheet for further descriptive analysis.

## Results:

A total of 6001 post-mortem reports (PMR) were reviewed for this study, of which 761 (12.6 %) were found to be eligible as per inclusion criteria and included in the analysis. Of the 761 geriatric autopsies reviewed, it was found that more than two-thirds of the autopsies (72.2%, n=550) were performed on males and less than one-third (27.8 %, n=211) were done on females. The majority of them belonged to 60-64 years (36.5 %, n=278) followed by 65-69 years(22.2%, n=169) and 70-74 years (20 %, n=152) (Table 1).

**Table 3. Manner of death in the geriatric population.**

| Manner of Death | | | | | |
|---|---|---|---|---|---|
| Variable | Accidental | Suicidal | Natural | Homicidal | Total |
| Sex wise Manner of Death | | | | | |
| Male | 350 | 63 | 58 | 15 | 486 (63.9%) |
| Female | 138 | 127 | 10 | 0 | 275 (36.1 %) |
| Total | 488 (64.1%) | 190 (25%) | 68 (9%) | 15 (1.9%) | 761 |
| Age wise Manner of Death | | | | | |
| 60-64 | 165 | 74 | 29 | 10 | 278 (36.5%) |
| 65-69 | 105 | 44 | 19 | 1 | 169 (22.3%) |
| 70-74 | 108 | 30 | 11 | 3 | 152 (20%) |
| 75-79 | 58 | 21 | 5 | 0 | 84 (11%) |
| 80 & above | 52 | 21 | 4 | 1 | 78 (10.2%) |
| Total | 488 (64.1 %) | 190 (25%) | 68 (9%) | 15(1.9%) | 761 |

Overall, craniocerebral injuries (32.7%, n=249) were found to be the leading cause of death in the autopsied geriatric population, followed by poisoning & its complications (21%, n=160). While craniocerebral injuries following traffic accidents contributed to the predominant deaths in males (n=204), burn and its complications were the major killer in females (n=58) (Table 2). Some of the other causes of death that were frequently encountered are vertebrospinal injuries (4.8 %, n=37), envenomation (4.4 %, n=34), and Asphyxia (3.4 %, n=26). Of note, natural causes were reported less frequently in our study as follows: cerebrovascular accident (3.4 %, n=26), cardiovascular diseases (2.6 %, n=20), senility/natural disease process (2.2 %, n=17), malignancy (0.3 %, n=3), and tuberculosis (0.3 %, n=3).

The results also revealed that nearly two-thirds of the geriatric deaths (64.1%) were due to accidents and one-fourth of them were due to self-harm i.e. suicide (25%). While accidents contributed to the majority of deaths among both males and females, suicides were found to be more frequently reported by females. Particularly, suicides were twice as common in females (n=127) than in males (n=63). Natural deaths like cardiovascular diseases and cerebrovascular accidents more commonly led to death in males than females in the autopsied geriatric population (Table 3).

## Discussion:

This descriptive retrospective study was carried out to analyse the cause and manner of geriatric deaths brought for autopsies at a tertiary care teaching hospital in the Eastern Indian state of Odisha. The significant findings of the study are that craniocerebral injuries from accidents were the most common cause of death in both males and females. Poisoning and burns were the second most common cause of death among males and females, respectively. Suicides were twice the more commonly seen manner of death in females than males, whereas natural diseases resulted in majority deaths among males than females.

One of the main objectives of the medicolegal autopsy is the determination of the cause of death. The cause of death certified by autopsy surgeons in medicolegal deaths plays a crucial role in death registration with the local authorities and in the mortality statistics of a country. This, in turn, helps implement the policies and legal frameworks to combat the factors responsible for such deaths in the future. Our study results suggest that the geriatric

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age group in this part of eastern India are more prone to die due to craniocerebral injuries from traffic accidents followed by poisoning complications and burns. This is consistent with a study from Karnataka[6] and Uttar Pradesh[7] that reported blunt injuries to the head as the most common cause of death. This may be likely resulting from senility and natural diseases induced functional disturbances, cognitive impairment, movement and reflex abnormalities, and vision difficulties which make the elderly vulnerable to frequent falls and accident-related deaths.[8] However, our results are inconsistent with a study from Egypt[9] which reported Homicides as the most common manner of death and a study from Nigeria[10] which revealed natural diseases were the most common manner of death among the elderly age group. These discrepancies may be due to different socioeconomic status, culture, literacy, availability of health care, and existing policies to safeguard the elderly in the studied population.

Among natural deaths, NCDs such as cerebrovascular accidents (3.4%) and cardiovascular diseases (2.6%) were found to be the more frequent killers than communicable diseases like tuberculosis (0.3%) in the elderly. This is likely due to the decreasing trend of tuberculosis cases[11] and the increasing trend of NCDs in the country for the past several years because of changing lifestyles, food habits, and stress in the elderly.[12] Regular health check-ups and screening programs for non-communicable diseases and malignancies should be made mandatory for the geriatric age group to avoid such preventable deaths.

Although senility and natural deaths from diseases dominate the causes of death of the geriatric population in general, they should not be compared with cases of medicolegal autopsies. Such sudden natural deaths are less frequently encountered in forensic practice as they become a medicolegal case only when brought dead to emergencies or when there is no family physician or last treating physician to certify the cause of death.

On the other hand, socioeconomic, physical, psychological, and emotional neglect in the elderly results in loneliness and suicide. In our study, poisoning was the most common means to commit suicide, especially among females. Conversely, the data from the National Crime Records Bureau "Accidental Deaths & Suicides in India 2019" report that suicides were more common among males than females with nearly a male: female ratio of 3:1 (8302:2709) among the elderly age group.[13] The report also estimated that hanging was the more common manner of death than poisoning, which also corresponds with a study from Tunisia.[8] However, in our study, poisoning and its complications were found to be the most commonly used method to commit suicide, possibly due to the easy availability of agricultural poisons and the selection of the study population i.e. geriatric age group.

Besides diseases and accidents, the elderly are also more prone to homicides because of the perceived burden by their family members with resultant vulnerability to physical abuse. Further, crimes against the elderly are reported rising in India.[14] However, the present study results reveal that only 1.9% (n=15) of the elderly deaths were due to homicides, and all victims were males. This surprisingly low prevalence of homicides among the elderly in this region also corresponds to the official figures for the state of Odisha in India.[14–16]

**Limitations:** Since the data was obtained from a single autopsy centre in Eastern India, the results could not be generalizable to the whole of India or any other country. However, the results can be utilised to compare studies from other regions. The demographic data such as occupation, social economic status, income, etc. and case-specific details for example, the exact type of vehicles in accidents, and the exact poisonous compound from the confirmatory analysis were either not available or could not be obtained from the records. Such additional information would have helped to draw more inferences.

**Conclusion:**

The results of the study reiterate that the geriatric population is more prone to accident-related deaths, particularly from craniocerebral injuries. The policies should be in place to make the roads safe and elder-friendly. Prompt screening for communicable and non-communicable diseases should be made available to the elderly especially those who are living in rural and semi-urban regions. It is also highlighted here that physical, psychological, and emotional support by family members is crucial to mitigate suicides among the elderly and to promote graceful ageing. The importance of medicolegal autopsies in determining the cause and manner of deaths in the elderly should not be underestimated. The autopsy surgeon should be able to delineate between natural and unnatural deaths in the elderly to meet the ends of justice. A nationwide study on the mortality profile of the elderly age group subjected to medicolegal autopsies is the need of the hour.

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ORIGINAL ARTICLE

# Association of Carboxyhemoglobin Levels with Yogic Breathing in Medical Undergraduate Students- An Observational Cross-sectional Study

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**Abstract:**

Carbon monoxide is produced from incomplete combustion of fuels like charcoal, briquette, fuel gas, petroleum, using a burner, heater or cooking equipment with inadequate ventilation, faulty water heaters, exhaust fumes from vehicles, industries and cigarette smoking leading to high Carboxyhemoglobin levels. The effect of low-level exposure to carbon monoxide on the cognitive functions of an individual is not very well documented as the clinical syndrome in occult cases have a very obscure clinical presentation with little awareness and knowledge in this particular domain. The various neurological manifestations resulting from carbon monoxide exposure could range from headache, fatigue, dizziness, syncope, lethargy, coma, seizures and death at high levels. It has been observed that deep breathing exercises help in reducing the carboxyhemoglobin levels in smokers. Pranayama or yogic method of breath regulation is an important component of Yoga. We had conducted this study with the objective of analysing the association of Carboxyhemoglobin and Methhemoglobin levels with Yogic Breathing in healthy undergraduate medical students. Design- Analytical observational cross sectional study. Setting- Tertiary Medical teaching Institute. Participants- Healthy undergraduate medical students. Study Period- September 2023. Our study was carried out on a total of 42 undergraduate medical students. The oxygen saturation pattern in both the groups came out to be normal (>98%). We found a significant difference between the Pulse rate ($p<0.05$) and carboxyhemoglobin ($p<0.02$) in both groups. Yogic breathing is definitely a healthier way of breathing; hence adoption of such healthy practices should be encouraged worldwide.

**Keywords:** Pranayama, Carboxyhemoglobin, Methhemoglobin.

## Introduction:

Carbon monoxide is produced from incomplete combustion of fuels like charcoal, briquette, fuel gas, petroleum, using a burner, heater or cooking equipment with inadequate ventilation, faulty water heaters, exhaust fumes from vehicles, industries like iron foundries, chemical plants, etc.[1] Carbon monoxide is also released through cigarette smoking (3-4%), with COHb saturation in Heavy smokers reaching to 10-15%.[2,3] The CNS is the organ system that is most sensitive to CO poisoning. The effect of low-level exposure to carbon monoxide on the cognitive functions of an individual is not very well documented as the clinical syndrome in occult cases have a very obscure clinical presentation with little awareness and knowledge in this particular domain. The various neurological manifestations resulting from carbon monoxide exposure could range from headache, fatigue, dizziness, syncope, lethargy, coma, seizures and death at high levels.[4] Respiration using 100% oxygen is the preferred treatment in case of high carboxyhemoglobin levels in blood. Some studies done abroad have pointed towards the effect of deep breathing exercises in reducing the carboxyhemoglobin levels in smokers.

Pranayama is an ancient yogic method of breath regulation by rapid breathing through diaphragm, alternate nostril breathing, slow and deep breathing and breathing with glottis contraction. All these exercises are usually done in a seated posture preferably in a well ventilated environment. Pranayama consist of four aspects of breathing comprising of sequential and controlled inhalation, exhalation, internal breath retention and external breath retention.[5,6] It helps in improving the oxygen reserves and removes the toxins from the body along with calming effect on the mind. The recent popularity of this 3000 year old Indian tradition across the globe has led to various research studies on the therapeutic effects of such practices.[7-10] These studies have demonstrated the beneficial effects of Pranayama on cardiovascular system, improved respiratory functions, balancing of nervous symptoms. However, there was no such study done in India where the effects of Yogic breathing exercises on carboxyhemoglobin levels were studied. Hence, we had conducted this study with the objective of analysing the association of Carboxyhemoglobin levels with Yogic Breathing in healthy undergraduate medical students.

## Materials and methods:

Ours is an analytical observational cross sectional study done during the month of September 2023, on Medical undergraduates after approval from the institutional Research Ethical

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Committee. The participants were recruited from the undergraduate medical students of all phases after getting their written informed consent. Our study was carried out on a total of 42 undergraduate medical students who agreed to participate in the study by signing the informed consent form. They were divided into two groups-Yoga group and the Non Yoga group, each containing the same number of participants (21) in the age group of 21-30 years. Those students who had been practising Yogic breathing exercises (Pranayama) regularly were recruited in Group 1, or the Yoga Group. The Pranayama exercises included Alternate Nostril Breathing (Anulom vilom), forced inspiration and forced expiration (Bhastrika), Inspiration and expiration with slight contraction of glottis (Ujaiyi), forced expiration (Kapalbhati), OM chanting (Bhramari). The other students who were not doing any yogic breathing exercises or gym training were recruited in Group 2 or the Non Yoga group. Presence of any haematological, acute or chronic disease was considered as exclusion criteria for both the groups.

Data collection: After collecting the demographic data of both groups, their haematological parameters comprising of Oxygen Saturation (SPO2), Pulse Rate (PR), Carboxyhemoglobin (COHb), Methhemoglobin (MethHb), and Perfusion Index (PI) were measured non-invasively through Pulse CO-oximeter of Masimo brand using an adult type finger tip sensor.

Statistical Analysis: Microsoft Excel was used for arrangement of data and descriptive analysis. Statistical analysis was done using SPSS 22 software. Student's t test was used to compare the readings between the Yoga group and Non Yoga group. Probability (p value) of <0.05 was considered as significant.

**Results:**

The mean age of Yoga group and Non Yoga group was found to be 23.09 and 25.09 years respectively. There were 11 females and 10 males in the Yoga group and 9 females and 11 males in the Non Yoga group. We didn't find any significant difference related to gender, for all parameters analysed in our study. However, we found smoking prevalence only among the males in both the groups. The oxygen saturation pattern in both the groups came out to be normal (>98%). On the contrary, there was a significant difference between the Pulse rate ($p<0.05$), with lower value seen in the Yoga group. The mean carboxyhemoglobin in the study population came out to 3.6, with a maximum of 8 in yoga practitioners 'group and maximum of 14 in the non yoga practising participant. We found a significant difference ($p<0.02$) in both groups. On assessing Perfusion Index and Methhemoglobin, all values were below clinical reference, that is, less than 20 % ( PI) and 2 % ( MethHb).

**Table 1. Age and sex related distribution in the yoga and non yoga groups.**

| Parameters | | Yoga Group | Non Yoga Group | p-value |
|---|---|---|---|---|
| Age | | 23.09±1.5781 | 25.09±2.1425 | 0.001 |
| Sex | Females | 11 | 9 | >1 |
| | Males | 10 | 12 | |
| Smoking status | NS | 18 | 15 | <0.05 |
| | S | 3 | 6 | |

NS: Non smokers; S: smokers.

**Table 2. Comparison of various parameters in the yoga and non yoga groups.**

| Parameters | Yoga Group (Mean ± SD) | Non Yoga Group (Mean ± SD) | p-value |
|---|---|---|---|
| SPO2 | 98.8095±0.6796 | 98.333±1.0646 | 0.09 |
| PR | 77.8095±8.84888 | 89.0476±17.9695 | <0.05 |
| SPCO | 2.619±2.3974 | 4.619±2.9407 | <0.02 |
| PI | 1.6219±1.1839 | 1.7633±1.7496 | 0.7606 |
| Meth Hb | 1.0619±0.4599 | 1.0857±0.4912 | 0.872 |

$SPO_2$-Saturation of Peripheral Oxygen; PR-Pulse Rate; SPCO-Saturation of Peripheral Carboxyhemoglobin; PI-Perfusion Index; MethHb-Methhemoglobin.

**Discussion:**

In the present study, it was noted that even with as little as 25 minutes of regular yogic breathing or Pranayama done by healthy adults resulted in significant positive changes in their haematological parameters like SPO2, Pulse rate, Carboxyhemoglobin, perfusion index and methhemoglobin. The mean age of our participants was 24.09 years. The female to male ratio in both the groups was not significant. However, smoking habit was found only among the males in both the groups. Though the mean partial pressure of oxygen did vary a bit in both the groups, but the results were not found to be significant.

PR varies in healthy individuals depending upon the physical, emotional or cognitive activity status. According to various studies done on Yoga practices, heart rate is reduced with regular exercise as it improves the heart's efficiency.[11-13] Yogic exercise stimulates the parasympathetic activity of the autonomic nervous system, thus reducing the heart rate.[14-16] In our study too, a significantly lower Pulse rate was observed in the yoga group. In our study, we noted that the carboxyhemoglobin concentration had the mean value of 2.619 and 4.619 in yoga and non yoga group respectively. The results were also statistically significant (<0.02).

We observed an increase in carboxyhemoglobin in the smokers which was in consistent with the findings of previous similar studies.[17,18] Noruzian et al. studied the effects of breathing exercise on carboxyhemoglobin level in men smokers and their results showed that 6 weeks of breathing exercise intervention significantly reduced COHb (P=0.001).[19] We got the similar findings in our study where the carboxyhemoglobin level of smokers in yoga group (mean 7.0) was found to be less than the non yoga group (mean 8.3). We didn't see any difference in methhemoglobin levels in the two groups and it was found to within normal range in all the participants. This is in accordance to comparative study of Nathalia et al. where he didn't report any significant difference in methhemoglobin level of smokers and non smokers.[20]

Limitations: Ours was an Analytical observational cross sectional study where we collected the data at a single point of time hence we couldn't determine the causal relationship between yogic breathing exercises and haematological parameters. Our sample size was very small as majority of the medical students were not inclined towards yoga and obtaining a representative sample was not an easy task. It is not sufficient to understand the various haematological readings especially carboxyhemoglobin solely on the basis of exercise status of an individual. Another limitation of our study is that we didn't cross verify the information given by the students hence, our research is also subjected to Information bias.

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**Conclusion:**

In our research, Pulse rate, $SPO_2$, Carboxyhemoglobin, Methhemoglobin were all found to be affected by the yogic breathing exercises. The cause of higher levels of carboxyhemoglobin in non-smokers needs to be explored further with a large sample size to give appropriate representativeness of both the groups. To conclude, we would say that Yogic breathing is certainly a healthier way of breathing and such simple exercises can definitely lead to long term overall benefits; hence adoption of such healthy practices should be encouraged worldwide.

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**Authors' Roles:** Dr. Richa Choudhary conceived and designed the study, analysed and interpreted the data and wrote the manuscript; Dr. Pradeep Kumar Yadav helped in data collection and statistical analyses. Both the authors reviewed and approved the final manuscript.

**Conflict of Interest:** The Authors declare that there are no conflicts of Interests.

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ORIGINAL ARTICLE

# A Retrospective Study of Custodial Deaths in Chhattisgarh Region

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**Abstract:**

The death of a person in custody has always been in the limelight. Some people in custody die because of some form of violence, some due to accidents and some because of natural disease. In this study, we have attempted to identify the various causes of death in a person under custody in the Chhattisgarh region. A single-centre, retrospective study was conducted for all cases (n=35) of custodial death between the years 2018 and 2019. Data collected included age, sex, manner of death, place of death and cause of death. Male inmates have a higher rate of custodial deaths. 100 % of male and 90 % of female deaths in custody are natural deaths. The most affected age group was the 51-60-year age group. The hospital was the place of death for 100 % of males and 90 % of females. Tuberculosis and cirrhosis of the liver were among the common causes of death in a person in custody. Deaths in custody in Chhattisgarh are primarily natural deaths. Regular health screening and proper health care facilities for the prisoners are the need of the hour.

**Keywords:** Custodial deaths; Custody; Prisoner.

## Introduction:

The death of a person either during pre-trial or after the conviction is called a Custodial death. It is important to emphasize that it not only includes deaths in jail or police lockups but also includes deaths in hospitals as well as in police or any other vehicle. Custodial deaths can occur as a result of direct or indirect involvement of police or it can be due to some disease. The issue gets highlighted when the death is unnatural and there is some sort of involvement of the police.[1] The death of a person in custody falls under the scrutiny of mass media as well and becomes a matter of public apprehension.[2] National Human Rights Commission (NHRC) of India has made guidelines to be followed mandatorily in every state in cases of custodial deaths. It is observed that lack of awareness and carelessness of the custodial authorities towards the health status of the jail inmates along with the unhygienic status of the cells are the main reasons for untimely custodial deaths.[3] It should be noted that not all custodial deaths are the result of violent acts of police, but at times it may also be due to natural disease or due to inadequate medical facilities and delayed treatment.[4] Many studies have been conducted on custodial deaths in different states of India except in Chhattisgarh. In the current study, we have tried to figure out the cause of custodial deaths in the Chhattisgarh region which can aid the policymakers in making necessary reforms in the prevailing condition of jail inmates.

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## Materials and methods:

Study setting: A single centre, retrospective study of custodial death cases which were brought to the Department of Forensic Medicine and Toxicology in a tertiary health care centre from January 2018 to December 2019. It is the largest tertiary health care centre in Chhattisgarh, which is also an authorised centre for conducting custodial death inquiries. Our original research was approved by the Institutional Ethics Committee.

Samples: During this period of 2 years, a total of 35 custodial death cases were analysed. Persons who were out on parole were excluded from our study. Prisoners in our study included both the convicted and those who were undertrial.

Procedure: Preliminary details of the deceased and their history were collected from magistrate inquest papers, autopsy reports and hospital indoor records.

Data analysis: Data analysis was done using Microsoft Excel version 2007 and Open Epi version 3.0 software package.

## Results:

Background characteristics of two-year data of custodial deaths: Out of the total 35 cases, the majority were male (91.4%) and only 3(8.57%) were female. Natural death occurred in 92% of the cases. The cause of death was natural in 31(88.6%) cases and the majority (92%) of the deaths occurred in 2019. 10(28.57%) of the custodial deaths occurred in the age group of 51-60 years. Most of the deaths occurred in the hospital [Table.1].

Manner and Cause of Death in Years 2018 and 2019: Natural deaths accounted for 23(92%) deaths whereas 2(8%) cases were of unnatural deaths in 2018 and 2019, Natural deaths occurred in 8(80%) cases and unnatural deaths occurred in 2(20%) cases. Tuberculosis and Cirrhosis of the Liver were the most common

causes of natural death, followed by Pulmonary Consolidation. Among the unnatural deaths, accidents constituted 8.57% of cases and homicide constituted 2.85% of cases cumulatively in 2018 and 2019.

## Discussion:

When a person's freedom of movement is restricted by a law enforcement agency, that individual is said to be under custody. A person in captivity is reliant on and under the watchful eye of the authorities. Therefore, any death that occurs while under the care of a person's authority is seen as their fault in some way.[3] As per NHRC annual report, 1936 custodial deaths were reported in the year 2018 and 1700 custodial deaths were reported in the year 2019.[5,6] A total of 35 custodial deaths occurred in Chhattisgarh in the year 2018 and 2019 out of which the majority were males (91.4%, n=32). A smaller number of female custodial deaths were reported by the National Human Rights Commission as well as in the research of the other authors.[4-7] The reason which can be attributed to this is the lesser number of crimes committed by females. In the present study most affected age group was the 51-60 years age group which is in contradiction to other studies[8,9] where the 21–40-year age group was the most affected age group. According to the manner of death, the majority (88.6%, n=31) of the cases were of natural death.[3,10-14]

**Table 1. Background characteristics of two-year data of custodial deaths.**

| Background | | 2018 (n=25) | 2019 (n=10) | Total (n=35) |
|---|---|---|---|---|
| Sex | Male | 24 (96%) | 8 (80%) | 32 (91.4%) |
| | Female | 1 (4%) | 2 (20%) | 3 (8.57%) |
| Manner of death | Natural | 23 (92%) | 8 (80%) | 31 (88.6%) |
| | Unnatural | 2 (8%) | 2 (20%) | 4 (11.42%) |
| Age-group (in years) | <20 | 1 (4%) | 0 (0%) | 1 (2.85%) |
| | 21-30 | 3 (12%) | 3 (30%) | 6 (17.14%) |
| | 31-40 | 3 (12%) | 1 (10%) | 4 (11.42%) |
| | 41-50 | 4 (16%) | 1 (10%) | 5 (14.28%) |
| | 51-60 | 7 (28%) | 3 (30%) | 10 (28.57%) |
| | 61-70 | 4 (16%) | 2 (20%) | 6 (17.14%) |
| | >70 | 3 (12%) | 0 (0%) | 3 (8.57%) |
| Place of Death | Judicial Custody | 0 (0%) | 1 (10%) | 1 (2.85%) |
| | Police Custody | 0 (0%) | 0 (0%) | 0 (0%) |
| | Police Firing | 0 (0%) | 0 (0%) | 0 (0%) |
| | Hospital | 25 (100%) | 9 (90%) | 34 (97.14%) |
| Total | | 25 (100%) | 10 (100%) | 35 (100%) |

**Table 2. Manner and cause of death in years 2018 and 2019.**

| Cause of Death | 2018 (n=25) | 2019 (n=10) | Total (n=35) |
|---|---|---|---|
| | No. (%) | No. (%) | |
| Natural | | | |
| Tuberculosis | 5 (20%) | 1 (10%) | 6 (17.14%) |
| Carcinoma | 1 (4%) | 2 (20%) | 3 (8.57%) |
| Pulmonary Consolidation | 3 (12%) | 1 (10%) | 4 (11.42%) |
| Bronchopneumonia, Septicemia | 2 (8%) | 0 (0%) | 2 (5.71%) |
| Cirrhosis of Liver | 4 (16%) | 2 (20%) | 6 (17.14%) |
| Coronary artery disease/ Heart disease | 3 (12%) | 0 (0%) | 3 (8.57%) |
| septicaemia following diabetic foot | 1 (4%) | 0 (0%) | 1 (2.85%) |
| Ischemic Cerebral infarction | 2 (8%) | 1 (10%) | 3 (8.57%) |
| Intracerebral haemorrhage | 1 (4%) | 0 (0%) | 1 (2.85%) |
| Status epilepticus | 1 (4%) | 0 (0%) | 1 (2.85%) |
| Ruptured Oesophageal Varices with Cirrhosis of Liver | 0 (0%) | 1 (10%) | 1 (2.85%) |
| Unnatural | | | |
| Suicide | 0 (0%) | 0 (0%) | 0 (0%) |
| Homicide | 0 (0%) | 1 (10%) | 1 (2.85%) |
| Accident | 2 (8%) | 1 (10%) | 3 (8.57%) |

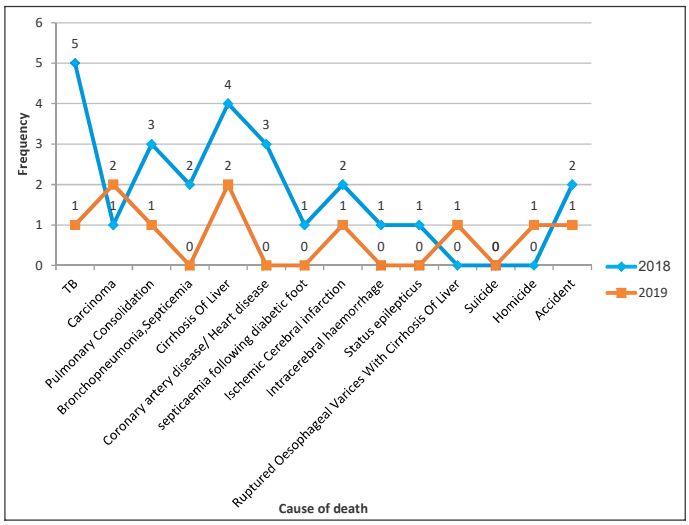


**Figure 1. Demonstrates different causes of death in the years 2018 and 2019. The blue line denotes the frequency of the cause of death in the year 2018 while the orange line denotes the frequency of the cause of death in the year 2019.**

In the present study, among the natural causes of death, Tuberculosis (17.14%, n=6) and Cirrhosis of the liver (17.14%, n=6) were the most reported. This is similar to other studies.[8,15] In the current study suicide was not reported in the study period. The most common manner of unnatural death was accidental (8.5%, n=3) in the current study. This is in contradiction to other studies where suicide was the most common manner of death among unnatural deaths.[8,11] Death because of homicide was reported in 2.85% (n=1) cases in the present study. Others have reported homicides as the manner of death in the 4-11% range.[8,16,17] In the present study, the majority of the deaths (97.14%, n=34) occurred in the hospital. This is in contradiction with another study where the majority of the deaths were reported in judicial custody.[15] The authorities are unaware of any prior health-related incidents involving the prisoners, and they only respond when the prisoners' health deteriorates. These incidents, whether they involve natural or unnatural deaths, all point to a lack of regard and concern on the part of the authorities for human life.[15]

## Conclusion:

Death in custody is always looked upon with suspicion. It takes a tragic turn if the death is premature. Thus, custodial authorities play a vital role in preventing such tragic premature deaths. In the present study majority of deaths were as a result of natural causes which if timely intervened by the custodial authorities can be prevented. Besides we recommend the following measures

1. Maintenance of hygiene, ventilation and proper light in the detention cells.
2. Pre-arrest health check-ups and Routine health check-ups of the inmates.
3. Detention cells should be separate according to the illness and

spacing is required between cells as per norms fulfilling the criteria of isolation in some diseases.

4. Imparting health education to the jail inmates.
5. Installing surveillance cameras with proper monitoring for any suspicious activity.
6. Time-to-time inspection by the policymakers and higher authorities to implement the above and prompt intervention if required.

**Ethical consideration:** The study was ethically approved by the Institutional Ethical Committee. Confidentiality was maintained.

**Conflict of interest:** None

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ORIGINAL ARTICLE

# Knowledge and Practice of Principles of Research and Publications Among Undergraduate Students- A Cross Sectional Study

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**Abstract:**

Abstraction, conceptualization, critical thinking, and reasoning skills are important for a medical researcher. Encouragement and motivation in medical research during undergraduate life can be helpful in creating future medical scientists. Very few medical students indulge and pursue career in research. The knowledge and practice of medical research are seldom assessed in undergraduate life. This study was conducted to assess the knowledge and principles of biomedical research and publications among undergraduate medical students and to compare the responses between genders and different academic years. All the students of phase 2 & Phase 3 were supplied a pretested and validated questionnaire containing 18 questions through Google forms. Informed consent was taken from each participant. The responses were tabulated in MS Excel spreadsheet and analysed with SPSS. 457 responses were collected with response rate= 76.16% with median age of 22 (22.12±1.11) years. Majority were male (57.5%). Majority of responders are not sure about the availability of guide, facility, and funding for research. Very few of them had knowledge about literature review and statistical analysis. Several studies done worldwide. Medical research is important for undergraduate students. Lack of awareness and training leads to confusion and less involvement. Exposure of undergraduate medical students to research activity is need of hours.

**Keywords:** Research methodology; Principles of research; Research publication; Undergraduate medical students; Questionnaire survey.

## Introduction:

The present world of medical science is driven by evidence-base medicine, which is to be taught during undergraduate medical education.[1-3] It requires comprehension and use of scientific principal and research methodology which are rarely dealt in medical schools in undergraduate curriculum.[4-8] Training and exposure to biomedical health research is an integral part of current medical education. Abstraction, conceptualization, critical thinking and reasoning skills are the important components for becoming a medical researcher. Studies have proven that undergraduate medical research helps the student in generating interest in the field and is strongly associated with post graduate initiatives.[4,9-12]

Knowledge and use of scientific methods are important for being a successful medical professional.[13,14] Encouragement and motivation in medical research during undergraduate life can be helpful in creating future medical scientist.[4,9-12] There is a growing need felt regarding involvement of undergraduate medical students in research activities.[15,16] The rapid expansion and progress of biomedical research is guiding the evolution of medical care at present.[16] The benefit of community and development of the nation along with economic growth is widely dependent on the financial investment and funding in medical research, proper training and education of the students and the medical scientists and innovative policy making decision.[17-26]

Not only for the experts, independent research is also a necessity for the postgraduate medical students also.[27] Unfortunately, not enough medical graduates indulge and prefer much in medical research after being professionals but student research activities with good research and publication experiences can lead to distinguished achievements in academic medicine.[12] Studies have proved that attitudes and practice of medicals students towards research experience are seldom assessed in undergraduate life.[4,28]

With this background the present study was conducted to assess the knowledge and practice of principles of research and publications among undergraduate medical students of 2nd and 3rd professional years.

## Methodology:

Institutional Ethics Committee approval was required in this study due to the interaction with human participants. This study was approved by the Institutional Ethics Committee with reference no EC-CNMC/2023/245 dated 30.05.2023.

It was a cross-sectional descriptive study. The sample size was 600. All 2nd and 3rd professional years students were included in the study and all the absentees were excluded from the study. To determine the knowledge and practice of principles of research

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**Table 1. Data collection tool.**

| Question | Yes | No | Not sure |
|---|---|---|---|
| Have you ever attended a scientific conference in MBBS life? | | | - |
| Have you ever presented a paper at a scientific conference in MBBS life? | | | - |
| Have you ever presented a poster at a scientific conference in MBBS life? | | | - |
| Have you ever written any synopsis for a research project? | | | - |
| Have you ever written any scientific paper? | | | - |
| Have you ever received any training on research methodology? | | | - |
| Do you feel confident in interpreting a research paper? | | | |
| Do you feel confident in writing a research paper? | | | |
| Do you think there is sufficient scope of guidance for conducting research in your institution in pre/para-clinical subjects? | | | |
| Do you think there is sufficient scope of guidance for conducting research in your institution in clinical subjects? | | | |
| Do you think there is sufficient scope of facility for conducting research in your institution? | | | |
| Do you think there is sufficient scope of funding for conducting research in your institution? | | | |
| Do you think there is sufficient scope of training for conducting research in your institution? | | | |
| Do you think there is sufficient scope of training in research methodology among teachers/guides? | | | |
| How many research publications do you have? | 0 | 1 to 5 | More than 5 |
| In your opinion how much is the participation of UG-students in research activities? | High | Moderate | Low |
| If your response to previous question is LOW, what may be the causes? (Choose multiple options is allowed) | Lack of motivation / Lack of guidance | Lack of exposure / No monitory benefit | No academic benefit / No professional benefit |

**Table 2.**

| Question | Male | | Female | | Phase 2 | | Phase 3 | |
|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No |
| Have you ever attended a scientific conference in MBBS life? | 94 (20.57) | 169 (36.98) | 60 (13.13) | 134 (29.32) | 41 (8.97) | 131 (28.67) | 113 (24.73) | 172 (37.64) |
| Have you ever presented a paper at a scientific conference in MBBS life? | 8 (1.75) | 255 (55.70) | 2 (0.44) | 192 (42.01) | 1 (0.22) | 171 (37.42) | 9 (1.97) | 276 (60.39) |
| Have you ever presented a poster at a scientific conference in MBBS life? | 3 (0.66) | 260 (56.89) | 3 (0.66) | 191 (41.79) | 2 (0.44) | 170 (37.10) | 4 (0.88) | 281 (61.49) |
| Have you ever written any synopsis for a research project? | 35 (7.66) | 228 (49.89) | 20 (4.38) | 174 (38.07) | 9 (1.97) | 163 (35.67) | 46 (10.07) | 239 (52.20) |
| Have you ever written any scientific paper? | 20 (4.38) | 243 (53.17) | 11 (2.41) | 183 (40.04) | 8 (1.75) | 164 (35.89) | 23 (5.03) | 262 (57.33) |
| Have you ever received any training on research methodology? | 49 (10.72) | 214 (46.83) | 32 (7.00) | 162 (35.45) | 19 (4.16) | 153 (33.48) | 62 (13.57) | 223 (48.70) |

among students at first a questionnaire was formulated and validated by three experts in this field. A google form was created. Link and QR code were generated. Informed consent was obtained from each participant before performing the procedure. The responses were tabulated in MS Excel spreadsheet and analyzed through SPSS software version 22.

Questionnaire: The questionnaire contained 17 questions. Some of the questions had dichotomous answers in the form of 'Yes' or 'No' and some questions included an additional option 'Not sure'. One question had response 'High-Moderate-Low' and two other questions were structured with different and multiple options. The whole data collection tool (questionnaire) is given in Table-1.

**Results:**

The questionnaire was distributed among 600 students, of which 457 responses were received (Response rate = 76.16%). Majority of the participants were male (n=263, 57.5%) and rest were female (n=194, 42.5%). Median age of participants was 22 years ranging from 19-25 years. The average age of the participants were $22.12 \pm 1.11$ years respectively. The binomial test was done to compare the distribution of genders. The p-value was significant (p=0.001) which implies male and female population do differ significantly from the binomial assumption of equal probability.

Out of 457 students only 1 student published more than five research papers, 14 students (3.06%) published one to five research papers and most of the students (n=442, 96.72%) did not publish any research paper.

Only one third of the responders attended scientific conference in their medical academic life. Among them only 10 students (2.2%) presented a scientific paper and only 6 students (1.31%) have presented a scientific poster in scientific conference. Majority of the responders have not written synopsis or scientific paper ever in their undergraduate life. More than 80% of the responders have never received any training on research methodology. The detailed responses regarding this are mentioned in Table- 2.

Most of the students were not sure about interpreting and writing

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**Table 3.**

| Question | Male | | | Female | | | Phase 2 | | | Phase 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | No | Not sure | Yes | No | Not Sure | Yes | No | Not sure | Yes | No | Not sure |
| Do you feel confident in interpreting a research paper? | 62 (13.57) | 39 (8.53) | 162 (35.45) | 25 (5.47) | 39 (8.53) | 130 (28.45) | 34 (7.45) | 25 (5.47) | 113 (24.73) | 53 (11.50) | 53 (11.50) | 179 (39.17) |
| Do you feel confident in writing a research paper? | 70 (15.32) | 61 (13.35) | 132 (28.88) | 23 (5.03) | 66 (14.44) | 105 (22.98) | 32 (7.00) | 48 (10.50) | 92 (20.13) | 61 (13.35) | 79 (17.29) | 145 (31.73) |
| Do you think there is sufficient scope of guidance for conducting research in your institution in pre/para-clinical subjects? | 102 (22.32) | 66 (14.44) | 95 (20.79) | 67 (14.66) | 67 (14.66) | 60 (13.13) | 63 (13.79) | 42 (9.19) | 67 (14.66) | 106 (23.19) | 91 (19.91) | 88 (19.26) |
| Do you think there is sufficient scope of guidance for conducting research in your institution in clinical subjects? | 76 (16.63) | 68 (14.88) | 119 (26.04) | 51 (11.16) | 59 (12.91) | 84 (18.38) | 45 (9.85) | 45 (9.85) | 82 (17.94) | 82 (17.94) | 82 (17.94) | 121 (26.48) |
| Do you think there is sufficient scope of facility for conducting research in your institution? | 87 (19.04) | 69 (15.00) | 107 (23.41) | 55 (12.04) | 52 (11.38) | 87 (19.04) | 49 (10.72) | 36 (7.88) | 87 (19.04) | 93 (20.35) | 85 (18.50) | 107 (23.41) |
| Do you think there is sufficient scope of funding for conducting research in your institution? | 95 (20.79) | 46 (10.07) | 122 (26.60) | 53 (11.50) | 44 (9.63) | 97 (21.23) | 49 (10.72) | 30 (6.56) | 93 (20.35) | 99 (21.66) | 60 (13.13) | 126 (27.57) |
| Do you think there is sufficient scope of training for conducting research in your institution? | 113 (24.73) | 47 (10.28) | 103 (22.54) | 77 (16.85) | 53 (11.50) | 64 (14.00) | 64 (14.00) | 29 (6.35) | 79 (17.29) | 126 (27.57) | 71 (15.54) | 88 (19.26) |
| Do you think there is sufficient scope of training in research methodology among teachers/ guides? | 50 (10.94) | 93 (20.35) | 120 (26.26) | 33 (7.22) | 72 (15.75) | 89 (19.47) | 32 (7.00) | 51 (11.16) | 89 (19.47) | 51 (11.16) | 114 (24.95) | 120 (26.26) |

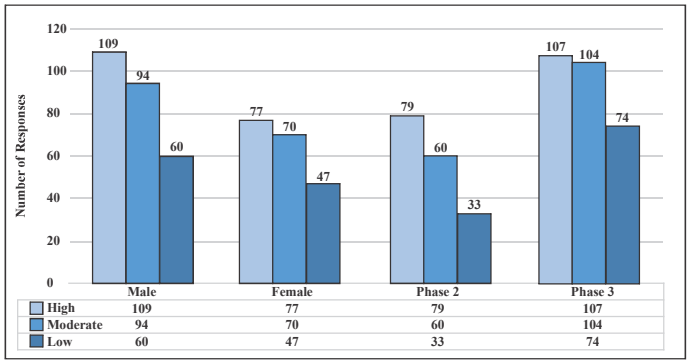


**Figure 1.**

a research paper. As opinionated by the responder more than one third affirmed that there is sufficient scope of guidance for conducting research in pre/para clinical subjects and almost half of the responder are not sure about the same in clinical subjects. About one third of the responders gave positive response regarding scope of facility and funding for conducting research. Majority of the students believe that there is scope of training of research methodology for students, but they are not sure about the same among teachers or guides. The detailed responses regarding this are depicted in Table- 3.

Exploring the lack of participation in research activities which is depicted in Figure-1. To enumerate the causes the responders pointed out majorly due to lack of exposure (n=271, 77.43%) followed by lack of motivation (n=249, 71.14%), lack of guidance (n=231, 66%), lack of monitory benefit (n=105, 30%), lack of academic benefit (n=108, 29.71%), lack of professional benefit (n=77, 22%).

A chi square test was performed between gender and all the responses. No observed cell value was zero. There was statistically significant relationship between confidence in interpreting a research paper (c2 (df=2) 9.03, p=.01), writing a research paper (c2 (df=2) 16.99, p=.0002), scope of training for conducting research in the institution (c2 (df=2) 6.01, p=.04). All the other relationships between the responses and gender were not statistically significant (p>.05).

A chi-square test was also performed between the academic year of the study population and all the responses. No observed cell value was zero. There were statistically significant relationship between attendance in a scientific conference in MBBS life (c2 (df=1) 12.00, p=.0005), written any synopsis for a research project (c2 (df=2) 12.06, p=.0005), scope of facility for conducting research in the institution (c2 (df=2) 8.09, p=.0174), scope of training for conducting research in the institution (c2 (df=2) 11.09, p=.0038), received any training on research methodology, c2 (df=1) 8.43, p=.0036. All the other relationships between the responses and academic year were not statistically significant (p>.05).

**Discussion:**

Several studies done worldwide to explore the importance, attitude and practice of research work as a part of the undergraduate medical curriculum. Higher response rate (as high as 97.73%) was observed in the studies conducted in Croatia, Iran and Chennai as their sample size were much smaller than our study sample.[13,17,29] The mean age of the study participants was higher in our study as compare to those in Pakistan, Iran and Chennai.[9,17,29] Most of the studies done on this topic includes a smaller sample size ranging from 65 to 301.[3,9,12,13,15-17,29,30] A study done in Southeast Europe include 4307 study participants.[1]

Study participants from USA and Chennai showed poor attendance, scientific paper and poster presentation at undergraduate level at different medical conferences.[16,29] Regarding the ability to interpret and write a research paper, 31% of the responders were confident in Kerala study and 90.3% showed positivity in Pakistan, compared higher than the present study.[9,15]

Writing a synopsis for a research project is imperative for getting Institutional Ethics Committee approval before starting a research work, which was not inquired in the study participants in

any of the studies conducted earlier. Writing a research paper for publication after the completion of research has been explored and found higher in Pakistan study (25.9%) and lower in Kerala study (3%) in comparison to the present study (6.8%).[9,15]

A longitudinal study conducted in Netherlands involving 318 undergraduate participants showed that after gaining extracurricular research experience participants publish more articles.[12] The facet of lack of guidance in pre/para clinical and clinical subjects which were not covered in other relevant articles. Regarding lack of facility for conducting research, 60% of the responders said positively in Kerala study which was comparatively higher than present study.[15] Study participants from USA and Kerala both showed lack of funding (64%) for conducting research.[15,16] The inquiry about received of training in research methodology was not included in other studies yet most of the studies found value and use of scientific methodology. 67% showed lack of knowledge in research methodology in a study done in Kerala which was higher in present study.[15]

Regarding lack of training in research methodology among teachers or guides, 39% participants gave positive response, compared higher than the present study.[15] Low level of participation research activities observed in Iran and Chennai studies which was similar to present study.[17,29] Study participants from Chennai showed 80.4% lack of guidance which was poorer in present study.[29]

The other significant factors influencing the lack of research activities, identified by the students, were monitory, academic and professional benefits which has not been explored in other studies. Thus, the present study reflects less involvement and indifferent attitudes of the undergraduate medical students of different academic years. They are also unsure about the scope of research activities in terms of availability of logistics and resources.

**Conclusion:**

It is the need of hour to integrate research methodology in undergraduate core curriculum. Students are to be encouraged and motivated to improve their research skills as government of India initiative like Indian Council of Medical Research – Short Term Studentship (ICMR-STS) and different university grants for the undergraduate medical researchers are sanctioned recently. Students should be motivated and encouraged by the teachers and guides. Training and exposure in research should be important part for the students. Conduction of monthly research workshop for undergraduate students as an initiative by the university is helpful.

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ORIGINAL ARTICLE

# Willems I and Willems II Methods for Dental Age Assessment in Children and Adolescents aged 3–16 years in the Varanasi Region: Applicability and Comparability

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**Abstract:**

In order to create new, simplified tables (Willems I method) for males and females in the Belgian Caucasian population, Willems G et al. (2001) reexamined Demirjian's technique. With these tables, dental age can be represented directly in years without the need for additional conversion tables. Using the prior data and a new study group, Willems G et al. (2010) created a common table for males and females to overcome cases of unknown gender and created a non-gender-specific method (Willems II method) that was not gender-specific. This study aims to evaluate the Willems I and Willems II methods for age estimation in a sample of the Varanasi region population. In this cross-sectional study, 432 samples (237 boys and 195 girls of age range 3–16 years) from the population of Varanasi region were evaluated to validate the Willems I and Willems II age estimation methods. A paired t-test was applied to determine the statistical significance between estimated dental age and chronological age. The Willems I method underestimated the dental age in boys by -0.27 ± 0.80 years and in girls by -0.60 ± 0.95 years. The Willems II method also underestimated the age by -0.57 ± 0.86 years in boys and -0.38 ± 0.93 years in girls. Pearson correlation revealed a strong positive association in both methods. The Willems I and Willems II methods are not exactly applicable, but the Willems I method is more relatable to the actual age of the boys sample and the Willems II method for the girls sample.

**Keywords:** Age estimation; Dental age; Tooth Development; Willems I method; Willems II method.

## Introduction:

Age estimation is one of the most common concerns in the personal identification of both living and deceased people. Estimating age is necessary to identify guilty, innocent, and victims in criminal cases, civil cases, advanced decomposed bodies, skeletal remains, mutilated bodies, and victims of a mass disaster. Age is the basis for assessing whether a child can go to school, the applicability of criminal laws, and whether a child has attained the age of criminal responsibility. Its significance rises in cases of rape, abduction, marriage, work, early birth, criminal abortion, falsified or nonexistent birth certificate, undocumented immigration, pediatric care, orthodontic care, and other age-restricted areas.[1,2]

A wide variety of age estimation approaches have been developed, including the use of skeletal age, morphological age, sexual age, and dental age. The dental age estimation method is the most accurate and reliable among these methods because teeth have the lowest turnover of all body tissues, and their growth is regulated by genes, making them less vulnerable to dietary and environmental influences.[3] Mineralization of teeth is a more accurate measure of dental maturity than eruption since it is unaffected by factors including primary tooth loss, lack of space, malnutrition, dental decay, ankylosis, and some orthodontic abnormalities.[4] Orthodontists and pedodontists also use dental age. It also aids in the detection of hormonal abnormalities in children, such as growth hormone hyposecretion. Additionally, it gives orthodontists hints regarding when to start orthodontic therapy. Researching tooth mineralization has potential applications in numerous scientific and therapeutic domains, including orthodontics, pediatric dentistry, forensic dentistry, pediatric endocrinology, orthopedics, and comparative anthropological research.[3,4] Several radiographic methods have also been developed for dental age estimation, but the method developed by Demirjian et al.[5] based on the evaluation of orthopantomograms of French-Canadian children is the most widely used dental technique for determining dental age.[6] This is most likely because of its relative simplicity and accuracy, as well as its thorough description and radiographic pictures of the stages of tooth growth. Willems G et al.[7] updated and simplified Demirjian's approach by analyzing the Caucasian child population of Belgium in their research. Willems' improvement was found to be slightly more precise than Demirjian's original scale.[6]

This cross-sectional study aims to test and compare the accuracy of the Willems I (gender-specific) method[7] and the Willems II (non-gender-specific) method[8] in the Varanasi region population of 3–16 year-old age groups. To the best of our knowledge, none of the studies have been conducted using the Willems methods alone or in combination with other methods in Varanasi region population.

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**Table 1. Showing the pearson`s correlation coefficient between estimated dental ages and chronological ages for the willems I and willems II methods.**

| Sample | Willems I | | Willems II | |
|---|---|---|---|---|
| | Correlation (r) | Significance | Correlation (r) | Significance |
| Total boys (n = 237) | 0.970 | 0.000 | 0.966 | 0.000 |
| Total girls (n = 195) | 0.952 | 0.000 | 0.955 | 0.000 |
| Total sample ( n = 432) | 0.962 | 0.000 | 0.962 | 0.000 |

Significant difference p<0.05

**Table 2. Paired t-test showing the mean differences between estimated dental ages using willems I and willem II methods and chronological ages for total boys, total girls and total sample.**

| Methods | Gender | Mean ± SD‖ | | | 95 % CI†† of (EDA – CA) ** | p-value |
|---|---|---|---|---|---|---|
| | | CA‡± SD | EDA§± SD‖ | (EDA – CA)**± SD | | |
| Willems I | Total boys (n=293) | 10.16 ± 3.28 | 9.89 ± 3.21 | -0.27 ± 0.80 | -0.38, -0.17 | 0.000* |
| | Total girls (n=195) | 11.37 ± 3.11 | 10.77 ± 2.91 | -0.60 ± 0.95 | -0.73, -0.47 | 0.000* |
| | Total Sample (n=432) | 10.71 ± 3.26 | 10.28 ± 3.11 | -0.42 ± 0.89 | -0.51, -0.34 | 0.000* |
| Willems II | Total boys (n=293) | 10.16 ± 3.28 | 9.59 ± 3.28 | -0.57 ± 0.86 | -0.68, -0.46 | 0.000* |
| | Total girls (n=195) | 11.37 ± 3.11 | 10.99 ± 2.92 | -0.38 ± 0.93 | -0.51, -0.25 | 0.000* |
| | Total Sample (n=432) | 10.71 ± 3.26 | 10.23 ± 3.20 | -0.48 ± 0.89 | -0.57, -0.40 | 0.000* |

CA‡ = chronological age; EDA§ = estimated dental age; SD‖ = standard deviation; (EDA – CA) ** = mean age difference; CI†† = confidence interval p* = statistically significant difference (p < 0.05)

## Materials and Methods:

This cross-sectional study evaluates digital panoramic radiographs of 432 people, 237 boys and 195 girls, ages 3-16 years, from the Varanasi region of Uttar Pradesh who visited the Banaras Hindu University, Varanasi, Faculty of Dental Sciences, Institute of Medical Sciences. All the subjects who were selected were of Indian origin with a known date of birth, a known date of radiograph, and clearly visible teeth in radiographs without any dental anomalies. None of the cases were taken primarily for study purposes. In this study, written informed consent was obtained from the participants or parents of the participants. The date of birth of participants was confirmed by the author himself after matching with any identity card issued by competent authority, i.e. Aadhaar card or school identity card.

In Willems I and II methods, the evaluation of dental age is based on the Demirjian's eight stages of tooth development and mineralization of seven left mandibular teeth, namely the second molar ($M_2$), first molar ($M_1$), second premolar ($PM_2$), first premolar ($PM_1$), canine (C), lateral incisor ($I_2$), and central incisor ($I_1$), from calcification of the cusp to closure of the root apex (A to H stages). The Willems-I method is a gender-specific method in which each tooth was allocated a score from a self-weighed score table developed in this method for males and females separately, based on Demirjian's stages of tooth calcification and development. The sum of the scores directly gives the dental age, or estimated age. The Willems II method is a non-gender-specific method in which scores were allocated to each tooth based on Demirjian's stages of tooth calcification from the Willems non-gender-specific table, which is the same for both males and females. The sum of the scores directly gives the dental age, or estimated age, in this method as well. Chronological age was calculated by subtracting the date of the radiograph from the date of birth of the subject. Age was calculated in days, which were further converted to decimal age up to two decimal places in Microsoft Excel software.

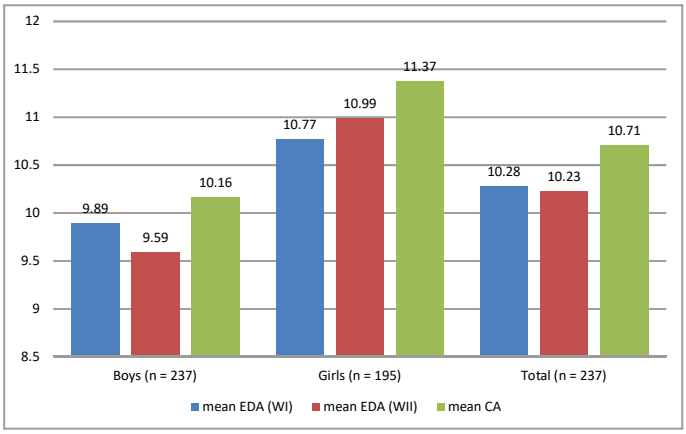
**Statistical Analysis:** The degree of inter and intra-observer agreement was assessed and calculated using Cohen`s Kappa statistics. The data were statistically analyzed using IBM SPSS version 24 software, according to the proposed study. A paired t-test was performed to determine the mean difference between estimated dental age and chronological age in the Willems I and Willems II methods. Pearson's correlation coefficient was calculated to establish the correlation at a 95% confidence interval. Statistical significance was set at $p < 0.05$.

**Ethical approval:** This study was approved by the ethical committee of the Institute of Medical Sciences, Banaras Hindu University (Ethical approval number: ECR/bhu/Inst/2013/Re-registration, 31.01.2017/Dean/2018/EC/585).

## Results:

The average chronological ages in this study were 10.16 (±3.28) for total boys, 11.37 (±3.11) for total girls, and 10.71 (±3.26) for total samples. The mean estimated dental ages for all boys, all

**Graph 1. Showing the mean estimated dental ages and mean chronological ages of the samples in years.**




**Graph 2. Showing the differences between mean estimated dental ages and mean chronological ages of the samples in years.**

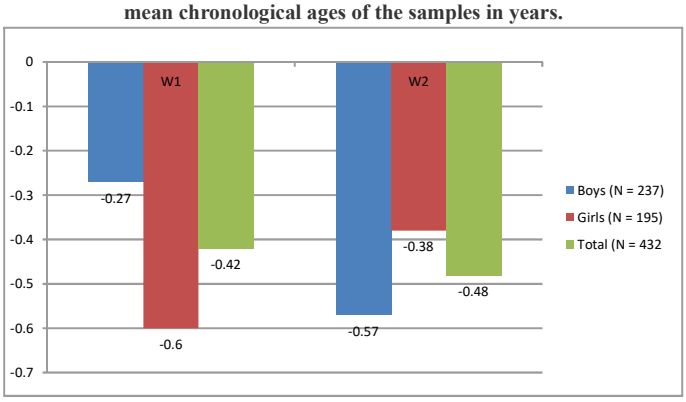


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**Table 3. Differences between estimated dental ages using Willems I method and chronological ages for specific age groups.**

| Age groups † | Samples | Mean ± SD‖ | | | 95 % CI†† of (EDA – CA) ** | p-value |
|---|---|---|---|---|---|---|
| | | CA‡± SD | EDA§± SD‖ | (EDA – CA)**± SD | | |
| Boys | | | | | | |
| 3 | 7 | 3.64 ± 0.25 | 3.69 ± 0.18 | 0.05 ± 0.42 | -0.34,0.43 | 0.767 |
| 4 | 10 | 4.57 ± 0.29 | 4.30 ± 0.44 | -0.27 ± 0.47 | -0.60, 0.07 | 0.102 |
| 5 | 14 | 5.52 ± 0.28 | 5.49 ± 1.05 | -0.02 ± 0.96 | -0.58, 0.53 | 0.926 |
| 6 | 20 | 6.38 ± 0.28 | 6.33 ± 0.36 | -0.06 ± 0.28 | -0.19, 0.08 | 0.398 |
| 7 | 13 | 7.54 ± 0.32 | 7.28 ± 0.55 | -0.26 ± 0.56 | -0.60, 0.08 | 0.117 |
| 8 | 19 | 8.48 ± 0.27 | 8.22 ± 0.79 | -0.26 ± 0.74 | -0.61, 0.10 | 0.149 |
| 9 | 25 | 9.51 ± 0.23 | 9.32 ± 0.79 | -0.20 ± 0.77 | -0.52, 0.12 | 0.212 |
| 10 | 28 | 10.50 ± 0.34 | 10.19 ± 0.83 | -0.30 ± 0.82 | -0.62, 0.02 | 0.061 |
| 11 | 22 | 11.53 ± 0.30 | 11.39 ± 1.03 | -0.15 ± 0.85 | -0.52, 0.23 | 0.433 |
| 12 | 22 | 12.45 ± 0.23 | 12.30 ± 0.71 | -0.15 ± 0.74 | -0.48, 0.18 | 0.356 |
| 13 | 28 | 13.43 ± 0.29 | 12.81 ± 1.04 | -0.62 ± 1.02 | -1.01, -0.23 | 0.003* |
| 14 | 11 | 14.43 ± 0.24 | 14.09 ± 0.74 | -0.34 ± 0.69 | -0.80, 0.13 | 0.135 |
| 15 | 18 | 15.48 ± 0.33 | 14.66 ± 0.96 | -0.82 ± 1.04 | -1.34, -0.30 | 0.004* |
| Girls | | | | | | |
| 3 | 4 | 3.50 ± 0.30 | 3.42 ± 0.51 | -0.08 ± 0.26 | -0.49, 0.33 | 0.565 |
| 4 | 2 | 4.53 ± 0.13 | 5.32 ± 1.25 | 0.79 ± 1.37 | -11.54, 13.12 | 0.565 |
| 5 | 9 | 5.53 ± 0.23 | 5.59 ± 0.60 | 0.06 ± 0.52 | -0.34, 0.46 | 0.733 |
| 6 | 7 | 6.54 ± 0.32 | 6.40 ± 1.17 | -0.14 ± 1.26 | -1.30, 1.02 | 0.774 |
| 7 | 9 | 7.56 ± 0.31 | 7.34 ± 0.49 | -0.22 ± 0.60 | -0.69, 0.24 | 0.297 |
| 8 | 14 | 8.50 ± 0.32 | 8.02 ± 0.69 | -0.48 ± 0.66 | -0.86, -0.10 | 0.017* |
| 9 | 15 | 9.51 ± 0.32 | 9.04 ± 0.43 | -0.47 ± 0.45 | -0.72, -0.22 | 0.001* |
| 10 | 21 | 10.65 ± 0.25 | 9.95 ± 0.99 | -0.70 ± 0.96 | -1.14, -0.27 | 0.003* |
| 11 | 19 | 11.48 ± 0.28 | 11.38 ± 0.83 | -0.11 ± 0.80 | -0.49, 0.28 | 0.565 |
| 12 | 24 | 12.55 ± 0.35 | 11.98 ± 1.31 | -0.58 ± 1.23 | -1.10, -0.06 | 0.032* |
| 13 | 26 | 13.56 ± 0.29 | 12.61 ± 0.93 | -0.95 ± 0.95 | -1.34, -0.57 | 0.000* |
| 14 | 22 | 14.46 ± 0.34 | 13.81 ± 0.81 | -0.66 ± 0.77 | -1.00, -0.31 | 0.001* |
| 15 | 23 | 15.41 ± 0.25 | 14.01 ± 0.80 | -1.41 ± 0.84 | -1.77, -1.04 | 0.000* |

†Age group 3 means: 3.00 – 3.99 years and so on
CA‡ = chronological age; EDA§ = estimated dental age; SD‖= standard deviation; (EDA – CA) ** = mean age difference; CI†† = confidence interval
p* = statistically significant difference ($p < 0.05$)

**Table 4. Differences between estimated dental ages using Willems II method and chronological ages for specific age groups.**

| Age groups † | Samples | Mean ± SD‖ | | | 95 % CI†† of (EDA – CA) ** | p-value |
|---|---|---|---|---|---|---|
| | | CA‡± SD | EDA§± SD‖ | (EDA – CA)**± SD‖ | | |
| Boys | | | | | | |
| 3 | 7 | 3.64 ± 0.25 | 2.64 ± 0.39 | -1.00 ± 0.36 | -1.33, -0.67 | 0.000* |
| 4 | 10 | 4.57 ± 0.29 | 3.57 ± 0.81 | -1.00 ± 0.90 | -1.64, -0.35 | 0.007* |
| 5 | 14 | 5.52 ± 0.28 | 5.43 ± 1.01 | -0.08 ± 0.91 | -0.61, 0.44 | 0.738 |
| 6 | 20 | 6.38 ± 0.28 | 6.21 ± 0.32 | -0.17 ± 0.30 | -0.31, -0.03 | 0.019* |
| 7 | 13 | 7.54 ± 0.32 | 7.03 ± 0.51 | -0.51 ± 0.55 | -0.84, 0.18 | 0.006* |
| 8 | 19 | 8.48 ± 0.27 | 7.92 ± 0.83 | -0.55 ± 0.78 | -0.93, -0.18 | 0.006* |
| 9 | 25 | 9.51 ± 0.23 | 9.01 ± 0.78 | -0.50 ± 0.77 | -0.82, -0.19 | 0.003* |
| 10 | 28 | 10.50 ± 0.34 | 9.87 ± 0.78 | -0.63 ± 0.78 | -0.93, -0.32 | 0.000* |
| 11 | 22 | 11.53 ± 0.30 | 11.07 ± 1.11 | -0.46 ± 0.94 | -0.88, -0.05 | 0.030* |
| 12 | 22 | 12.45 ± 0.24 | 12.03 ± 0.89 | -0.43 ± 0.92 | -0.83, -0.02 | 0.042* |
| 13 | 28 | 13.43 ± 0.29 | 12.59 ± 1.07 | -0.84 ± 1.06 | -1.25, -0.43 | 0.000* |
| 14 | 11 | 14.43 ± 0.24 | 13.87 ± 0.76 | -0.56 ± 0.71 | -1.04, -0.08 | 0.026* |
| 15 | 18 | 15.48 ± 0.33 | 14.41 ± 1.01 | -1.07 ± 1.11 | -1.62, -0.52 | 0.001* |
| Girls | | | | | | |
| 3 | 4 | 3.50 ± 0.30 | 3.06 ± 0.63 | -0.45 ± 0.35 | -1.01, 0.12 | 0.085 |
| 4 | 2 | 4.53 ± 0.13 | 5.56 ± 1.36 | 1.03 ± 1.49 | -12.31, 14.37 | 0.506 |
| 5 | 9 | 5.53 ± 0.23 | 5.63 ± 0.58 | 0.10 ± 0.49 | -0.27, 0.47 | 0.549 |
| 6 | 7 | 6.54 ± 0.32 | 6.52 ± 1.17 | -0.02 ± 1.25 | -1.17, 1.14 | 0.970 |
| 7 | 9 | 7.56 ± 0.31 | 7.65 ± 0.48 | 0.08 ± 0.60 | -0.38, 0.54 | 0.690 |
| 8 | 14 | 8.50 ± 0.32 | 8.33 ± 0.57 | -0.17 ± 0.55 | -0.48, 0.15 | 0.267 |
| 9 | 15 | 9.51 ± 0.32 | 9.38 ± 0.51 | -0.13 ± 0.51 | -0.42, 0.15 | 0.329 |
| 10 | 21 | 10.65 ± 0.25 | 10.27 ± 0.93 | -0.39 ± 0.89 | -0.80, 0.02 | 0.059 |
| 11 | 19 | 11.48 ± 0.28 | 11.66 ± 0.79 | 0.18 ± 0.75 | -0.19, 0.54 | 0.322 |
| 12 | 24 | 12.55 ± 0.35 | 12.24 ± 1.27 | -0.31 ± 1.19 | -0.82, 0.19 | 0.213 |
| 13 | 26 | 13.56 ± 0.29 | 12.82 ± 0.88 | -0.75 ± 0.91 | -1.11, -0.38 | 0.000* |
| 14 | 22 | 14.46 ± 0.34 | 13.97 ± 0.79 | -0.49 ± 0.75 | -0.82, -0.15 | 0.006* |
| 15 | 23 | 15.41 ± 0.25 | 14.18 ± 0.75 | -1.23 ± 0.79 | -1.58, -0.89 | 0.000* |

†Age group 3 means: 3.00 – 3.99 years and so on
CA‡ = chronological age; EDA§ = estimated dental age; SD‖ = standard deviation; (EDA – CA)** = mean age difference; CI†† = confidence interval
p* = statistically significant difference ($p < 0.05$)

girls, and all samples were 9.89 (±3.21), 10.77 (±2.91), and 10.28 (±3.11) years, respectively, when using the Willems-I approach. The mean difference between estimated dental age and chronological age for the total sample analyzed was -0.42 (±0.89) years; for total boys, it was -0.27 (±0.80) years; and for total girls, it was -0.60 (±0.95) years, respectively, with a statistically significant value ($p < 0.05$) in both genders and total sample (Table 2). For boys, the differences were statistically significant in age groups 13 and 15, while for girls, they were significant in age groups 8–10 and 12–15 ($p < 0.05$). There were no statistically significant differences found in the remaining age categories for both genders (Table 3). The mean estimated dental age, as determined by the Willems II method, was 9.59 (±3.28) years for total boys, 10.99 (±2.92) years for total girls, and 10.23 (±3.20) years for the combined samples. For total boys, total girls, and total samples, the mean differences between estimated dental age and chronological age were -0.57 (±0.86), -0.38 (±0.93), and -0.48 (±0.89) years, respectively, and significant differences were found ($p < 0.05$) for each of them (Table 2). With a p-value < 0.05, the statistically significant differences were found for females in particular age categories of 12–15 years and boys in all age groups with the exception of a particular age group of 5 year (Table 4). According to Table 1, Pearson's correlation coefficient showed a significant positive association between boys, girls, and the population as a whole in both methods.

## Discussion:

In this study, 432 samples, including 237 boys and 197 girls, were evaluated for dental age estimation using the Williams I and Willems II methods. Early dental development is indicated by a positive mean difference, whereas delayed dental development is indicated by a negative mean difference. In the Willems I method, negative mean age differences were observed in total boys, total girls, and total samples by -0.27 (±0.80), -0.60 (±0.95), and -0.42 (±0.89) years, respectively. In boys, all specific age groups (except 3) and in girls, all specific age groups (except 4 and 5) are delayed in dental development. In the Willems II method, delayed dental age was also observed by -0.57 (±0.86), -0.38 (±0.93), and -0.48 (±0.89) years in total boys, total girls, and total sample, respectively. In boys, all specific age groups, and in girls, all specific age groups (except 4, 5, 7, and 11) reported delayed dental development. The total samples of boys, girls, and combined form and majority of specific age groups in both approaches showed negative mean age differences when compared to chronological ages, indicating delayed dental development and the remaining age groups showing early dental

development. A recent study conducted in the Indian population by Hegde S et al.[9] reported overestimation of age in males by 0.09 years, in females by 0.08 years, and in the total sample by 0.09 years using the Willems I method, overestimation of age in males by 0.11 years, total sample by 0.01 years, and underestimation of age by -0.06 years in females using the Willems II method. No statistically significant difference was present for males, females, or the total sample. Urzel et al.[10] conducted a study on the French population and compared the Willems I and Willems II methods. In Willems, I, overestimation of age in the male by 0.14 years and underestimation by -0.09 years, and in Willems II method, no mean difference was reported in the total sample. Ortega-Pertuz AI.[11] on Venezuelan children reported overestimation of age in boys by 0.21 years and underestimation in girls by 0.03 years using the Willems I method, and overestimation of age in both boys and girls by 0.06 years and 0.18 years, respectively, using the Willems II method. All these studies have reported different results from our study.

When we consider only the Willems I method of our study which shows delayed dental development and the result was in agreement with studies conducted by Mohammad RB et al.[12] and Priya E.[13] in the Indian population, Ranasinghe S et al.[14] in the Sri Lankan population, Lee SS et al.[15] in Korean children, Zhai Y et al.[16] in Chinese children, and Kelmendi et al.[4] in Kosova children. This result was contradicted by Rai B et al.,[17] Gupta et al.,[18] Kumar Vinod et al.,[19] Shekhar Grover et al.[20] and Akbar A et al.[21] in the Indian population, and El Bakary AA et al.[22] in the Egyptian population. Djukic K et al.[6] in the Serbian population, Javadinejad S et al.[23] in the Iranian population, Mani SA et al.,[24] Nik-Hussein NN et al.[25] and Yousof MY et al.[26] in Malaysian children, Amberkova V et al.[27] in the Former Yugoslav Republic of Macedonia, Medina AC et al.[28] in Venezuelan children, Galie I et al.[29] in Bosnian and Herzegovian children, Franco A et al.[30] in Brazilian children, Maber M et al.[31] in British Caucasian and Bangladeshi children, and Cortés MM et.[32] in Spanish children have reported overestimation in dental age. Some studies show partial agreement, as conducted by Metasannity M et al.[33] in Somali children, the study reported overestimation of age in males, underestimation in females, and total population; Ramanan N et al.[34] in the Japanese population reported overestimation of age in males and underestimation of age in females; Cameriere R et al.[35] a combined study of Italian, Spanish, and Croatian children, reported overestimation of age in boys by 0.247 years and underestimation of age in girls by 0.073 years.

The differences observed while comparing our results with other studies from different areas may be due to sampling size, sampling method, and biological variation in children, ethnicity, geographical location, environmental factors, nutrition, socioeconomic status, and the time difference between the two studies.[12,36] The results of this study are somewhat relevant to the forensic context, even if the mean difference between estimated age and chronological age is within the range of ±0.5 or ±1.0 years, which is thought to be an acceptable range for forensic anthropology.[12]

**Conclusions:**

The differences in the mean estimated dental age and chronological age are statistically significant for the total boys, total girls, and total samples and showing delayed dental development in the Willems I and Willems II methods; therefore, none of them is accurate. However, findings in this study reveal that the Willems I method is more relatable to actual age for boys and the Willems II method for girls. Both methods are prone for underestimation of dental age; therefore, it is required to develop a population-specific methodology for dental age estimation in the Varanasi region.

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ORIGINAL ARTICLE

# Morphometric Analysis of Foramen Magnum and Occipital Condyles for Sexual Dimorphism: Exploring Reliability Through Computed Tomography Investigation

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**Abstract:**

Anatomical differences between males and females, has been of significant interest in various scientific fields. This study aims to investigate sexual dimorphism in North Indian population by analyzing the dimensions of the foramen magnum, a critical opening at the base of the skull and occipital condyles utilizing computed tomography (CT) imaging. Furthermore, variations in the shape of the foramen magnum are noted and classified into seven distinct types. CT scans of 299 individuals aged between 18 and 87 years underwent precise measurements of the foramen magnum dimensions. Eleven parameters were scrutinized, including foramen magnum length, width, the length and width of the right and left occipital condyles, minimum and maximum intercondylar distance, foramen magnum index, and foramen magnum area calculated using both the Teixeira and Radinsky formulas. Intraobserver and interobserver tests were conducted to assess measurement reliability. Statistical analyses were applied to investigate potential variations in these measurements based on sex. With the exception of the minimum intercondylar distance, all measurements were significantly greater in males. The most common shape of the foramen magnum was oval, while the least common was the pentagonal shape. However, it was found that the shape of the foramen magnum was not a reliable parameter for determining sex. Sexing accuracy, calculated through binary logistic regression and ROC curve analysis, indicated an accuracy of 68.2% for foramen magnum length (FML), 65.8% for foramen magnum width (FMW), and 75.2% and 74.9% accuracy for foramen magnum area when calculated using the Teixeira and Radinsky formulas, respectively, signifying their reliability in distinguishing gender. A multivariate analysis incorporating all eleven parameters demonstrated an overall accuracy of 73.6%. The foramen magnum and occipital condyles do not serve as strong determinants for sexual dimorphism. Nonetheless, this study suggests potential applications in forensic anthropology, paleontology, and medical fields where determining sex from fragmented skeletal remains is essential.

**Keywords:** Foramen magnum; Occipital condyle; CT imaging; Sexual dimorphism.

## Introduction:

The skull has proven to be the second best indicator of sex of an individual. Krogmann claims that sexing of adult skeletal remains can be done with 92% accuracy using skull alone. However often in mass disasters, ballistic injuries, high velocity road and rail traffic accidents it is difficult to extract an intact skull. The base of the skull in such instances is often well preserved from physical aggression due to its protected positioning and relative thickness. The foramen magnum is one such important feature of the base of the skull. It is a large opening in the posterior cranial fossa allowing the passage of the spinal cord and its membranes, the anterior and posterior spinal arteries, vertebral arteries, the tectorial membranes, alar ligaments and the accessory nerve. Thus, it forms an integral part of the craniovertebral junction. The position and location of the foramen magnum has been long researched by anthropologists to study evolution of bipedal species. Human evolutionists have also noted sexual dimorphism in the positioning of the foramen magnum with a more anteriorly positioned foramen magnum in females as compared to males. The size of the foramen magnum provides important information pertaining to species. Humans have a larger foramen magnum to support their erect postures as opposed to other primates. The size of the foramen magnum also varies with age, infants having a smaller size than adults. The foramen magnum area has also been proposed as indicative of relative brain size as studied in different species There are also clinicopathological causes which can be interpreted from the size of foramen magnum. A smaller sized foramen magnum is indicative of conditions like skeletal dysplasia (Achondroplasia ), sclerosis of skull, while a larger size can be associated with raised intracranial pressure as seen in Arnold-Chiari malformation. The shape of the foramen magnum can also hint towards craniovertebral anomalies like premature synostosis and hydrolethalus syndrome. Hence, it also assists the autopsy surgeon in arriving at a cause of death, be it of traumatic or pathological origin.[1,2]

The foramen magnum holds distinct merit for the forensic anthropologist in accomplishing the principal objective of

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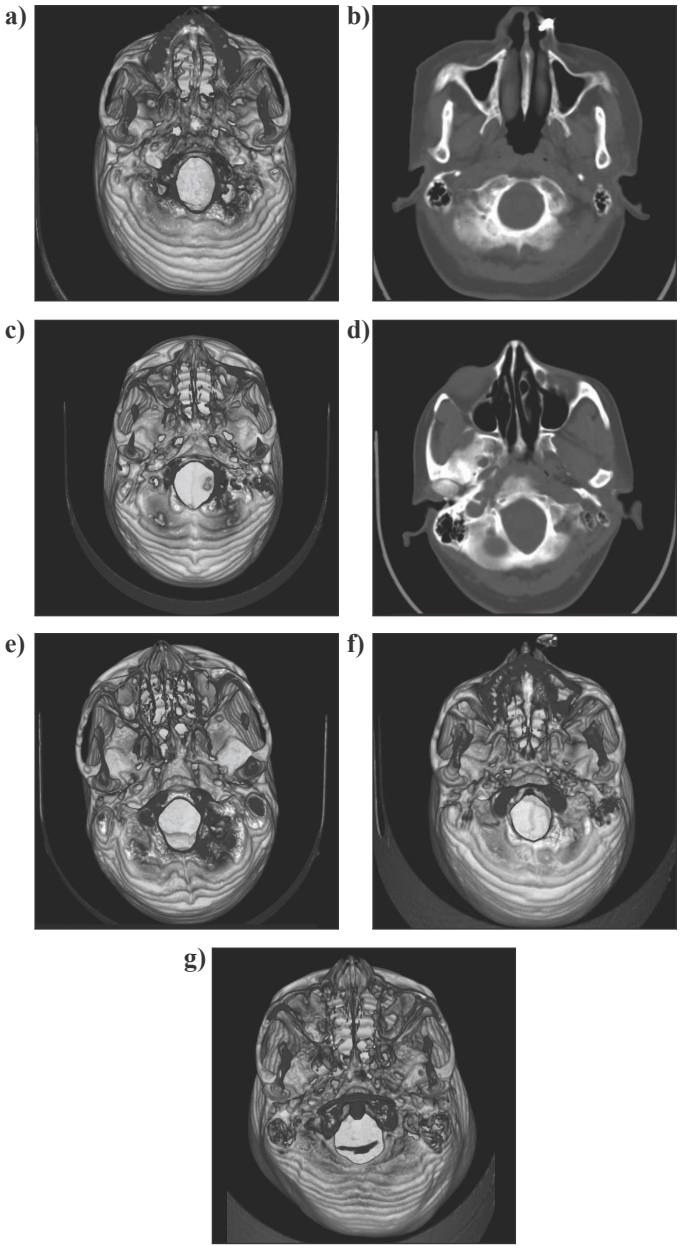



**Figure 1: CT Images of different shapes of foramen magnum a) oval, b) round, c) egg, d) tetragonal, e) pentagonal, f) hexagonal, g) irregular.**

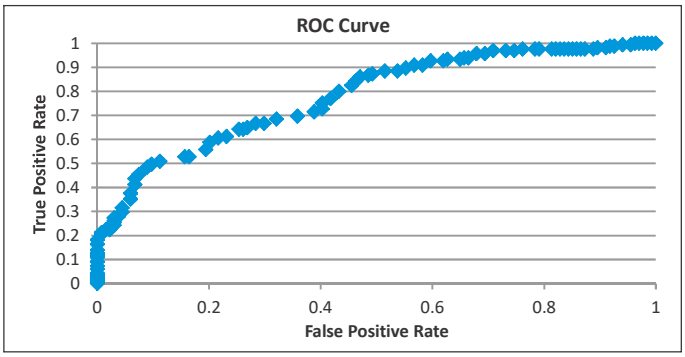
**Table 19. Cumulative table of male.**

| Values | FML | FMW | LR OC | WR OC | LL OC | WL OC | MnI CD | MxI CD | FMI |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 3.66 | 2.99 | 2.27 | 1.20 | 2.27 | 1.23 | 1.35 | 3.27 | 81.97 |
| SD | 0.23 | 0.20 | 0.30 | 0.20 | 0.25 | 0.19 | 0.41 | 0.33 | 6.93 |
| Range | 1.30 | 1.16 | 1.26 | 1.15 | 1.16 | 1.06 | 2.99 | 2.16 | 40.69 |
| Minimum | 3.00 | 2.57 | 1.70 | 0.76 | 1.74 | 0.70 | 0.41 | 2.36 | 60.23 |
| Maximum | 4.30 | 3.73 | 2.96 | 1.91 | 2.90 | 1.76 | 3.40 | 4.52 | 100.92 |
| p50 | 3.68 | 2.99 | 2.25 | 1.18 | 2.22 | 1.22 | 1.40 | 3.25 | 81.36 |

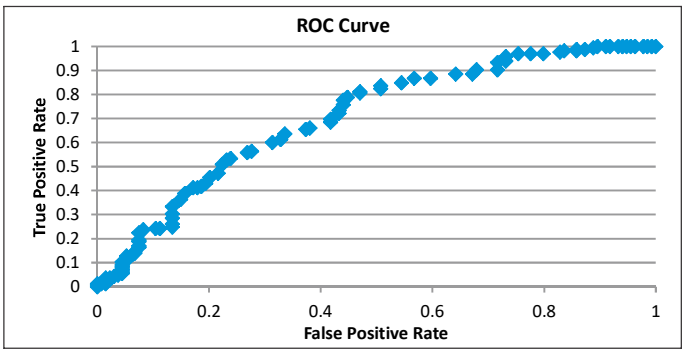
identification especially in fragmented, advanced decomposition and commingled cases. The measurements can be recorded either by the conventional method of metric measurements using spreading callipers on dry bones or radiographically which has been favoured in recent times. With focus shifting from traditional autopsy techniques to virtopsy, post mortem skeletal imaging can be used for comparative data analysis with the antemortem film images of the same individual. CT imaging other than its primary application in cranial, oral and maxillofacial surgeries and studies can be used concurrently for the purpose of identification, bite-mark analysis, anthropology and expanding the database on sexual dimorphism.

The following will be the objectives of the study:

1. To measure the different metric and descriptive parameters to ascertain whether there is any anthropologically significant sexual dimorphism.
2. If there is , the exact metric range of the parameter in male and




**Graph 1. FML - ROC Curve with AUC of 0.8135.**




**Graph 2. FMW- ROC Curve with AUC of 0.7118.**

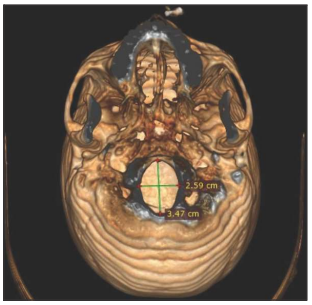


**Figure 2A. CT Scan image showing measurements of foramen magnum length (FML) and breadth (FMW).**

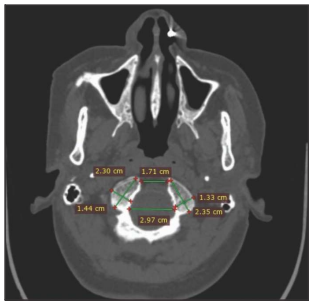


**Figure 2B. CT Scan image showing measurements of length and breadth of right and left occipital condyles (LROC, WROC, LLOC,WLOC), minimum intercondylar distance (MnICD), maximum intercondylar distance (MxICD).**

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female skulls.

3. To study the shape of the foramen magnum and ascertain if there are variations to the classical "circle"/ "oval" shape which determines the formula for calculation of area of foramen magnum.
4. To compare and study the difference in mean areas achieved from the two formulas (Radinsky & Teixeira) popularly used to calculate the foramen magnum area.
5. To determine whether different measurements computed from occipital condyles provide supplemental data for gender determination.

## Materials and methods:

The study design is a retrospective observational study on cranial CT scan images obtained from the department of Radio - Diagnosis Imaging, BHU, Varanasi. In accordance with the National Ethical Guidelines For Biomedical And Health Research Involving Human Participants by ICMR 2017, the scans were anonymized by the principal investigator, retaining only age and sex while recording data. Research ethics approval was obtained from the Institute Ethical Committee. Cranial CT Scans of male and female from North Indian population belonging to the age group 18 -87 years were included.

High quality scans displaying the entire extent of foramen magnum and occipital condyles were only included whilst excluding scans which were of poor quality, displaying artefacts, with history of trauma, surgery or displaying pathology affecting the skull base. Thus, after screening, out of a total of 468 Scans, 299 scans from North Indian population were studied for six months which comprised of 165 males and 134 females belonging to the age group of 18-87 years. The scans were obtained using GE Light speed VCT 128 slice CT scanner and axial scanogram settings of 300 mA, 120 kV, slice thickness of 5mm, with reconstructed images of same slice thickness. All measurements were done using an inbuilt electronic calliper in the RadiAnt DICOM (Digital Image Communication in Medicine viewer) 2022. 1 (64bit) software. The reconstructed images were analysed by two independent observers (by department of Forensic Medicine and department of Radio - Diagnosis Imaging, BHU) to exclude observer bias. All images were viewed on HP Laptop Intel Core i5(11TH generation) Screen 15.5" LED full HD, UHD Graphic (Hewlett Packard Company, 71004 Boeblingen, Germany) done in axial cross

**Table 1. Basic metric measurements.**

| Variable | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| FML | 3.55 | 0.27 | 2.68 | 4.3 |
| FMW | 2.92 | 0.23 | 2.35 | 3.7 |
| LROC | 2.22 | 0.27 | 1.62 | 2.9 |
| WROC | 1.17 | 0.2 | 0.66 | 1.9 |
| LLOC | 2.22 | 0.25 | 1.47 | 2.9 |
| WLOC | 1.2 | 0.2 | 0.70 | 1.7 |
| MnICD | 1.33 | 0.39 | 0.41 | 3.4 |
| MxICD | 3.22 | 0.34 | 2.36 | 4.5 |

**Table 2. Foramen magnum index and area calculation using radinsky and teixeira formula.**

| Variable | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| FMI | 82.72 | 7.35 | 60.23 | 104.92 |
| AREA(R) | 8.15 | 1.04 | 5.36 | 11.77 |
| AREA(T) | 8.24 | 1.05 | 5.37 | 11.79 |

**Table 3: Different shapes and its frequency.**

| Shape | Frequency | Percent |
|---|---|---|
| Round | 7 | 2.34% |
| Egg | 18 | 6.02% |
| Hexagonal | 26 | 8.69% |
| Irregular | 40 | 13.3% |
| Oval | 136 | 45.48% |
| Pentagonal | 4 | 1.33% |
| Tetragonal | 68 | 22.7% |
| Total Observations | 299 | 100% |

**Table 4. Two sample t-test with equal variance on sex of the individual.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 48.6 | 1.59 | 18.4 | 45.4-51.7 |
| Male | 165 | 44.5 | 1.60 | 20.6 | 41.3-47.7 |
| Total (n=299) | 299 | 46.3 | 1.14 | 19.7 | 44.1-48.6 |

**Table 5. Two sample t-test with equal variance on foramen magnum length (FML) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 3.40 | 0.02 | 0.25 | 3.35-3.44 |
| Male | 165 | 3.66 | 0.01 | 0.23 | 3.62-3.70 |
| Total (n=299) | 299 | 3.54 | 0.01 | 0.27 | 3.51-3.57 |

**Table 6. Two sample t-test with equal variance on foramen magnum width (FMW) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 2.83 | 0.01 | 0.22 | 2.79-2.87 |
| Male | 165 | 2.99 | 0.01 | 0.20 | 2.96-3.02 |
| Total (n=299) | 299 | 2.93 | 0.01 | 0.22 | 2.89-2.94 |

**Table 7. Two sample t-test with equal variance on length of right occipital condyle (LROC) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 2.16 | 0.01 | 0.23 | 2.12-2.20 |
| Male | 165 | 2.27 | 0.02 | 0.30 | 2.23-2.32 |
| Total (n=299) | 299 | 2.22 | 0.01 | 0.27 | 2.19-2.25 |

**Table 8. Two sample t-test with equal variance on width of right occipital condyle (WROC)of both sexes.**

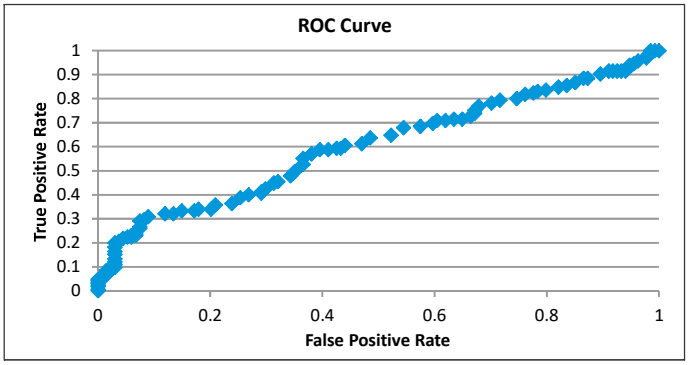
| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 1.13 | 0.01 | 0.19 | 1.10-1.17 |
| Male | 165 | 1.20 | 0.01 | 0.20 | 1.17-1.23 |
| Total (n=299) | 299 | 1.17 | 0.01 | 0.20 | 1.15-1.20 |

**Table 9. Two sample t-test with equal variance length on left occipital condyle (LLOC)of both sexes.**

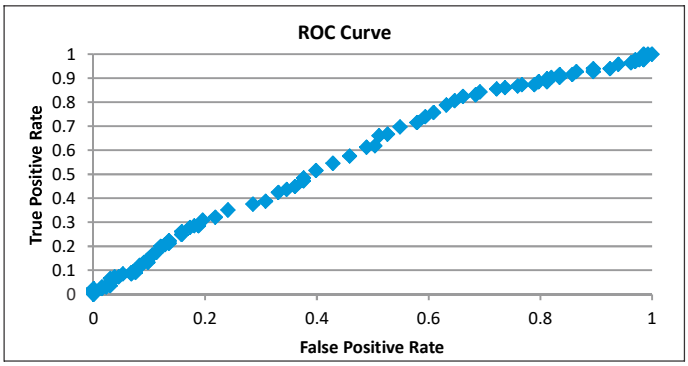
| Group | Observation | Mean | Standard error | Standard deviation |
|---|---|---|---|---|
| Female | 134 | 2.16 | 0.01 | 0.25 |
| Male | 165 | 2.27 | 0.01 | 0.25 |
| Total (n=299) | 299 | 2.22 | 0.01 | 0.25 |

**Table 10. Two sample t-test with equal variance on width of left occipital condyle (WLOC)of both sexes.**

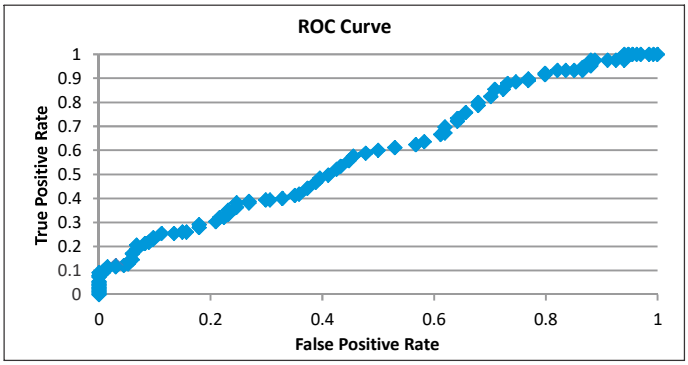
| Group | Observation | Mean | Standard error | Standard deviation |
|---|---|---|---|---|
| Female | 134 | 1.17 | 0.01 | 0.20 |
| Male | 165 | 1.23 | 0.01 | 0.20 |
| Total (n=299) | 299 | 1.20 | 0.01 | 0.20 |




Graph 3. LROC-- ROC Curve with AUC of 0.6103.



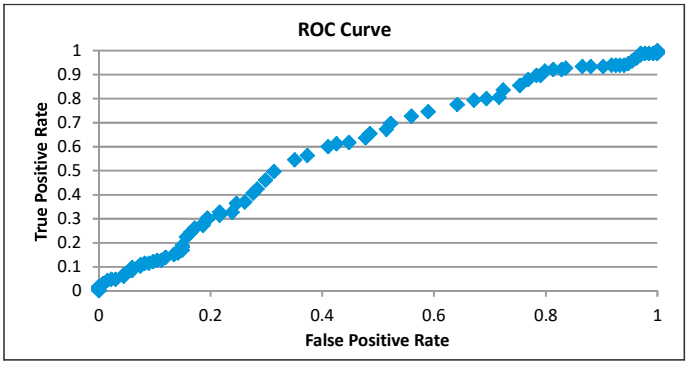

Graph 4. WROC-- ROC Curve with AUC of 0.5986.



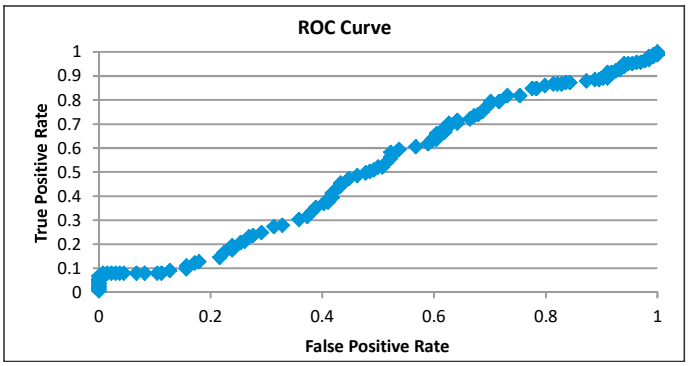

Graph 5. LLOC-- ROC Curve with AUC of 0.5989.

section view. Bone window was used to accentuate the bone details, with automatically set window level at 300 and window width at 1500. Both 2-D and 3-D images of the same case were analysed for optimal viewing. The following measurements were taken (metric and descriptive) according to Alijarrah K et al.,[3] Abtehag A Taib et al.,[4] Chovalopoulou and Bertsatos[5] : Foramen magnum length (FML): maximum antero- posterior distance, in median plane from basion to opisthion-

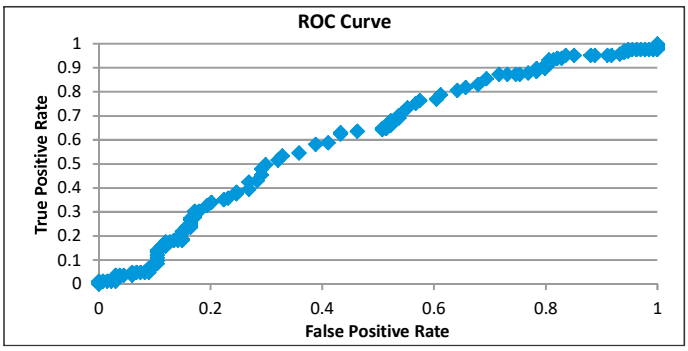
1. Foramen magnum width (FMW): Maximum width perpendicular to the FML, which is the greatest transverse distance between the lateral borders of the foramen magnum.
2. Length of the right occipital condyle (LROC): The maximum length of the articular surface, measured along its long axis.
3. Width of the right occipital condyle (WROC): The maximum width of the articular surface, measured perpendicular to the long axis.



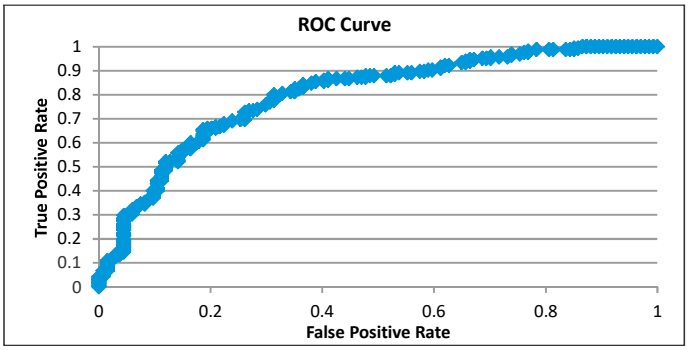

Graph 6. WLOC- ROC Curve with AUC of 0.6123.




Graph 7. MinICD- ROC Curve with AUC of 0.5133.




Graph 8. MxICD- ROC Curve with AUC of 0.6184.




Graph 9. FMA by Radinsky formula- ROC Curve with AUC of 0.7981.

4. Length of the left occipital condyle (LLOC): The maximum length of the articular surface, measured along its long axis.
5. Width of the left occipital condyle (WLOC): The maximum width of the articular surface, measured perpendicular to the long axis.

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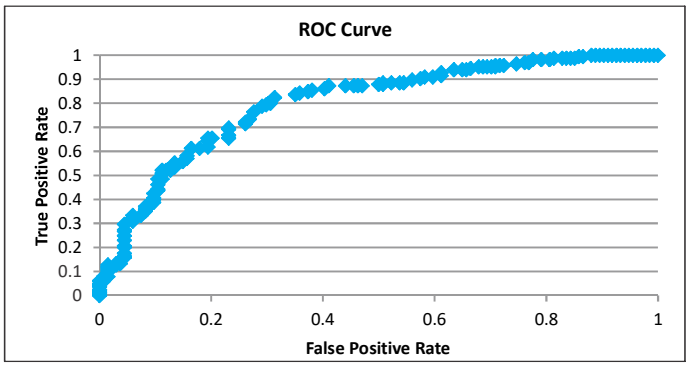
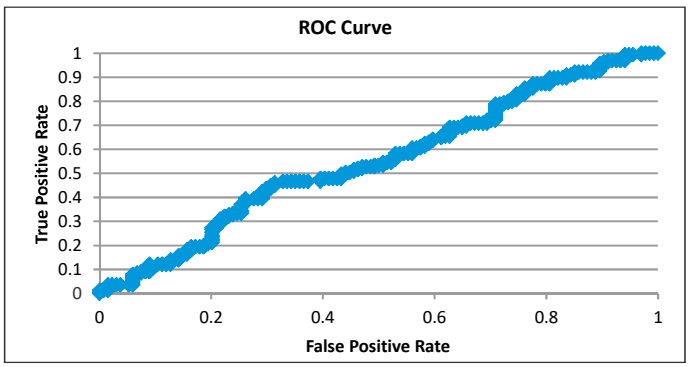



**Graph 10. FMA by Tiexera formula- ROC Curve with AUC of 0.8044.**




**Graph 11. FMI- ROC Curve with AUC of 0.5531.**

6. Maximum intercondylar distance (MxICD): The maximum distance between the medial margins of the condyles.
7. Minimum intercondylar distance (MnICD): The minimum distance between the medial margins of the condyles.
8. Foramen magnum index (FMI) = Foramen magnum width (FMW)/Foramen magnum length (FML) X 100.
9. The area of the FM was calculated by using 2 different formulas as described by Radinsky (1967) (1/4x π x FML x FMW) and Teixeira (1983) (considering the area of foramen magnum of that of a circle with radius as medium value of half measures of length and width) Area =πx [(length + width)/4]2 "π" = 3.14 in both formulas. The Foramen magnum area obtained from each of these 2 methods was compared to study whether there were any significant differences in between their results.
10. Classification of foramen magnum based on shape as noted grossly was categorised into 7 types, Abtehag A Taib et al.;[4] Oval, Egg, Round, Tetragonal, Pentagonal, Hexagonal type, Irregular type (Figure 1, 2A,2B).

## Results:

At the start of the study, we initially had a total sample size of 468 individuals. However, after applying our exclusion criteria, we narrowed it down to 299 scans for analysis, consisting of 165 males and 134 females. These participants' ages spanned from 18 to 87 years. The various variables that were considered for this particular study are foramen magnum length, width, index and area using Radinsky and Teixeira formula that are the oldest and most reliable formulas to derive the same. In addition, the maximum length and width of both the occipital condyles have been measured along with the minimum intercondylar distance, and maximum intercondylar distance. The variations in shapes of foramen magnum were also appreciated and subjectively inferred. The differentiation between oval and round shapes were done using foramen magnum index where a FMI of less than 1.2

**Table 11. Two sample t-test with equal variance on minimum intercondylar distance (MnICD) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 1.31 | 0.03 | 0.35 | 1.25-1.37 |
| Male | 165 | 1.35 | 0.03 | 0.41 | 1.29-1.42 |
| Total (n=299) | 299 | 1.33 | 0.02 | 0.40 | 1.29-1.38 |

**Table 12. Two sample t-test with equal variance on maximum intercondylar distance (MxICD) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 3.16 | 0.03 | 0.36 | 3.10-3.23 |
| Male | 165 | 3.27 | 0.02 | 0.33 | 3.22-3.32 |
| Total (n=299) | 299 | 3.22 | 0.02 | 0.35 | 3.20-3.30 |

**Table 13. Two sample t-test with equal variance of foramen magnum area using Radinsky formula -FMA (r) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 7.58 | 0.08 | 0.94 | 7.42-7.74 |
| Male | 165 | 8.62 | 0.06 | 0.88 | 8.49-8.76 |
| Total (n=299) | 299 | 8.16 | 0.06 | 1.04 | 8.04-8.28 |

**Table 14. Two sample t-test with equal variance of foramen magnum area using teixeira formula -FMA (t) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation | 95% CI |
|---|---|---|---|---|---|
| Female | 134 | 7.66 | 0.08 | 0.94 | 7.50-7.82 |
| Male | 165 | 8.72 | 0.07 | 0.88 | 8.59-8.86 |
| Total (n=299) | 299 | 8.25 | 0.06 | 1.05 | 8.13-8.37 |

**Table 15. Two sample t-test with equal variance of foramen magnum index (FMI) of both sexes.**

| Group | Observation | Mean | Standard error | Standard deviation |
|---|---|---|---|---|
| Female | 134 | 83.64 | 0.01 | 7.75 |
| Male | 165 | 81.97 | 0.01 | 6.93 |
| Total (n=299) | 299 | 82.72 | 0.01 | 7.34 |

**Table 16. Chi square test of foramen magnum index (FMI) in the study sample.**

| FMI Category | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| Narrow | 157 | 52.51 | 52.51 |
| Medium | 57 | 19.06 | 71.57 |
| Large | 85 | 28.43 | 100.00 |
| Total (n=299) | 299 | 100 | |

**Table 17. Chi square test of foramen magnum index (FMI) in the both the sexes.**

| FMI Category | Sex | | Total |
|---|---|---|---|
| | Female | Male | |
| Narrow | 68<br>43.31 | 89<br>56.69 | 157<br>100.00 |
| Medium | 27<br>47.37 | 30<br>52.63 | 57<br>100.00 |
| Large | 39<br>45.88 | 46<br>54.13 | 85<br>100.00 |
| Total (n=299) | 134<br>44.82 | 165<br>55.18 | 299<br>100.00 |

was considered as round and more than 1.2 as oval (Mas N, Sibel et al.).[6] There was no significant statistical differences for the interexaminer reliability test for all the parameters studied indicating significant agreement and consistency between the two observers. The data were expressed in terms of mean and standard deviation. Inferential statistics was performed using t-test on the collected data for comparing different parameters between male and female groups. $p<0.05$ was considered significant. To study the correlation between data points, Pearson's two tailed Correlation was done. Statistical analysis of the collected data was done using SPSS 22.0 version.

The foramen magnum length ranged from 2.68mm to 4.3mm, the foramen magnum width 2.35mm to 3.73mm. The right occipital condyle length varied between 1.62mm to 2.96mm and the right occipital condyle width between 0.66mm to 1.91mm. The left occipital condyle length measured between 1.47mm to 2.9mm and the left occipital condyle width measured between 0.70mm to 1.76mm. Minimum intercondylar distance was 0.41mm to 3.4mm whilst maximum intercondylar distance was 2.36mm to 4.52 mm (Table 1).

The foramen magnum index had a mean of 82.72 ±7.35 with a minimum of 60.23 and maximum value of 104.92. Area of the foramen magnum calculated using Radinsky formula yielded a mean of 8.15mm.[2]

**Discussion:**

In a a study conducted by Aljarrah et al.[3] on 472 CT scans (236 males and 236 females; age range, 18-72 years), the results were similar to our study. In their study, shapes were classified into 8 types: oval, egg, round, hexagonal, pentagonal, tetragonal, irregular (A) and irregular (B).They revealed a sexing accuracy of FML (62.5%), FMW (62.5%) and FM area (66.1%), and concluded that they could be reliable individual variables in sex determination. This is similar to our study which showed an accuracy of 68.2% for FML, 65.8% for FMW and 75.2% and 74.9% accuracy for FM area calculated by Tiexera and Radinsky formula respectively. These results indicate that these variables are dependable when it comes to distinguishing gender when analyzing the foramen magnum.

Tambawala et al.[8] conducted a study using 266 CBCT scans and employed four parameters (FML, FMW, FMA) by two methods for sex determination, resulting in an overall accuracy rate of 66.4%. In contrast, our study utilized eleven parameters and achieved an overall accuracy of 73.6%.

Aghakhani et al.[9] examined foramen magnum parameters like sagittal diameter, transverse diameter, and area, concluding that these parameters had high sensitivity and specificity in determining sex, with a maximum accuracy of 96%. This finding aligns with a study conducted by Gargi et al.[10] in Uttar Pradesh, where measurements of the FM sagittal diameter, FM transverse diameter, FM circumference, and FM index (FMI) led to an overall accuracy of 90.9%. However, the small sample size in both of these studies raises questions about the validity of the results. After a comprehensive literature review, the highest accuracy on a considerably larger sample size of 720 was reported in a study conducted by Kartal et al.[11] in Turkey. They achieved an overall accuracy of 86.7% using four parameters: foramen magnum length, width, foramen magnum index, and foramen magnum area.

**Table 18. Cumulative table of female.**

| Values | FML | FMW | LR OC | WR OC | LL OC | WL OC | MnI CD | MxI CD | FMI |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 3.40 | 2.83 | 2.16 | 1.13 | 2.16 | 1.17 | 1.31 | 3.16 | 83.64 |
| SD | 0.25 | 0.22 | 0.23 | 0.19 | 0.25 | 0.19 | 0.35 | 0.35 | 7.75 |
| Range | 1.2 | 1.13 | 1.15 | 0.96 | 1.18 | 0.93 | 1.38 | 1.68 | 36.67 |
| Minimum | 2.68 | 2.35 | 1.62 | 0.66 | 1.47 | 0.74 | 0.49 | 2.57 | 68.25 |
| Maximum | 3.88 | 3.48 | 2.77 | 1.62 | 2.65 | 1.68 | 1.87 | 4.25 | 104.92 |
| p50 | 3.41 | 2.80 | 2.15 | 1.14 | 2.16 | 1.15 | 1.37 | 3.16 | 81.93 |

In studies using CT images of the foramen magnum, Aljarrah et al.[3] predicted an overall accuracy of 66.1%. Singh PK et al.[12] conducted a study on the Nepalese population and found that measurements of the foramen magnum and its calculated areas demonstrated high predictability for both sexes, with a maximum predictability of 75%. Meral et al.[13] examined the relevance of the foramen magnum in sex determination among the Turkish population using CT images and found that the discriminant parameters were reliable with an accuracy of 75%.

Jaitley et al.[14] analyzed 280 CBCT scans and observed a sexing accuracy of 72.1% by measuring the sagittal diameter, transverse diameter, area, and circumference of the foramen magnum. This result closely mirrored our study, which achieved an overall sexing accuracy of 73.6%.

Similar results in terms of overall accuracy were reported by other researchers, such as Tambawala et al. (66.4%),[8] H.M.A El Atta et al. (64.7%),[15] Hosseni et al. (70.9%),[16] Lashin et al. (69%),[17] Madadin et al. (65%),[18] Mehta et al. (69.1%),[19] Patricia et al. (66%),[20] and Vinutha et al. (65%).[21] Consequently, the overall range for accuracy across diverse populations predominantly falls between 65% and 75%.

The best parameter as per Tambawala et al.[8] for sex determination was the Area of the FM. Jaitley et al.[14] also. found area of the FM as most dimorphic with 72% sexing accuracy. Our study is in agreement with both these studies and found FMA to be the most accurate parameter.

Mehta M et al.[19] studied applicability of foramen magnum for sex determination in Western Indian population on a sample size of 553 adults and found foramen magnum length to be the best variable for gender differentiation (69.1%). In concurrence Tellioglu et al.[22] studied 100 CT scans in Turkey and concluded foramen magnum length to be the best predictor.

Madadin et al.[18] performed radiological measurements of the foramen magnum region on 200 adults of Saudi Arabia comprising of 100 males and 100 females. They observed five parameters - length of the right occipital condyle (LROC), length of the left occipital condyle (LLOC), width of the foramen magnum (WFM), area of the foramen magnum (AFM) and length of the foramen magnum (LFM). They found length of right occipital condyle to be the best individual parameter with an accuracy of 65.5% for discriminating sex. This was followed by length of the left occipital condyle which showed an accuracy of 65% in determining sex. This was in agreement with a study by

Chovalopoulou et al.[5] on Greek population who found occipital condyles to be superior determinants of sex than foramen magnum.

Our research revealed that the oval shape of the foramen magnum is the most frequently observed shape. This finding aligns with similar studies conducted on the Indian population by Vinutha et al.,[21] Rajkumar et al.,[23] Sampada PK et al.,[24] Mishra AK et al.,[25] and Singh D et al.,[26] all of which also identified oval as the predominant shape. Additionally, Alvia Batoo et al.[27] in Lahore and Aghakhani et al.[9] in Iran reported oval as the most common shape. However, in studies conducted on the Saudi Arabian population, Aljarrah et al.[3] found hexagonal to be the most prevalent shape, while Taibi et al.[4] observed hexagonal as the most common shape in the Libyan population. On the other hand, round shape was reported as the most frequent shape in studies by Rohinidevi M et al.[28] and Sharma S et al.[29] in the Indian population and by Mursheed KA et al.[30] in the Turkish population. In South African population, Moodley[31] identified egg shape as the most widespread shape. Though shape of the foramen magnum has been extensively studied in different parts of the world, however they show no utility in sex determination.

Variations in research outcomes exist across various populations, highlighting the need for more comprehensive studies that are specific to each population group. This underscores the importance of conducting in-depth investigations into the morphometry of the basicranium within distinct populations. The low degree of variation in sexual differences of foramen magnum was explained by Gapert et al.[32] They suggested that since foramen magnum attained the adult size in dimensions early on in life hence is immune to secondary sexual changes. From a biomechanical perspective, the foramen magnum is not influenced by muscles. Its primary function is to allow the passage of structures , particularly the medulla oblongata, which matures at a young age and doesn't require size increase. As the head's weight is supported through the atlanto-occipital joint, there is little influence on weight transfer in the foramen magnum region.

**Conclusion:**

One could make the case that because sexually distinctive characteristics are not very pronounced in the foramen magnum region, it might not be advisable to rely on methods involving this anatomical feature when dealing with intact skulls. However, if confronted with an incomplete human skull or a fragment of the cranial base, the statistically significant accuracy demonstrated in this study provides an accessory tool for determining whether the skull belonged to a male or female. This is especially true when employing the formulas tailored to the relevant population data.

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ORIGINAL ARTICLE

# Stature Estimation from Humerus bone in Gorkha Population

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**Abstract:**

Stature estimation is a key aspect of personal identification, especially in absence of other identification markers. One of the most widely used method for stature estimation is to use the measurements of long bones. Extensive studies have proved that humerus, femur, radius, ulna, tibia, and fibula produce substantial accuracy in predicting the stature. However, the regression equation can vary with the population used in prediction. In the present study, the correlation between the humerus length and stature has been explored for the 89 individuals (80 males and 09 females) of Gorkha population of Jharkhand armed forces. For this, the measurements of left and right humerus of males and females were used. Additionally, two methods were used for the measurements and these measurements were compared to see which yielded better results. Significant p-values were obtained for all the measurements suggesting that the results obtained in the present study were significant and can be used in real cases.

**Keywords:** Stature estimation; Anthropology; Forensic science; Humerus; Personal identification.

## Introduction:

The study of forensic anthropology, a subdivision of physical anthropology, involves analyzing human skeletal remains to assist in legal cases.[1] The estimation of stature is a key focus in forensic anthropology, involving the determination of an individual's height through skeletal remains. Anthropological techniques are used in forensic anthropology to reveal information about human remains, playing a crucial role in the legal system.[2] In cases involving decomposed, mutilated, or fragmented remains, this field becomes relevant because of the limitations of traditional methods. The expertise of forensic anthropologists is used in analyzing skeletal structures to determine a person's identity, age, sex, and stature.[3]

A comprehensive understanding of human skeletal anatomy and its relationship with height is crucial in forensic anthropology, making the estimation of stature one of the primary challenges in this field.[4] The process of estimating stature involves the utilization of mathematical formulas and statistical methods that are derived from analyzing particular skeletal elements. An individual's height is influenced by the long bones, such as the femur, tibia, and humerus, which are vital components in this process because of their significant association.[5] Regression equations that have been developed by researchers can now accurately correlate the length of different bones with stature. These equations take into consideration important factors like sex and population differences.[6] These equations play a crucial role in forensic anthropology as they provide a valuable tool for accurately estimating stature, which contributes to the establishment of a comprehensive biological profile for an individual.[7]

Stature estimation considers various factors, including sexual dimorphism, which highlight the physical distinctions between males and females. When developing stature estimation methods, forensic anthropologists take into consideration these differences and acknowledge that the correlation between bone length and stature may differ between males and females. The accuracy of stature estimates is enhanced by researchers when they incorporate sex-specific equations, which in turn further refines the identification process.

In forensic investigations, the estimation of stature can assist in victim identification, especially where only skeletal remains are available.[8] By comparing the estimated stature with demographic data and missing person's records, forensic anthropologists can narrow down potential matches and aid law enforcement agencies in solving cases.[9] Stature estimation is valuable in mass disaster scenarios, where the identification of multiple individuals is required in a timely manner. The information obtained from stature estimation can be essential in courtrooms, providing scientific evidence that supports legal proceedings.[10] Forensic anthropologists may be called upon as expert witnesses to present their findings and explain the methodologies used in stature estimation. The reliability and objectivity of these scientific methods contribute to the credibility of forensic anthropology in the legal system.[11-12]

The relation between stature and upper arm length (UAL) or percutaneous humerus length can be explored by researchers, who can then create formulas to elucidate this association within

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**Figure 1. Data collection using first method.**

**Figure 2. Data collection using the second method.**

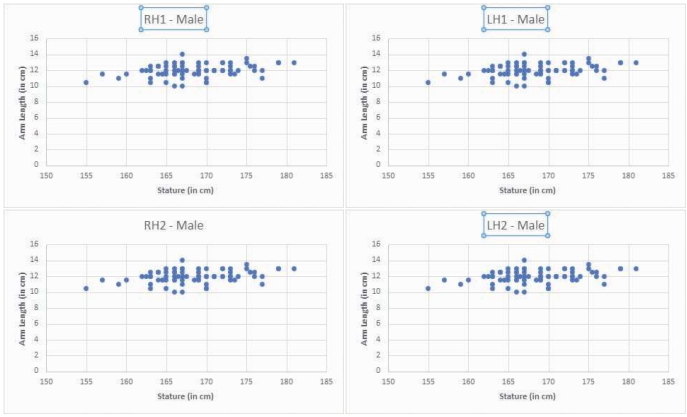


**Figure 3. Scatter plot for male for Gorkha population.**

diverse age cohorts.[13-16] The formulae derived from the results exhibited varying levels of reliability and prediction power.[17-19] There is a direct correlation between the stature of an individual and the different body parts, highlighting the strong biological and genetic relationship they share. 'Anatomical' and 'mathematical' techniques are commonly employed in forensic cases for the purpose of estimating stature, or body height.[20] In Northern India, specifically in the Ranchi region, the present study was conducted on the Gorkha population. To the best of author's knowledge no previous study on stature estimation of this population are available.

## Materials and methods:

In order to conduct the study, measurements were obtained from the Gorkha population in Jharkhand Armed Police-1, after receiving approval from the Director General of Police, Jharkhand. Prior to commencing the study, the researchers took the time to explain both the objectives and methods to the sample population, ensuring that they were well-informed about the study's purpose and procedures. It is worth mentioning that prior

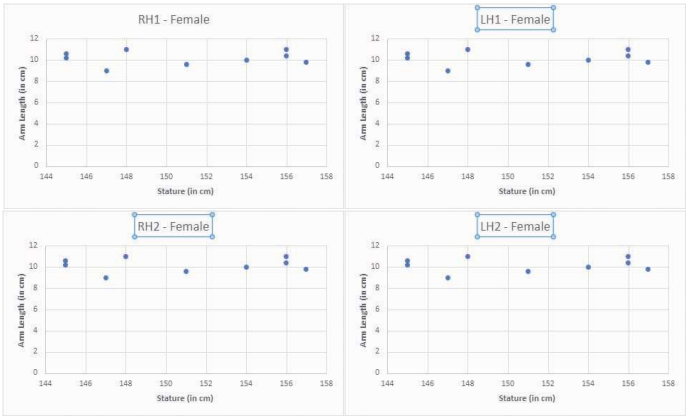


**Figure 4. Scatter plot for female for Gorkha population.**

to their involvement, all participants were provided with detailed information and they gave their informed consent willingly. In order to obtain precise measurements, standard anthropometric instruments were employed, and all measurements were recorded in centimeters, with a level of detail down to the nearest millimeter. To ensure accurate results and eliminate diurnal variation, all measurements are taken in a reasonably well-lighted room at a fixed time between 12.00 p.m. and 4.00 p.m. The humerus bone of each individual was measured on both the left and right side to ensure precise measurements. The recorded measurements of each person's stature were used to find the average height. In this study, a comprehensive dataset was gathered, which included a total of 160 individuals. The participants selected for this study consisted of an equal number of males and females, totaling 160 individuals, all falling within the age range of 25 to 40 years. Once the data was collected, it was meticulously coded and then entered into MS Excel for analysis. Linear regression was used to evaluate statistical associations. Two types of measurements were taken of humerus bone from left and right side of each individual.

For the first measurement, the subject was instructed to stand in an upright position with equal weight distribution on both feet, while bending the right arm at a 90º angle at the elbow and facing the right palm upwards. By tracing the scapula from the back towards the arm, you will reach the point where its spine ends before it sharply turns in a V-shape towards the front of the body. The uppermost edge of the posterior border of the spine was marked with a horizontal line using the cosmetic pencil, which extended from the acromion process. To measure accurately, the measuring tape was initially positioned at this mark, and then it was carefully extended downwards along the posterior surface of the arm until reaching the tip of the olecranon process, which is the bony protrusion at the mid-elbow area. Then the measurement was taken to the nearest 0.1 cm. The tape must be centered on the posterior surface of the arm. During the second measurement, the examiner could feel the medial and lateral epicondyle through palpation. It was necessary to mark two distinct points on the designated area. Then both the points were joint using a horizontal line; midpoint of this line was taken as reference point. The length of humerus was measured in living subject in between two points.

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**Table 1. Table showing data of males and females**

| Sex | Measu-rement | Intercept | Slope | p-value | R2 | SEE | EQUATION |
|---|---|---|---|---|---|---|---|
| Male | LH1 | 168.865 | -0.030 | 0.00 | 0.006 | 5.024 | 168.865+ (0.030) LH1 |
| Male | RH1 | 109.218 | 4.125 | 0.00 | 0.389 | 3.940 | 109.218901+ (4.125) RH1 |
| Male | LH2 | 142.929 | 2.123 | 0.00 | 0.115 | 4.743 | 142.929+ (2.123) LH2 |
| Male | RH2 | 140.357 | 2.327 | 0.00 | 0.146 | 4.658 | 140.357+ (2.327) RH2 |
| Female | LH1 | 101.839 | 3.710 | 0.0084 | 0.143 | 5.094 | 101.839+ (3.710) LH1 |
| Female | RH1 | 80.558 | 5.207 | 0.0309 | 0.503 | 3.877 | 80.558+ (5.207) RH1 |
| Female | LH2 | 133.655 | 1.758 | 0.006 | 0.046 | 5.377 | 133.65+ (1.7587477) LH2 |
| Female | RH2 | 155.531 | -0.438 | 0.00 | 0.078 | 5.283 | 155.531+ (-0.438) RH2 |

**Table 2. Descriptive Statistics of Parameters studied in 80 Males.**

| Parameters | Stature | RH1 | LH1 | RH2 | LH2 |
|---|---|---|---|---|---|
| Mean | 168.37 | 14.33 | 15.79 | 12.03 | 11.98 |
| Median | 167 | 14 | 14.5 | 12 | 12 |
| Mode | 167 | 14 | 14 | 12 | 12 |
| S.D. | 5.009 | 0.757 | 0.719 | 0.82 | 0.8 |
| S.E.M | 0.563 | 0.085 | 0.08 | 0.092 | 0.09 |
| Maximum | 181 | 16 | 16 | 14 | 14 |
| Minimum | 155 | 13 | 13 | 10 | 10 |
| Range | 26 | 03 | 03 | 04 | 04 |

**Table 3. Descriptive statistics of parameters studied in 80 females.**

| Parameters | Stature | RH1 | LH1 | RH2 | LH2 |
|---|---|---|---|---|---|
| Mean | 151 | 13.7 | 13.4 | 9.65 | 10.17 |
| Median | 151 | 13.5 | 13.5 | 10.6 | 10.2 |
| Mode | 145 | 13.4 | 14.3 | 10.5 | 11 |
| S.D. | 4.89 | 0.715 | 0.58 | 0.57 | 0.65 |
| S.E.M | 1.63 | 0.23 | 0.19 | 0.19 | 0.21 |
| Maximum | 157 | 15 | 14.3 | 11.8 | 11 |
| Minimum | 145 | 12.6 | 12.7 | 10.1 | 09 |
| Range | 12 | 2.4 | 1.6 | 1.7 | 02 |

## Results:

In the present study, the data of humerus length and stature was collected from 160 individuals comprising of 80 males and 80 females. The data was then fed to Microsoft excel for further statistical analysis. Table 1 summarizes the results of data analysis for both male and female measurements.

Table-2 shows the descriptive statistics of parameters studied in 80 males. The mean of the stature of the male is 168.37 cm. The mean of right humerus length (RH1) & left humerus length (LH1) from first measurement is 14.3 cm and 15.79 cm respectively. The mean of right humerus length (RH2) & left humerus length (LH2) from second measurement is 12.03 cm and 11.98 cm respectively. Same as the median, mode, standard deviation, and standard error of mean can be seen. The range is highest for stature followed by humerus length from second measurement for both hands and is lowest for humerus length from first measurement for both hands.

Table-3 Shows the descriptive statistics of parameters studied in 80 females. The mean of the stature of the female is 151 cm. The mean of right humerus length (RH1) & left humerus length (LH1) from first measurement is 13.7 cm and 13.4 cm respectively. The mean of right humerus length (RH2) & left humerus length (LH2) from second measurement is 9.65 cm and 10.17 cm respectively. Same as the median, mode, standard deviation and standard error of mean can be seen. The range is highest for stature followed by humerus length from first measurement in right hand, from second measurement in right hand and is lowest for left hand from both measurements. When compared with the data in Table-2 and 3 we can observe that each parameter has a greater value of range for males except for mode in LH1. In males, the average stature was 168 ±5 cm. The average humerus length of right and left hand from first measurement is 14.3±0.75 cm & 15.7±0.71 cm respectively. The average humerus length of right and left hand from second measurement is 12.03±0.82 cm & 11.98±0.8 cm respectively. In female, the average stature was 151±4.89 cm. The average humerus length of right and left hand from first measurement is 13.7±0.71 cm & 13.4±0.58 cm respectively. The average humerus length of right and left hand from second measurement is 9.65±0.57 & 10.17±0.65 cm respectively.

## Discussion:

Age, sex and stature are the primary characteristics of identification of the individuality of a person. Stature is an important and useful anthropometric parameter occupies relatively a central position in anthropometric research. Reconstruction of stature used by forensic experts for narrowing down the investigation process. Apart from this, the estimated height is of paramount importance in medico-legal examinations. In establishing the individuality of a person mostly in cases of decomposed bodies and skeletal remains, stature is one of the important parameters.

The observations of the current work claimed that the humerus bone length can be used for prediction of stature by forensic experts, law agencies and by anthropologists. India is a land of genetic and cultural diversity and for all the races and populations these parameters are different due to the differences in nutrition, genetic makeup, geographical location, climatic conditions and due to different levels of physical activity. Hence these formulae are population specific from which the data has been collected.

In the present study, Stature of Gorkha males ranges from a minimum of 155 cm to a maximum of 181 cm which shows a mean stature of 168.37 ± 5 cm and for Gorkha female from a minimum of 145 cm to maximum of 157 cm which shows a mean stature of 151 ± 4.89 cm. Furthermore, the value of co-efficient correlation is found to be significant with p-value ($P<0.005$).

Humerus length of Gorkha males of Ranchi ranges from a minimum of 13cm to maximum of 16 cm showing a mean value of 14.3±0.75 for right hand and for left hand it ranges from a minimum of 13cm to maximum of 16 cm showing a mean value of 15.7±0.71 cm. Humerus length of Gorkha female ranges from a minimum of 12.6 cm to maximum of 15 cm showing a mean value of 13.7±0.71 cm for right hand and for left hand it ranges from a minimum of 12.7cm to maximum of 14.3cm showing a mean value of 13.4±0.58 cm.

## Conclusion:

Throughout history, crimes and criminals have consistently been intertwined within all societies across the globe. The interest and

integrity of members of society have always been safeguarded through the collective efforts of many societies, which involve identifying criminals, isolating them, and ensuring appropriate punishment. Solving crime investigation problems now requires the indispensable application of forensic science knowledge. The application of advanced forensic science techniques has the potential to effectively address and resolve the complex issues surrounding heinous crimes. Within the realm of forensic science, there is a specialized branch known as forensic anthropology, which serves the vital purpose of determining the stature or height of an individual who has been linked to a criminal offense. Where the person's identity has been established by analyzing the length of their limbs or other body parts, it becomes feasible to generate a comprehensive evidential report that can significantly impact the outcome of criminal proceedings. Extracting relevant personal information about the victim, through the examination of skeletal remains recovered from crime scenes, has long been a common practice among forensic anthropologists.

Estimation of stature from skeletal remains is a task that they undertake in such situations. The significance of forensic anthropology has increased in today's world, primarily because of the advancements made in scientific methods to uncover foul play. Among the various tasks undertaken by forensic anthropologists, personal identification holds tremendous significance. When we mention "the individual" in this context, we are including a wide range of possibilities, such as a living person, a deceased person, a body that is partially decomposed or mutilated, or even remains that have undergone skeletonization but can still be recognized. An individual's stature, a personal attribute, is anatomically complex and can be determined by evaluating the combined length dimensions of the legs, pelvis, vertebral column, and skull.

The estimation of stature can involve the use of different body dimensions. Numerous studies have unequivocally showed that there is a direct and positive relationship between height and the dimensions of various body parts. Using personal identification as a measure is important in forensic examination, especially when dealing with unknown, highly decomposed, fragmentary, and mutilated human remains. This assistance plays a crucial role in narrowing down the investigation process, ultimately offering valuable clues to the investigating agencies.

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ORIGINAL ARTICLE

# Pulp Volume - An In-depth Tool in Age Estimation- A Comparative Retrospective Forensic Based Cone Beam CT Study

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**Abstract:**

The field of forensic utilizes various cranio-facial structures and skull in identifying an unknown deceased. This identification deals with assessing the gender and age of skeletonized remains based on eliciting the ethnicity of the population at archaeological sites and comparison of post-mortem records with the presumed antemortem records. Interestingly, even a single tooth can be used to assess the age of an individual and this is widely used in forensic for investigating legal matters as well as in scientific research purpose. Teeth are resistant to environmental insults and post-mortem decomposition and hence can be retained without distortion. The objective of this study is to analyse the volumetric data of canine and first molars in cone beam CT for estimating age among samples of various age groups and to compare between those values to evaluate which tooth indexed volumetric data gives more specificity in age estimation. It is a retrospective Institutional based Forensic study conducted using 180 samples from 90 full skull CBCT images whose age ranged between 20-65 years, acquired from the dental archives of department of Oral Medicine and Radiology were are equally divided among both genders. Further the samples were categorized into three groups as (20-35), (36-50) and (51-65) years in both the genders. All data samples were assessed using the ITK –SNAP 3.8.0 software. Using semi-automatic active contour segmentation method, the volumes of pulps of upper canine and upper first molar were analysed and calculated data were statistically analysed using discriminant functional analysis and multivariate regression analysis to evaluate the correlation of pulp volumes with respect to chronological age.

The multivariate regression analysis done for estimating age among the given groups of samples using upper canine gave statistically highly significant p value of 0.001,0.004 and 0.039 for group I [20-35 years], group II [36-50 years] and group III [51-65 years] respectively. The regression analysis done using upper first molar for age estimation gave statistically highly significant p value of 0.001 for group I, whereas group II and group III gave out insignificant results. The comparative analysis between multivariate regression analysis for age estimation of upper canine and upper first molar to determine which tooth index has more specificity, gave statistically significant results for canine samples in all age groups. The samples were also analysed for Pearson correlation in estimating age, which resulted in high correlation in group I samples for both canine and first molar, moderate correlation for group II and group III samples for canine pulp volumes and low correlation for group II and group III for molar pulp volumes. Over the years, CBCT has evolved a lot and today they are being used in various sectors of dentistry. In the field of forensic, various oral and maxillofacial structures are being used as an adjuvant in personal identification with more precision using cone beam CT. The results of the present study show statistically highly significant correlation between age and upper canine samples in all the age groups analysed. Hence, based on the results of present study, the upper canine can be used as a promising adjuvant tool in forensic odontology for age estimation.

**Keywords:** Pulp volume; CBCT; Oral and maxillofacial radiology; Forensic odontology; Age estimation.

## Introduction:

The science of dentistry as related to the law is known as forensic dentistry or forensic odontology.[1] The theory behind forensic dentistry is that "no two mouths are alike." Kieser-Nielsen[2] defined Forensic odontology as the branch of dentistry that deals with proper handling and estimation of dental evidence and proper evaluation and presentations of dental findings in the interest of dental science. Age estimation plays an important role in Forensic Dentistry for dead individual identification as well as for alive persons to clarify criminal and civil liability issues.[3] Teeth, skeleton or both structures are used in age estimation as maturity indicators. However, the teeth maturation provides a valuable index of dental age and serves as a better index of the maturation than any other index as they are seldom affected by systemic, nutritional and endocrine status[4] and most of the individuals would have been to dentist in their mean course of life and thus, their ante-mortem data would be available which help in victim identification more precisely. The oral and maxillofacial radiographic field had discovered tracks which are advantageous to mankind in which the radiographs play a crucial role in personal identification. Studies have demonstrated that CBCT is a highly accurate method in personal identification in forensic due to their resolution and the quality of producing images of high

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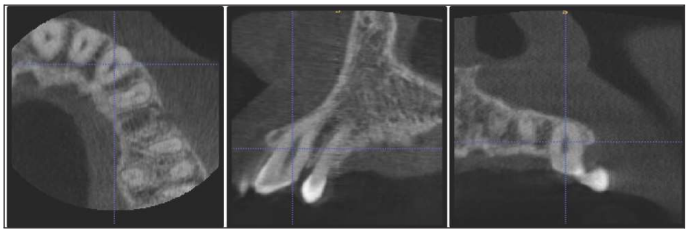


**Figure 1. Standardisation.**

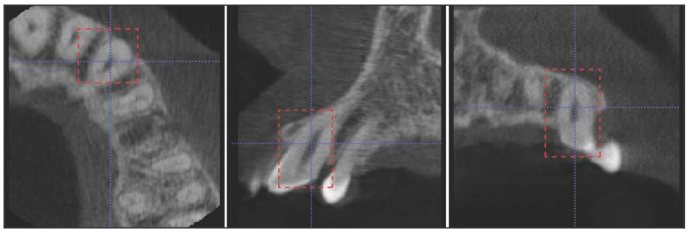


**Figure 2. Active contouring of region of interest.**

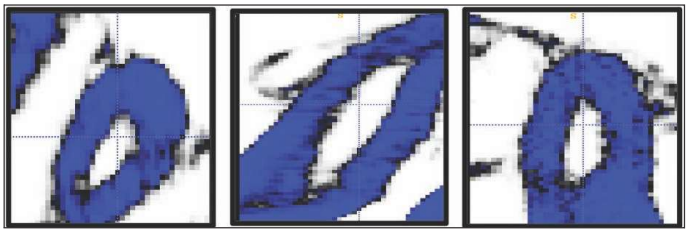


**Figure 3. Conversion of grey scale images into blue white window.**

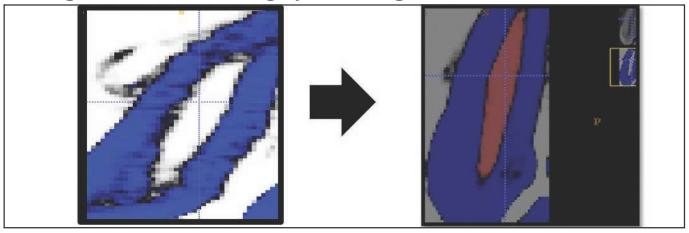


**Figure 3. Pre-processing, initialization and evolution.**

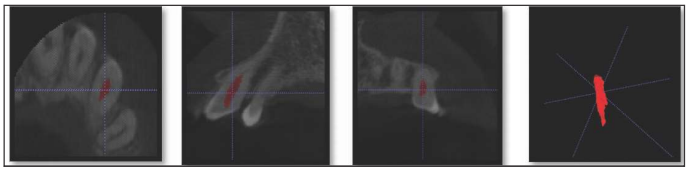


**Figure 4. Extraction of pulp volumes from canine.**

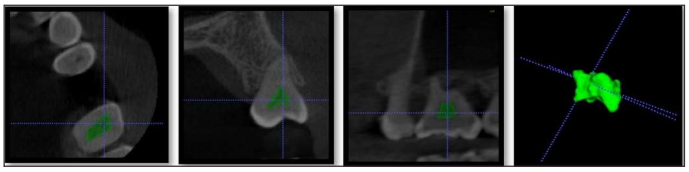
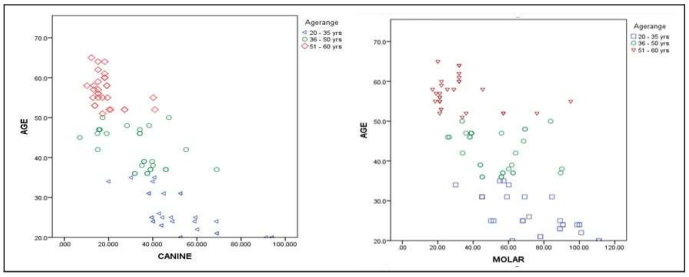


**Figure 5. Extraction of pulp volumes from first molar.**




**Graph 1 and 2. Pearson correlation.**

contrast.[5] This present study evaluated pulp volumes of upper canine and upper first molar irrespective of sides to estimate age and to analyse which tooth index gives high specificity with respect to age.

## Materials and Methods:

Full skull CBCT images of the 90 patients reported to the institution for various dental problems taken in the time period between 2020 – 2022 were acquired from the dental archives. The scans were generated using the Planmeca Promax 3D Mid Proface CBCT machine obtained at 90Kvp, 10mA and with large FOV 13x15cm. The study population included 45 males and 45 females, CBCT images of good quality and the study group was divided into three subdivisions; group I: age 20-35, group II: age 36-50, group III: age 51-65. Each group contained 60 samples, so total of 180 samples were analysed for estimating age using pulp volumes. All the images were assessed using ITK-SNAP software version 3.8.0. The images with artifacts, developmental disturbances, pathologies in the jaw region were excluded.

## Methodology:

Step 1: Standardisation [figure 1]. All the CBCT images were standardised prior to measurements by placing the intersection of horizontal and vertical toggle in the pulpal region of tooth of interest in all the 3 sections [Axial, Coronal and Sagittal].

Step 2: The region of interest [figure 2]. From the field of view, the region of interest is marked and highlighted by an active contour segmentation mode in such a way that it only involves the tooth of interest from which the volume of pulp is going to be extracted. This process in done in all the 3 sections coinciding each other and the complete tooth structure should be included to avoid the discrepancies

Step 3: Volume generation using auto segmentation in ITK SNAP software [figure 3]. The cropped out selected region of interest is updated into 3D segment option in ITK SNAP software, which

**Table 1 & 2: Multivariate regression analysis for age estimation using canine constant as indicator.**

**Table 1. Model Summary.[a]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 [20 - 35 years] | .663[b] | .639 | .419 | 3.7519 |
| 2 [36-50 years] | .510[b] | .560 | .234 | 4.3755 |
| 3 [51-65 years] | .379[b] | .414 | .113 | 3.7183 |

a. Age range. b. Predictors: (Constant), CANINE

**Table 2. Coefficients.[a,b]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | p-value | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | 35.350 | 2.151 | | 16.431 | .000 | 30.943 | 39.756 |
| | Canine | -.183 | .039 | -.663 | -4.682 | .0001 | -.264 | -.103 |
| 2 | (Constant) | 48.188 | 2.068 | | 23.304 | .000 | 43.953 | 52.424 |
| | Canine | -.185 | .059 | -.510 | -3.140 | .004 | -.305 | -.064 |
| 3 | (Constant) | 60.757 | 1.932 | | 31.449 | .000 | 56.799 | 64.714 |
| | Canine | -.211 | .097 | -.379 | -2.169 | .039 | -.411 | -.012 |

1(A)] Age range = 20 - 35 years, 2] Age range = 36 - 50 years, 3] Age range = 51-65 years. B. Dependent Variable: Age

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**Table 3. Descriptive analysis of mean value and standard deviation for individual age groups using one way anova for canine samples.**

| Anova[a, b] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 308.644 | 1 | 308.644 | 21.925 | .000[c] |
| | Residual | 394.156 | 28 | 14.077 | | |
| | Total | 702.800 | 29 | | | |
| 2 | Regression | 188.731 | 1 | 188.731 | 9.858 | .004[c] |
| | Residual | 536.069 | 28 | 19.145 | | |
| | Total | 724.800 | 29 | | | |
| 3 | Regression | 188.731 | 1 | 188.731 | 9.858 | .004[c] |
| | Residual | 536.069 | 28 | 19.145 | | |
| | Total | 724.800 | 29 | | | |

a. Age range [1(20 - 35 years), (36 - 50 years) and (51 - 60 years)]
b. Dependent Variable: Age, c. Predictors: (Constant), Canine.

**Table 4 & 5. Multivariate regression analysis for age estimation using first molar constant as indicator.**

**Table 4. Model summary.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1[20 - 35 years] | .648b | .420 | .399 | 3.8150 |
| 2[36-50 years] | .273b | .075 | .042 | 4.8942 |
| 3[51-65 years] | .259b | .067 | .034 | 3.8814 |

a. Age range, b. Predictors: (Constant), Molar.

**Table 5. Coefficients.[a, b]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | p-value | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | 36.736 | 2.526 | -.648 | 14.544 | .000 | 31.562 | 41.910 |
| | MOLAR | -.144 | .032 | | -4.504 | .0001 | -.210 | -.079 |
| 2 | (Constant) | 46.380 | 2.922 | -.273 | 15.875 | .000 | 40.396 | 52.365 |
| | MOLAR | -.079 | .052 | | -1.503 | .144 | -.186 | .029 |
| 3 | (Constant) | 58.649 | 1.463 | -.259 | 40.096 | .000 | 55.653 | 61.645 |
| | MOLAR | -.057 | .040 | | -1.419 | .167 | -.139 | .025 |

1(A)]. Age range = 20 - 35 years, 2] Age range = 36 - 50 years, 3] Age range = 51-65 years. B. Dependent Variable: AGE

changes the grayscale images of tooth in interest into a blue and white window, Then, the volume generation using auto segmentation will be done using 3 steps: Pre-processing, initialization and evolution.

1] Pre-processing: In this step, upper and lower thresholds are selected to delineate the pulpal area from rest of the tooth structure.

2] Initialization: The delineated pulpal area is filled with colour bubble using bubble at cursor option in all 3 sections in multiple areas which serves as a source to semiautomatic segmentation of the entire pulp in following processes.

3] Evolution step: In this step, the added bubble marks will start to spread in all directions completely covering the entire pulp without crossing the delineated areas, once the complete area of interest is segmented, it is cross checked in all three planes and 3- dimensional model of extracted pulp can be obtained [figure 4 & 5].

Step 4: Volumetric assessment: Once the area of interest is 3 dimensionally extracted, the volumetric assessment of it could be done by using the same software, using the segmentation mode which gives out precise volumetric data of pulp of tooth in interest and the data were statistically evaluated.

**Results :**

The collected data were analysed with IBM SPSS Statistics for Windows, Version 23.0. (Armonk, NY: IBM Corp). To describe about the data descriptive statistics frequency analysis, percentage analysis was used for categorical variables and the mean & S. D were used for continuous variables. To find influence of canine & molar with age, the regression analysis model was used to fit the equation. This study evaluated and compared pulp volumes of maxillary canines and first molars in full skull CBCT images of male and female patients for age estimation. The descriptive analysis [One-way Anova] of the pulp volumes and age using canine as indicator, there is a statistically highly significant P value of 0.0001 and 0.004 for group I and group II samples and a statistically significant P value of 0.039 for group III samples [table 3] and for molar as an indicator, there is a statistically highly significant P value of 0.0001 for group I and non-significant P value of 0.144 and 0.167 for group II & III samples [table 6]. Multivariate regression analysis for age estimation using upper canine for both females and males showed statistically highly significant P value of 0.001, 0.004 and 0.039 with correlation [r value] of 0.663 , 0.510 and 0.379 with the error rate of 3-4% for age group I, II and III respectively [table 1 & 2] and a Multivariate regression analysis for age estimation using upper molars for both females and males showed statistically highly significant P value of 0.001for group I sample with correlation [ r value] of 0.649 and an insignificant P value of 0.144 and 0.167 with correlation of 0.273and 0.259 for group II and III samples with the error rate of 3-4% [table 4 & 5]. Graph 1 and 2 depicts Pearson correlation of canine and molar pulp volumes as an age indicator in which canine showed high correlation between group I sample and moderate correlation between group II and III samples whereas in molar, the correlation was high in group I samples but low in group II and III samples. Comparative regression analysis of canine and first molar for age estimation in group I sample gave R value of 0.007 and shows statistically significant P value of 0.048 for canine and statistically non-significant P value of 0.082 for first molar and for group II, the estimated R value is 0.513 and shows statistically significant P value of 0.014 for canine and statistically non-significant P value of 0.760 for first molar and for group III , the estimated R value is 0.451 and shows statistically significant P

**Table 6. Descriptive analysis of mean value and standard deviation for individual age groups using one way anova for molar samples.**

| ANOVA [a,b] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 295.285 | 1 | 295.285 | 20.289 | .000c |
| | Residual | 407.515 | 28 | 14.554 | | |
| | Total | 702.800 | 29 | | | |
| 2 | Regression | 54.099 | 1 | 54.099 | 2.258 | .144c |
| | Residual | 670.701 | 28 | 23.954 | | |
| | Total | 724.800 | 29 | | | |
| 3 | Regression | 30.336 | 1 | 30.336 | 2.014 | .167c |
| | Residual | 421.831 | 28 | 15.065 | | |
| | Total | 452.167 | 29 | | | |

a. Age range = [ 1(20 - 35 years), (36 - 50 years) and (51 - 60 years) ]
b. Dependent Variable: AGE. c. Predictors: (Constant), MOLAR

**Table 7 & 8. Multivariate regression analysis for age estimation using canine and first molar constant as indicator among group i sample [20-35 years of age].**

**Table 7. Model Summary.[a]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1[a] | .707[b] | .500 | .463 | 3.6091 |
| 2[b] | .513[b] | .263 | .208 | 4.4480 |
| 3[c] | .451[b] | .204 | .145 | 3.6515 |

1[a]. Age range = 20 - 35 years, 2[b] Age range = 36 - 50 years, 3[c] Age range = 51 - 65 years. b. Predictors: (Constant), MOLAR, CANINE.

**Table 8. Coefficients.[a,b]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | p-value | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | 37.649 | 2.430 | -.407 | 15.494 | .000 | 32.663 | 42.635 |
| | Canine | -.113 | .054 | | -2.070 | .048 | -.224 | -.001 |
| | Molar | -.079 | .044 | -.355 | -1.806 | .082 | -.169 | .011 |
| 2 | (Constant) | 47.665 | 2.700 | -.550 | 17.654 | .000 | 42.125 | 53.205 |
| | Canine | -.199 | .076 | | -2.627 | .014 | -.354 | -.044 |
| | Molar | .019 | .060 | 0.65 | 0.309 | .760 | -.105 | .143 |
| 3 | (Constant) | 62.427 | 2.230 | -.981 | 27.999 | .000 | 57.852 | 67.001 |
| | Canine | -.547 | .254 | | -2.153 | .040 | 1.067 | -.026 |
| | Molar | -.143 | .100 | .650 | 1.426 | .165 | -.063 | .348 |

a. Age range = 20 - 35 years b. Dependent Variable: AGE

value of 0.040 for canine and statistically non-significant P value of 0.165 for first molar.

## Discussion:

Forensic odontology is one of the integral parts of dentistry which is intended for the handling, examination and evaluation of evidences generated by dental structures, which are to be then evaluated, tabulated and presented to jurisprudence.[6] Forensic specialists initially focus on morphology of the skeletal remains followed by morphometrics in the process of personal identification. Human dentition is often considered as a hard tissue analogue like fingerprints.[1] In several situations, teeth and bones are frequently the only sources available for identification of degraded or fragmented human remains. For age estimation using teeth, increase in secondary dentin deposition and decrease in pulp volume remains one of the reliable and historical indicators.[7] The studies done by Kvaal et al. (1995),[8] Cameriere et al. (2007)[9] and Palak H. Shah et al. (2016),[10] Nima Biuki et al. (2017),[11] stated that there is a negative correlation between age and pulp volume stating that the volume of pulp decreases as the person ages which is also observed in the present study. So far in literature, several 2D imaging modalities have been applied to evaluate the decrease of pulp chamber volume, but it seems that the use of 3D images which demonstrate the real morphological change is the most suitable one in this kind of dental age estimation methods. The advent of Cone beam CT radiography for evaluation of oral and maxillofacial structures had been widely used in dentistry for clinical purposes. The application of CBCT for hard and soft tissues in the body, especially facial bones and teeth, that allows a clinician to obtain a detailed 3-dimensional images.[12] Another advantage of the CBCT machine is that they are easy to operate, ease of handling and ability to offer (from a single scan) a dataset of multiplanar cross-sectional and 3D reconstructions.[13] In contrast to the present study, several studies were conducted for age estimation in literature using morphometric analysis such as tooth pulp ratio or tooth coronal index. The information obtained in those studies remains inadequate in assessing the fine details. Thus, with the introduction of specialised software technologies like ITK SNAP'S semiautomatic segmentation for volume analysis provides greatest advantage due to their ability to classify the structures precisely. Previous studies in various literature used linear mathematical models to estimate age, but a logarithmic model was developed in the present study. To compare with logarithmic models with linear models, a linear multivariate regression analysis was also conducted with age as dependent variable, pulp chamber volume as independent variable for maxillary first molars and maxillary canine, respectively, in the present study.

The present study focuses on estimating the age using semiautomatic segmentation of pulp volumes of upper canine and upper first molar using CBCT imaging. The results from the present study showed significant ($p < 0.001$) value for younger age samples and an insignificant p value for age group above 50 using first molar as age indicator which came in accordance with the study by Zhi et al. in 2015,[14] whereas Shiva Kumar et al. in 2016[15] analysed age using same method in Indian Population which also resulted in significant results between younger age group and maxillary molar pulp volumes with a correlation of 27.0% which is in accordance with the present study with the difference in correlation value of 64.0% between estimated age and actual age of samples of younger age groups. In CBCT analysis of age estimation using multi-rooted teeth by Faezeh Yousefi et al. in 2020[16] showed significance between maxillary, molar and age which also coincides with the current study.

Tardivo et al. in 2014,[17] Nima buki et al. in 2017,[11] Kasmi et al. in 2019[18] and Mehrdad Abdinian et al. in 2021[19] reported that use of maxillary canine is better and stronger in estimating age in their respective analysis with a significant correlation ($p < 0.001$) between maxillary canines and age. Whereas the results of the current study also stated that canine shows statistically high correlation ($p < 0.001$) between age and canine pulp volume of all the considered samples of different age groups, these results are also in accordance with above mentioned studies. The fundamental result of this study is that on comparing the volumes of maxillary first molar and maxillary canine among various age groups which gave out a statistically significant result ($p < 0.001$) for canine samples in all the subdivided age groups for both males and females. On the contrary, the results of the current study are in disharmony with the study done by Hazha star et al. in 2011[20] which might be due to reduced sample size and manual processing method of segmenting the pulp from rest all tooth structure unlike this particular study. This commenced study utilised advanced imaging system such as CBCT combined with the use of advanced software methods to obtain absolute pulp volume by using semiautomatic segmentation without using the morphometrics and formulae, which remains superior and can provide up to three times more practical volumetric estimations than manual methods and also to our best knowledge, this current

study is the first among literature to compare the accuracy of pulp volumes of monoradicular and multiradicular teeth of a same individual in estimating age among Indian population. One limitation of the present study is that only maxillary first molars and canines were included as age indicators, this makes difficult to study or estimate age of an unknown deceased person when these teeth are missing or lost or endodontically treated, hence, in near future if teeth volume analysis is estimated for anterior and posterior teeth of both arches using the methodology of current study, the data of such study could provide a better view on selection of tooth for age analysis in forensic context.

**Conclusion:**

In the field of forensic, personal identification is an important component and fundamental aspect in the identification of deceased individuals. Circumstances where the comparative DNA samples and fingerprints are not found, the use of the other structures such as teeth or skeleton with radiological identification comes into play. There are many numbers of studies and researches that had been done focusing on the radiological identification of a person in forensic aspect which proved to an effective adjuvant method. As dental professionals, we play a key role in forensic by maintaining quality records of patients and thus could be a part of the investigating team in the field of forensics.

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ORIGINAL ARTICLE

# Quantitative and Qualitative Profiling and Extraction of Acephate Pesticide Residues in Soil and Water using SOLLE and LLE Coupled with Multidimensional Chromatographic Techniques and UV-Visible Spectroscopy

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**Abstract:**

Acephate is an organophosphate insecticide that has been used to control a wide range of pests, including insects, mites and nematodes. It is commonly used in agricultural settings, as well as for residential and commercial pest control. In water, acephate can undergo degradation through hydrolysis, particularly under alkaline conditions. The half-life of acephate in water can range from a few days to several weeks, depending on factors such as pH and temperature. After degradation, the primary breakdown product is methamidophos which can also exhibit toxicity to aquatic organisms. In soil, acephate can undergo various processes, including degradation, adsorption, and leaching. The persistence of acephate in soil depends on factors such as soil type, organic matter content, pH and microbial activity. In general, acephate has a moderate to high potential for adsorption to soil particles, which can reduce its mobility and availability for degradation. The half-life of acephate in soil can range from a few weeks to several months. A rapid and highly sensitive UV-visible Spectrophotometer were used for the qualitative analysis of Acephate in soil and water. A solution of 500 ppm acephate powder was spiked in soil and water. The analyte was extracted using Sugaring/Salting Out Liquid Liquid Extraction (SOLLE) and Liquid Liquid Extraction (LLE). The solvent used for SOLLE method was Acetonitrile, Hexane and Acetone for LLE. The extract were analysed by Thin Layer Chromatography, Gas Chromatography. Thin Layer Chromatography was performed to find the best solvent system for Acephate. Gas Chromatography and UV-Visible spectrophotometer were used for quantification.

**Keywords:** Acephate; Thin layer chromatography; Gas chromatography; UV-visible spectrophotometer.

## Introduction:

Pesticides are substances that are used to control pests, including weeds.[1] Pesticide includes herbicides, insecticide, nematicide, rodenticide, mollucicide, piscicide, avicide, insect repellent, fungicide, disinfectant and sanitizer.[2] Most of the pesticides are generally intended to use for plant protection against weeds, fungi or insects.[3] It improves the crop livestock yields and quality by controlling pest and plant disease vectors.[4] It can be categorized by target organism like insecticides, herbicides, rodenticides etc., by their chemical structures like organo-phosphate, organochloro and carbamtes. Organochloro pesticide disturbs the Na/K balance of the nerve fiber and allows the nerve to transfer continuously. They are very persistent and stay in the environment for a longer period. Due to the potential bioaccumulation, organochloro is replaced by carbamates and organophosphates.[5] Both inhibit the activity of acetylcho-linesterase, causing weakness of the muscles and paralysis.

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1.1 Organophosphates: Organophosphate insecticide was introduced be Chevron Chemicals in 1973.[6] It is an insecticide used primarily for control of aphids, including leaf miners, caterpillar, sawflies and thrips, on food crops, vegetables and horticulture.[7] They are derived from phosphoric acid which is toxic to vertebrates and also to other animals.[8] They are popularly used more often than other pesticides due to their lack of persistence in the environment since they are chemically unstable in nature and their effectiveness.[9] They are cheaper and easily available in developing countries like India, Nepal and Bangladesh. Poisoning rates in the suicide attempters who attend hospital varies from around 40% to over 80% in many Indian studies and OP compounds available as pesticides are amongst the most common poisons used.[10] Out of the total deaths from self-harm, in the regions of developing countries of Asia, 60% are due to pesticide poisoning and out of the total of 60%, almost 70% accounts to organophosphate.[11]

1.2 Acephate : Acephate (See Figure.1) (O,S-Dimethyl acetylphosphoramidothioate) is an organophosphate insecticide of moderate persistence of about 3-6 days in soil, plants and insects.[12] Although in some soils the half-life may be increased to more than 13–60 days due to variation of properties (physical, chemical and biological) of soils.[13] Acidic nature of soil is responsible for long life span of acephate in soils. After decomposition, acephate converts into metha-midophos (O,S-

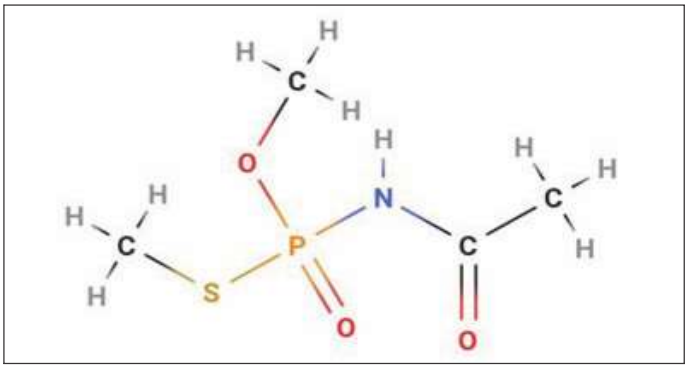

Figure 1. Structure of acephate.

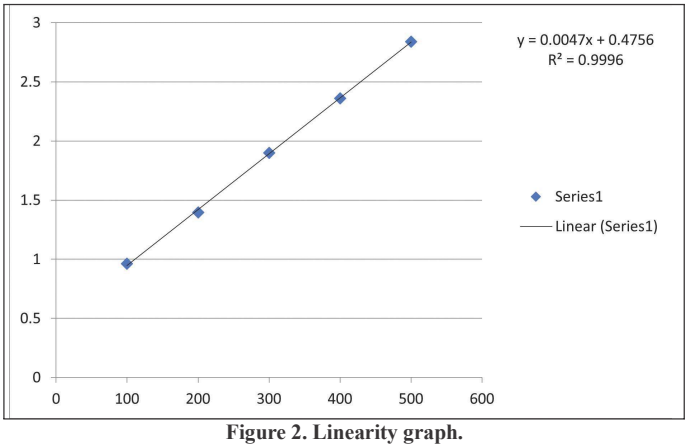


Figure 2. Linearity graph.

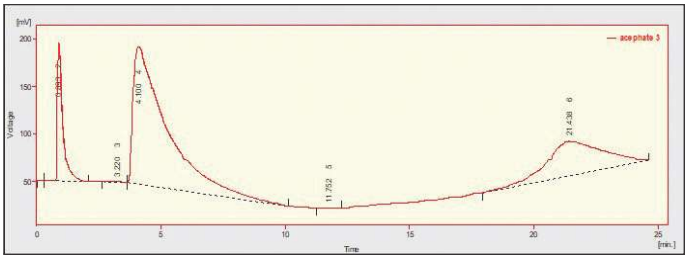

Figure 3. Standard acephate.

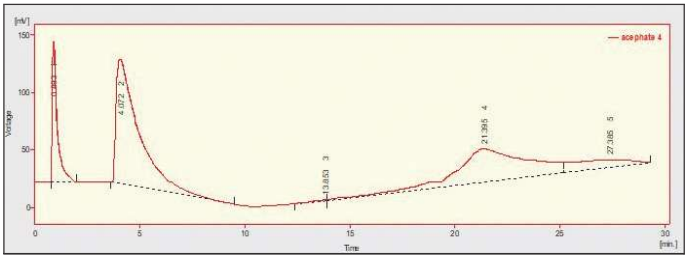

Figure 4. Extracted sample from SOLLE.

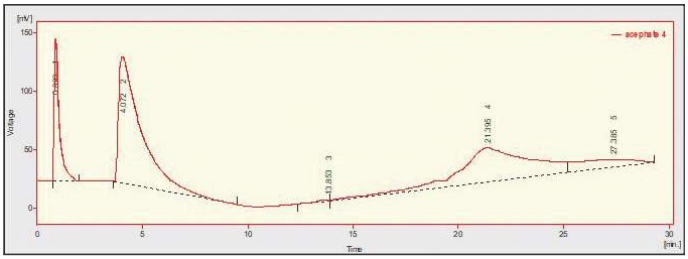

Figure 5. Extract Sample From LLE Using Hexane:Acetone, 1:1.

dimethyl phosphoramidothioate), which is more toxic than Acephate. Methamidophos is the major metabolite of Acephate. When heated to decomposition, it gives off toxic fumes of various oxides of phosphorous, sulphur and nitrogen.[14]

This research paper presents a comprehensive study on the extraction and analysis of Acephate, an organophosphate insecticide, from soil and water samples. The extraction methods employed in this study include Salting Out Liquid-Liquid Extraction (SOLLE) and Liquid-Liquid Extraction (LLE). Qualitative and quantitative analyses of Acephate were conducted using Thin Layer Chromatography (TLC), UV-Visible Spectroscopy and Gas Chromatography (GC).

## Methodology:

2.1 Sample preparation : Preparation of standard solution : 10 mg standard Acephate was weighted, for working standard and transferred into 10ml volumetric flask and add about 5ml methanol and sonicated for 5min. Further fill up the remaining 5ml upto the mark with the same methanol. Further dilutions of 100ppm, 200ppm, 300ppm, 400ppm, 500ppm were made.

- 10ml of 1000ppm + 10ml methanol = 500ppm
- 1ml of 500ppm + 4ml methanol = 100ppm
- 2ml of 500ppm + 3ml methanol = 200ppm
- 3ml of 500ppm + 2ml methanol = 300ppm
- 4ml of 500ppm + 1ml methanol = 400ppm

Preparation of samples: In the experiment, a 5mg quantity of Acephate 75% SP, Acetox, was measured and placed into a 25ml Tarson tube. To facilitate mixing, 5ml of tap water was added to the tube along with 15gm of soil. The soil sample was then allowed to dry under the sun. Additionally, another 5mg of Acephate 75% SP, Acetox, powder was taken and placed into a separate 25ml Tarson tube. This time, 10ml of ground water was added to the tube. To ensure thorough mixing, the solution in the tube was vortexed for 10 minutes and subsequently subjected to sonication for 30 minutes.

2.2 Sample analysis: Method of extraction:

1. Extraction of Acephate from soil using acetonitrile
2. Extraction of Acephate from water using SOLLE (salting out liquid liquid extraction).
3. Extraction of Acephate from water using LLE.

The use of SOLLE proves to be a good method of extraction of Acephate, and polar compounds, in general. The classical method

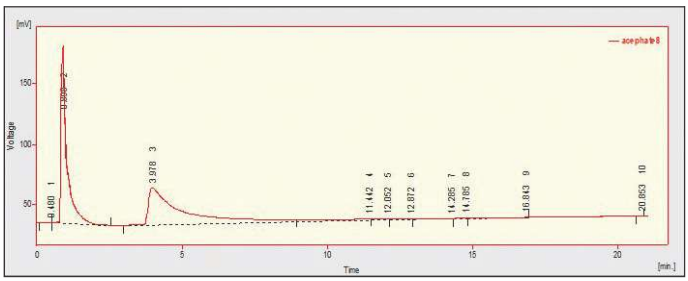

Figure 6. Extract From LLE Using Hexane (2).

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**Table 1. Various solvent systems were used to find out the best solvent system:**

| Sl. No | Solvent system | Ratio |
|---|---|---|
| 1 | Chloroform:methanol | 8:2 |
| 2 | Chloroform:methanol | 9:1 |
| 3 | Hexane:acetone | 8:2 |
| 4 | Hexane:acetone | 7:3 |
| 5 | Hexane:acetone | 6:4 |
| 6 | Chloroform:acetone | 7:3 |
| 7 | Hexane:methanol | 8:2 |
| 8 | Hexane:methanol | 7:3 |
| 9 | Hexane:methanol | 6:4 |
| 10 | Hexane:methanol | 5:5 |
| 11 | Chloroform:ethylacetate | 7:3 |
| 12 | Hexane:acetonitrile | 9:1 |
| 13 | Hexane:acetonitrile | 7:3 |
| 14 | Dioxane:ethanol | 8:2 |
| 15 | Dioxane:ethanol:ammonia | 9:1:4drops |
| 16 | Ethyl acetate:acetic acid | 8:2 |
| 17 | Ethyl acetate:acetic acid:ammonia | 8:2:4drops |
| 18 | Dioxane:acetone | 7:3 |

of extraction using LLE is not possible for polar compounds like Acephate. For the extraction of polar compounds, like Acephate, the general method of extraction follows the Solid Phase Extraction (SPE). It is a good extraction technique, but using SOLLE, the extraction procedure is more cost effective. It is an alternative method of extraction of polar compounds [16]. The various steps involved in SPE such as preconditioning (which involves the conditioning of the sorbent to make it compatible with the sample), loading samples, washing, elution, which is time consuming. SOLLE method is simple and less time consuming.

2.3 Extraction procedure: I. Extraction of Acephate from soil: 15g soil sample which was previously spiked with Acephate was taken to a china dish and the dried at room temperature. The soil sample was taken into a 25ml tarson tube and then 10ml of acetonitrile was added, vortex for 10min. It was then filtered, passed through sodium sulphate and then transferred into centrifuge tubes.

II. Extraction of Acephate from water sample by SOLLE: 10ml tap water is taken into 25ml tarson tube and mixed with 5mg of Acephate powder and then vortex for 10min., followed by sonication for 30min. The water sample was taken into a separating funnel and added 5ml acetonitrile and was shaken properly with hand. The solution was then allowed to settle and then saturated sugar (glucose) 5gm was added and allowed to stand still. The two miscible liquid begin to separate. The upper layer, i.e. acetonitrile layer (3.5ml) was then taken out and passed through 1g sodium sulphate.[10]

III. Extraction of Acephate from water using LLE: a. Using hexane- 5ml water sample spiked with acephate (500ppm) was taken into a separating funnel. 5ml of hexane was added to the separating funnel and gently shake for 2min. Allow the mixture to rest and collect the organic layer. This procedure was done twice; the organic layers were combined and passed through sodium sulphate. The organic layer was then concentrated by allowing it to evaporate on a water bath upto 5ml.

**Table 2. Results of various solvent system after applying spray reagents.**

| Sl. No | Solvent system | Solvent run (a) | Solute run (b) | Under UV light (366nm) | Rf value (b/a) | Spray (Para nitro benzyl pyridine, tetra ethylene pentamine) |
|---|---|---|---|---|---|---|
| 1. | Chloroform, methanol (8:2) | 7cm | 6cm | white flourescence spots | 0.85 | Bluish purple spots |
| 2. | Chloroform, methanol (9:1) | 5.5cm | 3.8cm | white flourescence spots | 0.69 | Bluish purple spots |
| 3. | Hexane, acetone, 8:2 | 7cm | 0 | white flourescence spots | 0 | No |
| 4. | Hexane, acetone, 7:3 | 6.3cm | 2.4cm | white flourescence spots | 0.38 | Bluish purple spots |
| 5. | Hexane, acetone 6.4 | 5.5cm | 3.1cm | white flourescence spots | 0.56 | Bluish purple spots |
| 6. | Chloroform, acetone 7:3 | 5.8cm | Tailing | white fluorescence | 0 | No |
| 7. | Hexane, methanol 8:2 | 6cm | 0 | No white flourescence | 0 | No |
| 8. | Hexane, methanol 7:3 | 7cm | Tailing | white flourescence | 0 | No |
| 9. | Hexane, methanol 6:4 | 4.3cm | 1.8cm | white flourescence spots | 0.41 | Bluish purple spots |
| 10. | Hexane, methanol 5:5 | 3.5cm | 1.5cm | white flourescence spots | 0.42 | Bluish purple spots |
| 11. | Chloroform, ethylacetate 7:3 | 5.7cm | 1.4cm | white flourescence spots | 0.24 | Bluish purple spots |
| 12. | Hexane, acetonitrile 9:1 | 6cm | 0 | No white fluorescence | 0 | No |
| 13. | Hexane, acetonitrile 7:3 | 5.5cm | Tailing | white fluorescence | Tailing | No |
| 14. | Dioxane, ethanol 8:2 | 6.3cm | 6.3cm | white fluorescence | 1 | No |
| 15. | Dioxane, ethanol, ammonia 9:1:4 drops | 4.8cm | 3.5cm | white flourescence spots | 0.72 | Bluish purple spots |
| 16. | Ethyl acetate, a cetic acid 8:2 | 4.2cm | 3.3cm | white flourescence spots | 0.78 | Bluish purple spots |
| 17. | Ethyl acetate, acetic acid, ammonia 8:2:4drops | 4.9cm | 3.3cm | white flourescence spots | 0.67 | Bluish purple spots |
| 18. | Dioxane, acetone 7:3 | 4.5cm | 3.8cm | white flourescence spots | 0.84 | Bluish purple spots |

b. Using hexane-acetone (1:1) : 5ml water sample spiked with acephate (500ppm) was taken into a separating funnel. 5ml of hexane-acetone (1:1) was added to the separating funnel and gently shake for 2min. Allow the mixture to rest and collect the organic layer. This procedure was done twice; the organic layers were combined and passed through sodium sulphate. The organic layer was then concentrated by allowing it to evaporate on a water bath upto 5ml.

1.4 Thin layer chromatography: 500ppm solution of the standard Acephate was prepared. 5µl of the standard was spotted, i.e. 2.5µg, along with 5µl of Acephate extract from soil. The spots were developed using Para nitro benzyl pyridine and tetra ethylene pentamine.

Preparation of spraying reagent: In the experiment, a solution of 2% para nitro benzyl pyridine was prepared by dissolving 1mg of

**Table 3. Qualitative analysis of extracted sample using uv-visible spectrophotometry.**

| S.no. | Sample | Lambda max | Absorption |
|---|---|---|---|
| 1. | Standard (acephate) | 271 | 0.809 |
| 2. | Extract sample from water: SOLLE | 270 | 3.043 |
| 3. | Extract sample from water: LLE (hexane:acetone, 1:1) | 271 | 1.504 |
| 4. | Extract sample from water, lle using hexane: | 269 | 0.766 |

**Table 4. Known standards.**

| Sl. no. | Concentration (in ppm) | Absorption |
|---|---|---|
| 1. | 100 | 0.9611 |
| 2. | 200 | 1.3961 |
| 3. | 300 | 1.9002 |
| 4. | 400 | 2.361 |
| 5. | 500 | 2.8381 |

**Table 5. Samples: extracted from water extracts (SOLLE and LLE)**

| Sl. no | Concentration (in ppm) | Absorption |
|---|---|---|
| 1. Hexane: acetone, LLE | 258.837 | 1.692 |
| 2. Hexane, LLE | 140.945 | 1.142 |
| 3. SOLLE | 473.594 | 2.7134 |

para nitro benzyl pyridine in 50ml of acetone. Similarly, a solution of 10% tetra ethylene pentamine was prepared by dissolving 1mg of tetra ethylene pentamine in 10ml of acetone. The plates were then sprayed with the 2% para nitro benzyl pyridine solution and placed in an oven for 5 minutes at a temperature of 1000°C. Afterward, the plates were sprayed again, but this time with the 10% tetra ethylene pentamine solution. As a result, blue-colored spots were observed on the plates. The Rf (retention factor) value was calculated as part of the analysis.

2.5 UV/visible spectrophotometer - The experiment began by switching on the instrument and allowing the lamps to warm up for 20 minutes. Once ready, the SCANALYSE Software was opened and the wavelength range was set between 200nm and 400nm. The range scan option was chosen from the toolbar. To establish the baseline, both cuvettes were filled with the reference solution (Methanol) and placed in the sample holder. After setting up the baseline, each of the prepared standards and extracts were individually scanned and their respective spectra were recorded. To prepare the standard Acephate, 10ml of a 1000ppm solution was initially created. Subsequent dilutions were made as follows:

- - 10ml of 1000ppm + 10ml methanol = 500ppm
- - 1ml of 500ppm + 4ml methanol = 100ppm
- - 2ml of 500ppm + 3ml methanol = 200ppm
- - 3ml of 500ppm + 2ml methanol = 300ppm
- - 4ml of 500ppm + 1ml methanol = 400ppm

Next, a calibration curve was plotted using the prepared working standards of different concentrations to determine linearity. This step was based on Beer Lambert's law, which states that concentration is directly proportional to absorbance. Finally, the extracts from soil and water were scanned to quantify the target substance.

2.6 Gas chromatography: The instrument was switched on and then programming of various temperature flow rate was done.

Programming:

Column – DB 624, 30mm, 3µm, 0.32 id

Injector temperature – 2500C

Flow rate N2 – 50cm/min

Pressure – 5.57 psi

Temperature – ramped to 2500C

Oven temperature – start at 1000C, raise it to 1800C at 250C/min, hold for 3min raise it to 2000C at 40C/min, hold for 1min and up to 2500C at 100C/min.

Detector – 2700C ECD

1µl standard solution of Acephate of 800ppm was injected into the injection port. After the standard was run, 1 µl of the extracts (from soil and water) were injected into the injection port under the same condition. Retention time of the standard and the extracts were noted down, also the peak area, for quantitation.

**Result and discussion:**

Acephate, a water soluble pesticide was spiked in water (500ppm). It was extracted using SOLLE (sugaring out liquid liquid extraction) and LLE (liquid liquid extraction).

3.1 Thin layer chromatography: Selection of suitable solvent system for Acephate. The existing normal solvent system, mentioned in DFS manual, hexane and acetone, does not give good result for acephate.

Spraying reagent: 2% Para nitro benzyl pyridine and 10% Tetra ethylene pentamine. After the TLC was run, the plates were sprayed with para nitro benzyl pyridine. The plates were kept in oven for 5min at 1000 C. The plates were removed and sprayed again with tetra ethylene pentamine. Blue color spots were observed, indicates thiophosphorous group. Rf value was calculated after spraying with reagent.

Various solvent systems were used and found chloroform, methanol (9:1) and dioxane, methanol, ammonia (9:1:4µl) to be the most suitable solvents for acephate as the spots were resolved, prominent and round. (See Table.1 and 2). The spray reagent used was stable upto 5 hrs, after which the color of the spots on the TLC plate disappeared.

3.2 UV-vis spectrophotometer: The result of qualitative analysis of extracted samples are given in (Table .3).

Linearity graph: (see Figure: 2).

3.3 Quantitative analysis: The calibration was made from 100ppm to 500ppm.

The lamda max of the standard and the extracted samples were

**Table 6. Data interpretation by GLC.**

| Sl. no. | Name | Retention time (min) | Peak area | Concentraction (ppm) |
|---|---|---|---|---|
| 1. | Acephate standard | 4.100 | 13716.153 | 800.00 |
| 2. | Extraction by SOLLE method | 4.072 | 8184.026 | 477.33 |
| 3. | Extraction by LLE (Hexane:Acetone, 1:1) | 4.048 | 4149.373 | 242.01 |
| 4. | Extraction by LLE using hexane | 3.978 | 2558.796 | 149.24 |

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found to be similar i. e. 270nm (see Table. 3) . Quantitative analysis was performed for the extracts from water and found to have 94.71% by SOLLE, 54.71% by LLE (hexane:acetone 1:1), 28.18% by LLE(hexane). Thus, the use of SOLLE technique for the extraction of Acephate was found to be better than LLE method using hexane or hexane:acetone (1:1). (See Table. 4 and 5).

3.5 Gas chromatography:

Programming: Column – DB 624, 30mm, 3µm, 0.32 id

Injector temperature – 2500C

Flow rate N2 – 50cm/min

Pressure – 5.57 psi

Temperature – ramped to 2500C

Oven temperature – start at 1000C, raise it to 1800C at 250C/min, hold for 3min raised it to 2000C at 40C/min, hold for 1min and up to 2500C at 100C/min.

Detector – 2700C ECD

Amount of injection – 1µl

I. Standard acephate (See Figure:3).

II. Extract Sample from Solle (See Figure:4).

III. Extract sample from lle using Hexane: Acetone, 1:1 (See Figure:5).

IV. Extract from lle using Hexane (2) (See Figure.6).

Calculation of concentration of Acephate in the extracts was done by comparing peak area.(See Table. 6).

Area of standard/concentration = area of the extract/ concentration of the extract i.e. concentration of Acephate in the extract = area of the extract x concentration of the standard/area of the standard 500ppm of acephate was spiked in each of the following extract procedure.

Percentage recovery of samples:

1. Extract using SOLLE – 95.46%.
2. Extract using LLE (hexane:acetone, 1:1) – 48.40%.
3. Extract using LLE (hexane) – 29.84%.

Thus, the use of SOLLE technique for the extraction of Acephate was found to be better than LLE method using hexane or hexane:acetone (1:1).

**Conclusion:**

The solvent system mentioned in Directorate of Forensic Science manual, Forensic Toxicology i.e, Hexane:Acetone for pesticides did not yield good result for Acephate pesticide, therefore, various other solvent systems for TLC were studied and the suitable solvent system found were Chloroform:Methanol (9:1) and Dioxane:Methanol:Ammonia(9:1:0.3). These solvent systems were comparatively better, because, the Rf values, shape of the spots. These solvent systems newly developed are not mentioned in the literature. The UV-Vis Spectrophotometric analysis is based on the experimental results and is not mentioned in the literature. The lamda max of the standard Acephate was found to be 271nm. The extraction of water soluble Acephate insecticide was done using LLE and SOLLE methods. The recovery percentage of the extracts from water using LLE was 48.40%, and 95.46% using SOLLE. Normally, LLE method of extraction is used for extraction of Acephate, so for better recovery percentage of Acephate, SOLLE method is suggested. The recovery percentage was done using Gas Liquid Chromatography. The percentage recovery was also studied using alternative technique, UV-Vis spectrophotometer and found to have 94.71% by SOLLE, 54.71% by LLE (hexane:acetone 1:1). So the percentage recovery of Acephate has been successfully done by using Gas Liquid Chromatography and UV-Vis spectrophotometry.

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ORIGINAL ARTICLE

# Perceptions of Medical Faculty towards Teaching Aids- Blackboard versus Power Point (PPT)

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**Abstract:**

Lectures were the most common form of teaching-learning method in medical school. It has its own merits and demerits. Use of black board in lecture was traditional method since ages. With the advance of technology, use of Power point presentation and smart boards became popular and preferred teaching aid than black board. In recent times the use of electronic media has become commonplace in Universities, as well as secondary and primary schools. Recent studies have sought to determine whether using PowerPoint or other such media are superior forms of delivery for lecturing over the traditional 'chalk and talk'.Many studies have reported about perceptions of students towards teaching learning aids PPT and chalk board. Present study was done to know perception of medical faculty (Clinical & Pre, Para clinical) towards teaching aids black board v/s Power Point Presentation. Total 90 faculty members were interviewed by prepared questionnaires using Likert scale. 87 faculties felt that PPT is an appropriate instructional aid for teaching present generation as against 59 for black board teaching. Majority of faculty agree that PPT helps better to organize the class instructions than chalk and talk method. 46 out of 90 faculty said that they need more time to prepare for the classes if they have chalk and talk as instructional aid as against 26 for PPT. Majority of them (84) feel that current generation of students usually prefer PPT as instructional aid than black board. Many agree that. Both instructional aid helps the students to be attentive throughout the session.

**Keywords:** Perception; Teaching aids; Blackboard; Powerpoint.

## Introduction:

Lectures have been the most common form of teaching and learning since ancient times.[1] Although discussion methods in small groups appear to be a superior method of attaining higher-level intellectual learning,[2] in India it is almost inevitable that medical students will experience lectures, as the number of students attending medical schools is too large in comparison to the teaching staff available. Hence, the lecture is here to stay, so it is immensely important that it should be as effective as possible.[3] During a lecture, both the visual and auditory senses are used to absorb information and here assistance in the form of a visual aid is useful.[4] A chalkboard is uniquely effective as a medium of classroom instruction and has been used commonly in lectures, while the use of transparencies with an overhead projector (TOHP) was also popular.[5] The once-popular 35-mm slide projector and TOHP seems to be headed for extinction. Recently the use of electronic presentations has become common and Microsoft PowerPoint (PPT) is now the most popular package used out of all electronic presentations.[6] PPT-based lectures are increasingly being delivered in medical colleges as in other colleges and universities.[7] However, educationists are divided on the superiority of PPT with respect to the traditional chalk and talk method.[8] Various studies have been conducted to assess the effectiveness of lectures using PPT or other such media in comparison to lectures using chalkboard, or the use of TOHP. According to one study, traditional classes with blackboard presentation were the most favored by students from biomedicine and medicine courses[9] while another study observed that most students preferred PPT presentations over traditional presentations (eg, chalk and talk).[10] It has been suggested that the use of PPT can help teachers to 'help their students learn'.[11] Hence, there is a mixture of views based on the studies and it is not clear whether a particular lecture delivery method is superior to others. Moreover, most of these studies have been conducted in the developed countries and the area has not really been explored in the developing countries where factors like power disruptions are important considerations. Therefore, the present study was planned in a medical college in the state of Pondicherry, India, to assess the faculty's perceptions of the impact of PPT presentations in lectures compared with the traditional chalk and talk method.

## Materials and methodology:

This cross sectional study was conducted in a medical college

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using the structured and pre tested questioner. The faculty involved in teaching (Pre, Para & clinical departments) was included in the study. The structured and pre tested questioner was administered with closed ended questions to 90 consented faculty of various departments in medical college. The closed ended questions have been framed using five-point Likert Scale (Strongly agree, Agree, Neutral, Disagree, Strongly disagree). As a part of the questionnaire validation process, we invited three faculty and ten students, to pilot test the initial survey draft. The questionnaire was modified based on their feedback and used for collection of data.

The data obtained were coded and entered into MS-Excel 2010. The data was analyzed using descriptive statistics like mean, median, standard deviation and percentages.

**Results:**

A total of 90 faculty participated in the study. Majority of the faculty were from pre clinical and Para clinical departments. 60 % of the staff were females and the remaining 40 % were males. 23 % of the faculty were Professor, 25% were Associate Professor and remaining 52 % were Assistant Professor and tutor.

As seen in table 1and 2, 20% of the staff strongly agreed that blackboard as an appropriate instructional aid whereas 56% of the staff perceived that PPT as an appropriate instructional aid. The perception of faculty regarding preparation for the class was that 53% disagreed for no much preparation required when black board is used and 47% agreed that not much preparation required when PPT is used.

35.5% of the teaching staff agreed that they like to use PPT as a teaching aid. 49% of the study subjects agreed that they feel professional when using a black board where as 59 % perceived PPT to be more professional.

**Discussion:**

The teacher's job is to find a way to help students understand something new. They do this by interpreting the information in ways that make it digestible, relatable, and meaningful. They convey information largely by discussion, but sometimes media other than vocal delivery or through the greatest efficacy they possess. The four most common modalities for conveying information are visual, verbal, aural, and kinesthetic. A good teacher tries to use all four. An effective teacher can bridge the gap between the learner and the knowledge being taught. He knows what their instructional level is and sets conditions for success. There is an intimate connection between the teacher and the learner. Effective teaching is a dynamic relationship between a teacher and a student. It is creating conditions for success based on the needs of the learning. There is no more complicated and

| Statements regarding perception | Black Board | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Strongly agree | | Agree | | Dis-agree | | Strongly disagree | |
| | No | % | No | % | No | % | No | % |
| I feel it is an appropriate instructional aid for teaching present generation | 18 | 20 | 41 | 45 | 25 | 28 | 06 | 07 |
| It helps to organize the class instructions | 09 | 10 | 43 | 48 | 33 | 37 | 05 | 06 |
| I usually look for availability of this instructional aid for my classes | 19 | 21 | 38 | 42 | 26 | 29 | 07 | 08 |
| I often use old prepared content for taking same topics for different batch of students every year | 01 | 01 | 14 | 16 | 46 | 51 | 29 | 32 |
| I need not prepare much for the classes if I have these instructional aids | 02 | 02 | 10 | 11 | 48 | 53 | 30 | 33 |
| I prefer to take class only with this instructional aid | 11 | 12 | 20 | 22 | 43 | 48 | 16 | 18 |
| This aid makes me feel confident when delivering instructions | 21 | 23 | 43 | 48 | 22 | 24 | 04 | 04 |
| I feel that current generation of students usually prefer this instructional aid | 05 | 06 | 23 | 26 | 47 | 52 | 15 | 17 |
| With this aid I can make the effective use of class time | 17 | 19 | 32 | 36 | 33 | 37 | 09 | 10 |
| This instructional aid helps me to cover vast content | 02 | 02 | 22 | 24 | 51 | 57 | 15 | 17 |
| This instructional aid helps the students to be attentive throughout the session | 21 | 23 | 33 | 37 | 27 | 30 | 09 | 10 |
| Technical problems/discomfort associated with this instructional aid often troubles the teacher | 02 | 02 | 15 | 17 | 50 | 56 | 23 | 33 |
| This aids my ability to present the information in a clear , organized & understandable manner | 17 | 19 | 46 | 51 | 18 | 20 | 09 | 10 |
| I feels professional with this instructional aid | 17 | 19 | 41 | 45 | 24 | 27 | 08 | 09 |
| This aid promotes my ability to express | 31 | 34 | 47 | 52 | 08 | 09 | 04 | 04 |

| Statements regarding perception | Power-Point (PPT) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Strongly agree | | Agree | | Dis-agree | | Strongly disagree | |
| | No | % | No | % | No | % | No | % |
| I feel it is an appropriate instructional aid for teaching present generation | 50 | 56 | 37 | 41 | 03 | 03 | 0 | 00 |
| It helps to organize the class instructions | 49 | 54 | 37 | 41 | 04 | 05 | 0 | 00 |
| I usually look for availability of this instructional aid for my classes | 41 | 45.5 | 41 | 45.5 | 07 | 08 | 1 | 01 |
| I often use old prepared content for taking same topics for different batch of students every year | 10 | 11 | 26 | 29 | 40 | 44 | 14 | 16 |
| I need not prepare much for the classes if I have these instructional aids | 12 | 13 | 42 | 47 | 26 | 29 | 10 | 11 |
| I prefer to take class only with this instructional aid | 17 | 19 | 32 | 35.5 | 32 | 35.5 | 09 | 10 |
| This aid makes me feel confident when delivering instructions | 33 | 37 | 48 | 53 | 09 | 10 | 0 | 00 |
| I feel that current generation of students usually prefer this instructional aid | 48 | 53 | 36 | 40 | 06 | 07 | 0 | 00 |
| With this aid I can make the effective use of class time | 38 | 42 | 48 | 53 | 02 | 02 | 02 | 02 |
| This instructional aid helps me to cover vast content | 54 | 60 | 31 | 34 | 02 | 02 | 03 | 03 |
| This instructional aid helps the students to be attentive throughout the session | 20 | 22 | 34 | 38 | 26 | 29 | 10 | 11 |
| Technical problems/discomfort associated with this instructional aid often troubles the teacher | 34 | 38 | 39 | 43 | 13 | 14 | 04 | 04 |
| This aids my ability to present the information in a clear , organized & understandable manner | 39 | 43 | 45 | 50 | 06 | 07 | 0 | 00 |
| I feels professional with this instructional aid | 30 | 33 | 53 | 59 | 06 | 07 | 01 | 01 |
| This aid promotes my ability to express | 28 | 31 | 49 | 54 | 11 | 12 | 02 | 02 |

finer art to understanding this relationship and bridging this gap. Due to advancement in the field of technology and the same are being incorporated in the medical education system. Hence the PPT presentations, an advancement in black board teaching is mode widely followed and also accepted method of teaching. PPT has become the common presentation and teaching tool in educational and professional settings all over the world. It provides encouragement and support to staff by facilitating the structuring of a presentation in a professional manner. In the present study 51.5% of the staff preferred to take class using PowerPoint the reason being enabling the user to create dynamic, informational slides through the use of text, graphics, and animation. But in a study done by Vikas Seth et al.[15] only 30.64% and in a study done by Nicholson DT[16] 40% of faculty used PPT for their teaching at least some occasions.

In our study highlighting the perceptions of teachers regarding the teaching aids showed that the maximum no. of teachers (56%) felt that PPT is an appropriate instructional aid for teaching present generation. 54% of faculty felt that the PPT helps to organize the class instructions. Similar observations were expressed in Vikas Seth et al study. [15]

Most of the faculty members (53%) agreed that the current generation of students usually prefer this instructional aid which was even echoed by the studies done by Nicholson DT,[16] Garg A et al.[17] and Vikas Seth et al.[18]

There was an agreement among 60% of the faculty that this instructional aid helps them to cover vast content and promotes their ability to express (49%). Similar opinons were expressed in the study done by Nicholson DT.[16]

Nowadays students and learners need a way to gain their knowledge in easy and interactive ways than before. The power point was an innovating tool that surged in the '20s. It changed, the way the classroom was made of giving the student audio-visual support. The communication and teaching tools have become interactive through the necessity of the market. The student and trainee stay in front of a screen over few hours, so the education must find a way to be more “aggressive”, in terms of solutions and interactive proposal. The Learning Management systems, the evolution of the traditional education way, are the solution for this matter.

Blackboard is a basic LMS that offers many integrations and solutions to the users and institutions; it's been used a long time ago since the LMS started in the market. While using the blackboard, a teacher personally repeats to the students what he read and understood about the subject he teaches. It allows for a lower speed of information output (writing speed which is slower than reading speed), which in turn encourages note taking. This was seen as perception of the 71 % of the teachers in the present study who felt confident while using a black board during their teaching. Similar observations are there in studies done by Ethel LB Novelli, Ana Angélica H Fernandes,[19] (77.5% of students) and Vikas Seth et al.,[18] (41.83%) of dental students were favoring the traditional blackboard teaching. Both Power Point and blackboards are mere tools. And their use (or abuse) is determined by the skill of the teacher.

To summarise, the choice of the tool must be dependent on what you're trying to achieve. PowerPoint and blackboard serve different purposes.

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ORIGINAL ARTICLE

# Determination of Sexual Dimorphism using Panoramic Radiograph –A Cross Sectional Study from Kerala, India

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**Abstract:**

Morphological features of mandible have a vital role in forensic anthropology. The objective of the study was to determine whether morphometric mandibular ramus measurements like minimum ramus width, maximum ramus width and condylar height from digital radiography can be used for the assessment of sexual dimorphism. Cross-sectional study from the 300 clear panoramic radiographs without any artefacts with the permanent dentition of adults between the age group 21 to 60 were included. Mandibular measurements were carried out using the standard inbuilt imaging Ez dent imaging software using anatomical points in the radiograph. Discriminant function analysis (DFA) was used to build a predictive model group based on gender. Receiver Operating Characteristics (ROC) curve was used to classify the gender with all three mandibular measurements. Males have higher values for all three measurements compared to female sex. Maximum ramus height coefficient (0.962) with large absolute values corresponds to variables with greater discriminating ability; while minimum ramus width (0.232) and maximum ramus width coefficient (-0.110) had lesser discriminatory function. ROC curve failed to discriminate gender for all three mandibular variables. Mandibular maximum ramus height was the most important predictor to assess sexual dimorphism in the present study. Morphometric measurements were accurate and in present study, DFA correctly classified 73.7% cases from Kerala population.

**Keywords:** Forensic odontology; Morphometric mandibular measurements; Discriminant function analysis.

## Introduction:

Identification of characteristics of an individual involves estimation of age, sex and ethnicity. In forensics, gender estimation is crucial since only people of the estimated sex need to be considered in the further investigations. Forensic skeletal remains are investigated to determine the gender of an individual based on anthropological metric and nonmetric analysis or biochemical analysis.

The whole body or skeleton when available for the study gender estimation becomes easy based on the physiologic and morphologic dimorphism exhibited by the human body. Forensic odontology forms a part of forensic anthropology. Various methods have been employed time to time to estimate age, sex and race of an individual. Morphometric analyses plays a major role in assessment of gender and male bone have found to be bigger and robust than female bones.[1,2] Mandible has been often recovered intact in the degenerated or burned skeletal remains due to the dense layer of cortical bone surrounding it. Morphological features of mandible have a vital role in sex determination. Numerous mandibular parameters have been put into study like minimum ramal width, maximum ramal width, gonial flexure, ramal height, coronoid height and position of mental foramen. The study in primates show that mandibular ramus exhibit marked sexual dimorphism since active bone remodelling takes place in ramus due to the different levels of masticatory forces and also due to varying growth trajectories in males and females.[3]

Digital panoramic radiography has been used as a routine investigation for diagnosis as well as treatment of various hard tissue and soft tissue related pathologies. The present study puts in use of the digital radiographic data of adults obtained as a part of routine dental evaluation and treatment for morphometric mandibular ramus measurements like minimum ramus width, maximum ramus width and condylar height for the assessment of sexual dimorphism.

## Materials and methods:

A cross-sectional study from the 300 digital panoramic radiographs was taken from the database of the department of Oral Medicine and Radiology from a tertiary care centre in Kerala after getting ethical clearance.

Inclusion criteria: Clear panoramic radiographs without any artefacts with the permanent dentition of adults between the age group 21 to 60 were included.

Exclusion criteria: Panoramic radiographs of the edentulous

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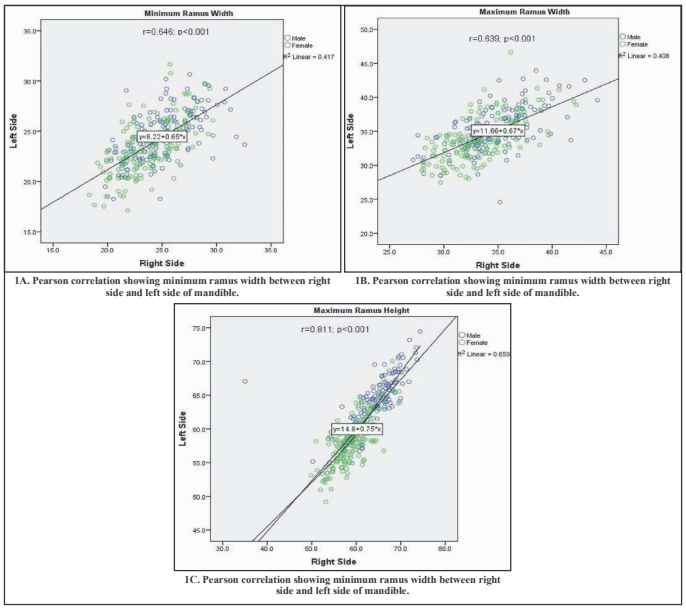


1A. Pearson correlation showing minimum ramus width between right side and left side of mandible.

1B. Pearson correlation showing minimum ramus width between right side and left side of mandible.

1C. Pearson correlation showing minimum ramus width between right side and left side of mandible.

**Figure 1. Pearson correlation showing relationship of height and width of mandible between right and left sides.**

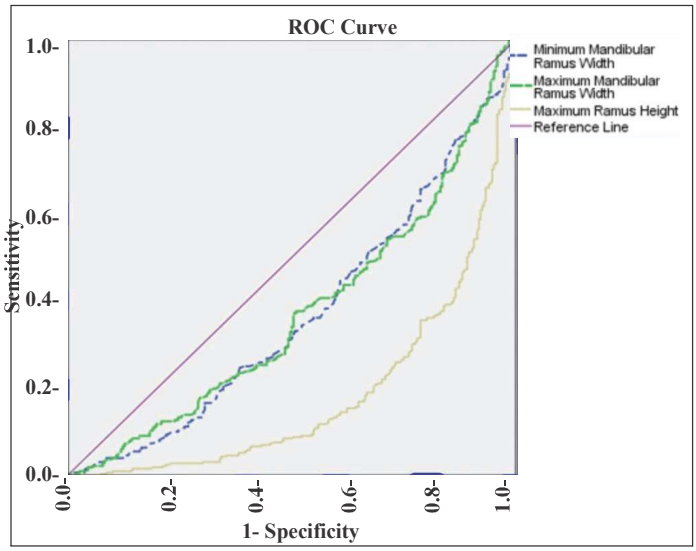


**Figure 2. Receiver operating characteristics (ROC) curve showing Discriminatory threshold of morphometric mandibular ramus measurements with gender.**

mandible, fractured mandibles of those having gross facial asymmetry, those with a history of orthodontic treatment or maxillofacial surgery were excluded from the study.

All digital radiographs were obtained using PaX-I digital panoramic and cephalometric machine of Villa tech (73kVp, 12mA, 13.9s). Measurements were carried out using the standard inbuilt imaging Ez dent imaging software using anatomical points in the radiograph. The following measurements were carried out

1. Minimum mandibular ramus width- the smallest anteroposterior breadth of the ramus[4]
2. Maximum mandibular ramus width-measured from anterior most point of the ramus and line connecting the most posterior point on the condyle and the angle of the jaw.[4]
3. Maximum ramus Height-Height of the ramus of the mandible from the most superior point on the mandibular condyle to the tubercle, or most protruding portion of the inferior border of the ramus.[5]

**Statistical Analysis:** Descriptive statistics for categorical data was represented in frequencies and for continuous data in mean (SD). Independent t test was used to study the age differences in males and females. Pearson correlation was used to study relationship between right and left side measurements. Discriminant function analysis (DFA) was used to build a predictive model group based on gender. The independent variables such as mandibular ramus measurements were used as predictors for determining gender. DFA assess how well the predictors separate the gender in mandibular measurements. Receiver operating characteristics (ROC) curve was used to classify the gender with all three mandibular measurements.

**Results:**

Out of 300 panoramic radiographs, 134 (45%) were selected from males and 166 (55%) were females, with mean age of 38± 11.6 years for males and 37 ± 11.6 years for females. The age distribution between the sexes were comparable (p= .702).

Figure 1 displays the correlation value which explains the relationship between right and left side measurements of mandible. There was a moderate correlation between the sides for minimum ramus width (Figure 1A; r=0.646; p<0.001). Moderate correlation was also seen for maximum ramus width between the sides (Figure 1B, r=0.639; p<0.001). Maximum ramus height displayed a strong correlation between the sides (Figure 1C, r=0.811; p<0.001).

Table 1 compares the mandibular measurements between the gender using DFA. Overall males have higher values for all three measurements compared to female sex. The Wilks lambda for Maximum ramus height was the lowest among three predictors (Lambda=0.704), with F =124.4, which can be considered as strong predictor among the mandibular measurements by DFA.

Table 2 explains whether any relationship present among the predictor variables selected. There was a moderate correlation between minimum ramus width and maximum ramus width (r=0.645), mild correlation was present between maximum ramus width and maximum ramus height (r=0.333). And no correlation was seen between minimum ramus width and maximum ramus height (r=0.251).

The canonical correlation value which measures the relation between discriminant score and gender was 0.551. The variance was 30%, estimated by square of the canonical correlation. 30% variance in dependent variable was explained by the predictors in the study. Standardized discriminant function coefficients allow comparing variables measured on different scales. Maximum ramus height coefficient (0.962) with large absolute values corresponds to variables with greater discriminating ability; while minimum ramus width (0.232) and maximum ramus width coefficient (-0.110) had lesser discriminatory function.

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**Table 1. Discriminant function analysis- mandibular measurements for males and females.**

| | Male | | Female | | Wilk's lambda | F | P value |
|---|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | | | |
| Min. ramus width | 24.8 | 2.4 | 23.5 | 2.3 | 0.934 | 20.9 | <0.001 |
| Max. ramus width | 35.0 | 2.9 | 33.6 | 2.7 | 0.947 | 16.7 | <0.001 |
| Max. ramus height | 63.9 | 4.3 | 58.8 | 3.6 | 0.704 | 124.4 | <0.001 |

**Table 2. Correlation coefficient between the predictor variables.**

| | Min. ramus width | Max. ramus width | Max. ramus height |
|---|---|---|---|
| Min. ramus width | 1.000 | .645* | .251$ |
| Max. ramus width | .645* | 1.000 | .333# |
| Max. ramus height | .251$ | .333# | 1.000 |

*- Moderate; #- Mild; $- No.

**Table 3. Unstandardized coefficient of mandibular measurements to Construct prediction equation for classifying males and females.**

| | Male | Female |
|---|---|---|
| Min. ramus width | 1.396 | 1.267 |
| Max. ramus width | 2.045 | 2.097 |
| Max. ramus height | 3.417 | 3.094 |
| Constant | -163.121 | -141.964 |

**Table 4. Classification statistics - mandibular measurements for males and females.**

| True Group | Predicted Group | | Total | % Accuracy |
|---|---|---|---|---|
| | Male | Female | | |
| Male | 95 (71%) | 39 (29%) | 134 | 73.7 |
| Female | 40 (24%) | 126 (76%) | 166 | |

Table 3 shows un-standardized coefficients for the predictors, which was used to construct the actual prediction equation for classifying new cases. Overall 73.7% cases with 71% Male and 76% Female were correctly classified by DFA in the present study (Table 4). Morphometric mandibular ramus measurements in ROC curve failed to discriminate gender for all three variables (Figure 2). The area under curve was least for maximum ramus height (0.184), while the minimum and maximum mandibular ramus width had 0.369 and 0.372 respectively.

## Discussion:

Overall males had higher mean values for all three (minimum ramus width, maximum ramus width and maximum ramus height) variables which can be used to construct the prediction equation for classifying new cases in Kerala. Overall 73.7% cases (71% Male and 76% Female) were correctly classified by DFA in the present study.

The age, sex and race form defining characteristics of an individual. The sex determination is carried out for identification in medicolegal cases and to identify the accident or natural disaster victims. Sex determination is considered to be the primary step since age and stature of an individual are dependent on it.[6] In situations where the whole body or skeleton is available sex determination can be done with the pelvic examination almost with 100% accuracy. For sex estimation, odontological and anthropological methodologies are utilised, both of which include different metric and nonmetric characteristics as well as biochemical studies. Odontological methods are based on sexual dimorphism in morphological and metrical features of teeth and adjacent structures (lips, mandible, palate, sinuses). It also involves biochemical structure of various tooth materials. Bitemark analysis, Palatal rugoscopy, cheiloscopy, tongue prints, digital imaging and dental records, DNA analysis, facial reconstruction profiling are a few among the odontological methods[7]. Anthropological methods are using morphological features and measurements of skeletal bones(skull, hip, sacrum, scapula, clavicle, sternum, humerus and femur mainly) as well as biochemical analyses of different skeletal materials.[8-10]

The role of Cranium in assessing sexual dimorphism is already known but an intact skull when not recovered, mandible is put to use. Because of the dense layer of cortical bone that covers it, mandibular bone is frequently recovered intact. Sexual dimorphism in mandible is evident since the bone is large in volume and robust in males compared to females. The different masticatory forces exerted by the males and females tend to influence the size, shape and mandibular flexure.[11] Mandibular ramal width, ramal height, condylar height, gonial flexure, inclination of synovial fossa, position of mental foramen were the few parameters studied to assess sexual dimorphism. In the recent study by Hazari et al the most prominent parameter showing the significant sex dimorphism was the mandibular ramus. Out of twenty morphometric studies of dry mandible 75% of studies showed a positive correlation between sex dimorphism and mandibular parameters. Mandibular ramal width and ramal height exhibited significant differences in both sexes.[12]

The craniofacial measurements which would likely contribute to sex differentiation were described by Stewart et al.[13] Hanihara et al assessed the sex difference in mandibles of Japanese population and found the parameters like mandibular symphysis height, mandibular ramus height, bigonial diameter, mandibular ramus minimum breadth contributing to the assessment.[14] The morphometric analysis of mandibular ramus width in American whites and Negroes had a remarkable sexual dimorphism compared to the mandibular body according to the study by Giles et al. The study also emphasize the fact that the assessment in a population cannot be extrapolated to another population.[15] In Korean population the anthropometric analysis done by Lin et al yielded results that favour the use of mandibular ramus measurements in sexing the individuals with 85.0% accuracy.[16]

The difference in the bigonial breadth and minimum ramus breadth exhibited by the male and female mandible were found significant by the study of Steyn et al in South African Whites.[1] Another study in South African population by Franklin et al highlighted the use of mandibular ramus to assess the sexual dimorphism. Mandibular coronoid height, ramal height and maximum mandibular length were found to be significantly different in males and females.[11] The study by Saini et al in Indian population used the parameters like minimum and maximum ramal breadth, height of ramus, condylar and coronoid height which reflected the significant role of mandibular coronoid height and mandibular ramal breadth. The study had a limited sample size and author's assumption of the effect of malnutrition which prevail commonly in Northern part of India affecting the study have been ruled out in our setting.[6] Another study done in Indians residing in South Africa by Ishwar Kumar et al reflected that males and females differed in the height of mandibular ramus to a significant level.[18] The significance of mandibular ramus

showing gender discrimination hence prompted us to do the study in our population.

The digital panoramic radiography has become a primary investigation to diagnose and treat common oral conditions. Schuller is being credited with the first to suggest the use of radiographs in human identification. He had studied the morphological variations exhibited by the sinuses in skull radiographs. Culbert and Law and Law have performed positive identification with measurements of mastoid sinuses obtained on skull radiograph and comparing with the antemortem data. Sassouni et al have discussed regarding the validity of use of different radiographs in obtaining the anthropometric measurements and highlighted the use of panoramic radiography as it ensures a high degree of standardization.[19] The principal advantage of digital panoramic radiograph involves broad coverage, low radiation dose, brightness and contrast enhancement, reproducibility, storage and computer aided metric analysis with the help of inbuilt Ez Dent imaging software. The technique is sensitive to patient positioning errors which could result in image distortion and magnification hence images obtained with standard positioning technique were only included in this study. Schulze et al had found that the Digital Panoramic radiographs are reliable in obtaining horizontal measurements and can be put to clinical use.[1] Kambylafkas et al. concluded that the use of the panoramic radiograph for evaluation of total ramal height is reliable and an asymmetry of more than 6% is an indication of a true asymmetry on the basis of study done by Kambylafkas et al.[20] Panoramic radiography has the advantage of cost effectiveness for gender and age estimation compared to the biological analyses and could be employed with ease even in fragmented skeletal remains.

An anthropological study done by Kumar MP et al in South India described significant differences in mandibular ramus breadth and height between males and females but the study warrants use of a combination of parameters rather than one alone.[21] Another study in South Indian population showed that bicondylar breadth, bigonial breadth and mandibular height measurements showed statistically significant difference in both the sexes and could form a baseline parameter in gender estimation.[22] A morphometric study on dry mandibles conducted in Pune, North India by Pokhrel and Bhatnagar depicted minimum and maximum ramus breadth showed very promising results and can be used for sexing from ramus of mandible.[23] Sex determination using digital panoramic radiographs were done in various cities of south India but not many studies have been done in the people of Kerala.

A retrospective study done in the population of Bangalore and Karnataka on the digital panoramic radiographs of complete dentate patients assessed five parameters like minimum ramus breadth, maximum ramus breadth, condylar height, projective height of ramus and coronoid height. This study by Indira et al highlighted the strong sexual dimorphism exhibited by mandibular ramus again. The mandibular ramus demonstrated greatest univariate sexual dimorphism in terms of minimum ramus breadth, condylar height, followed by projective height of ramus. Overall prediction rate using all five variables was 76%.[6]

The research done by Sairam et al on the panoramic radiographs in Andhra Pradesh measured five mandibular parameters and found male mandibles bigger than females and projective height of ramus exhibited greater sexual dimorphism.[24] Based on studies by Mathew et al in Mangalore, Karnataka comparing two parameters; gonial flexure and Minimum ramal breadth, minimum ramal breadth was found to be more useful to predict sex.[25] Poongodi et al described differences in both angular and linear dimensions of mandibular ramus in Chennai population and stated both measurements were significantly higher in males compared to females.[26] The above studies were consistent with the results of the present study.

**Conclusion:**

Mandibular maximum ramus height was the most important predictor to assess sexual dimorphism in the present study. Morphometric measurements were accurate and in present study, DFA correctly classified 73.7% cases from Kerala population.

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ORIGINAL ARTICLE

# A Retrospective Analysis of Age Assessment using Visual and Radiological Methods in South Indian Population

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**Abstract:**

Teeth are one of the most important biological indicators of ageing due to their high mineral content and resistance to change after death. Dental maturity indicates biological age for criminal, forensic, and anthropological purposes. When no information is known about the deceased, forensic human identification requires age estimation. This study used Lamendin's and Kvaal methods to evaluate and construct a regression model for dental age assessment in extracted single-rooted mandibular premolar teeth in south Indian population. Mandibular extracted first premolars were obtained from the patient from 15 to 75 years old. The patient details were blinded before analysis. The root height, root translucency, and periodontosis parameters were measured using Lamendin et al's technique. Based on the method proposed by Kvaal et al the morphological measurements of the teeth were calculated with six measurements for each tooth. In the results to determine the mean and standard deviation, descriptive statistics were used, and unpaired t-tests /Pearson correlation were used to compare age to other parameters and P-value <0.05 indicated as significant. South Indian population had a greater standard error of estimated age using Lamendin et al. and Kvaal's approach. Then modified Lamendin's and Kvaal's formula was used to South Indians and yielded accurate findings. This study concludes that the formula which was derived from the French population(Lamendin's) and the Norwegian population(kvaal's) does not apply to the South Indian population.

**Keywords:** Age estimation; Forensic sciences; Mandibular premolars; Lamendin’s method; Kvaal's method.

## Introduction:

The tooth is an extremely valuable biological indicator of age due to its mineralized composition and ability to withstand alterations after death. Dental maturity status is a dependable indicator of biological age, especially in the domains of forensic research, criminal investigations, and anthropology. Age assessment is vital in forensic human identification, especially in circumstances when there is a lack of information regarding the deceased person.[1]

Several factors, including genetics, race, diet, temperature, hormones, and environment, might potentially impact an individual's growth. Therefore, it is essential to assess age estimation techniques in a particular group utilising basic tools such as optical methods and digital imaging.[2,3] Dental radiographs, including intraoral periapical, bitewing, and orthopantomography, or a combination of radiographs involving the third molar tooth, hand, wrist, and cervical vertebrae, can be utilised to accurately calculate age until the onset of puberty.[4] However, precisely calculating age becomes difficult once the third molar has emerged, and the only things that assist in this procedure are the normal ageing process and regressive changes.

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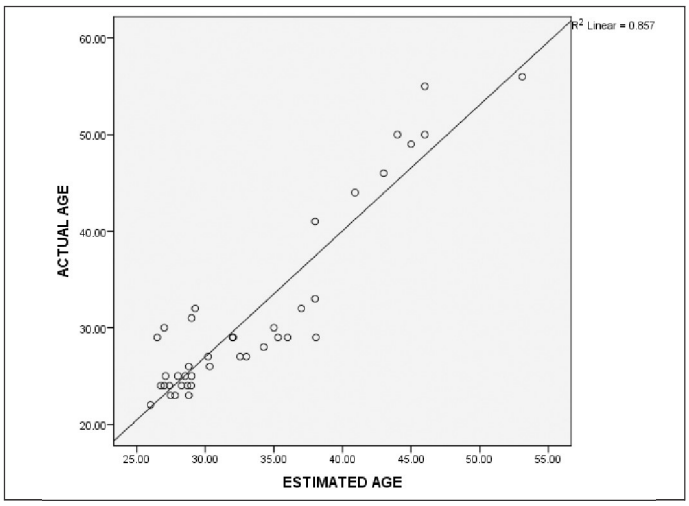
Age estimates based on root translucency are typically dependable for those who are 30 years old and older, providing a benefit compared to other measures of skeletal ageing that lose accuracy for those who are 50 years old and older.[5,6] Lamendin et al. performed a comprehensive evaluation of the patient's health by analysing the transparency of the tooth roots, the extent of periodonal retraction, and the length of the roots on both the labial and lingual sides of the teeth.[7,8]

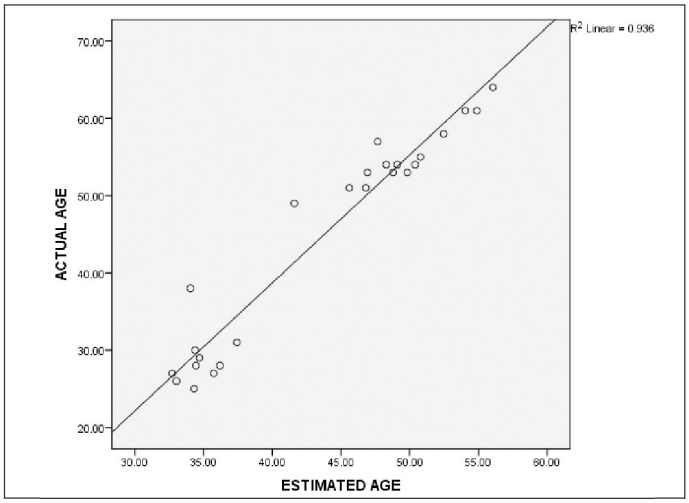
This approach is distinguished by its simplicity and lack of intricate equipment demands, rendering it highly versatile. Most studies have retrospectively utilised extracted teeth to determine an individual's age using this approach. Only a small number of recent studies have employed this technique on patients who have undergone panoramic radiographs, CBCT, digital intraoral radiography, and traditional intraoral radiographs (either alone or in a combination of maxillary and mandibular teeth). These investigations have yielded statistically significant evidence indicating a link between the actual age and the estimated age.[9] Insufficient research has been conducted to compare these two strategies for dental age evaluation. Thus, this study aimed to ascertain the chronological age and devise a new regression model for calculating dental age in extracted single-rooted mandibular premolar teeth. This would be achieved by employing Lamendin's technique and Kvaal's method in a population from South India.

## Methods:

A retrospective study was conducted in our institution's Department of Oral Medicine and Radiology. A total of 65




**Graph 1. Comparison of actual and chronological age in original formula.**




**Graph 2. Comparison of actual and chronological age in newly derived formula.**

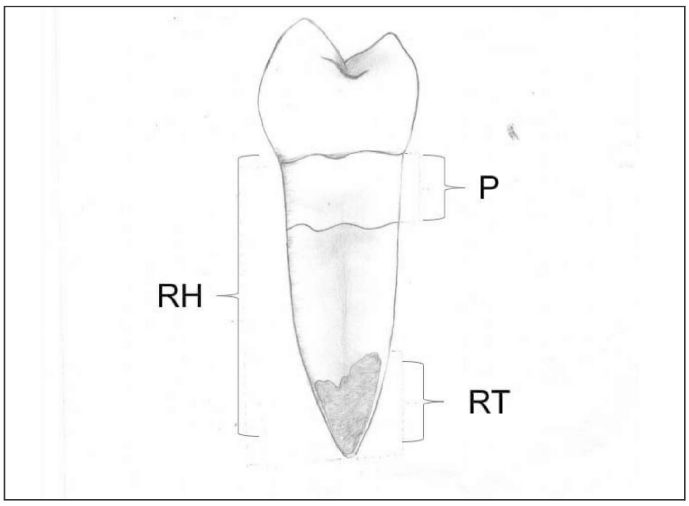



**Figure 1. Schematic representation.**

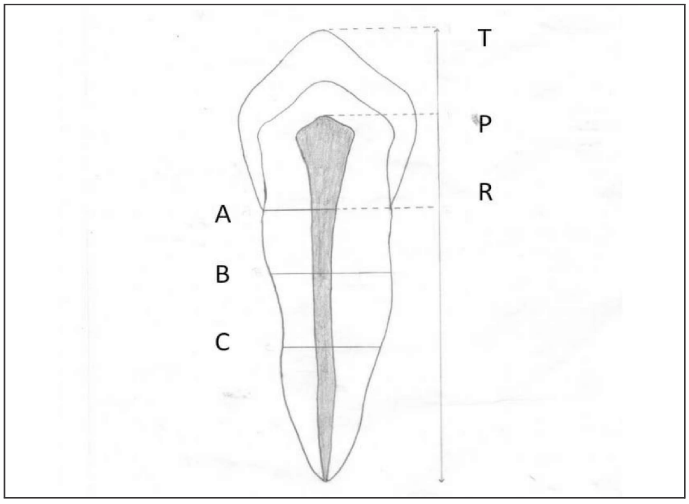



**Figure 2. Schematic representation.**
Tooth length/root length (T), pulp length/root length (P), pulp length/tooth length (R), pulp width/root width at level "a" (A), pulp width/root width at level "b"(B), pulp width/root width at level "c"(C).

mandibular premolars with a single root were randomly selected for analysis. Inclusion criteria encompassed individuals aged 18 to 75 years with documented date of birth, who had undergone tooth extraction for periodontal issues, orthodontic reasons, or any other cause.

Clinically absence of any developmental, endocrine, or nutritional problems that may impair tooth development, was considered. Exclusion criteria were teeth that had undergone restoration, had fractures, decay, or root resorption. The chronological age was calculated using Microsoft Excel by subtracting the date of birth from the date of tooth extraction. After sample collection, observers were blinded to patient data. All measurements were taken twice over 15 days by the same observer to reduce intra-observer bias. All the measurements were obtained to the millimeter. To test repeatability and reproducibility, 25 teeth were randomly selected from 65 teeth and all variables were re-measured by the observers.

Techniques: Lamendin's technique[10]: The data collection was done by using a visual technique where three measurements, namely Root height, Periodontosis, and Root translucency, were taken using a digital vernier calliper with a precision of 0.01 mm. The evaluation focused on the height of the root and the presence of periodontosis on the labial surfaces. Translucency of the root was assessed on the proximal surface of every premolar. The root height was measured as the distance from the tip of the root to the cementoenamel junction of the premolars. The periodontal height (periodontosis) was determined by measuring the greatest distance between the cemento-enamel junction and the line formed by the attachment of soft tissue on the neck and/or root of a tooth. The observation of root transparency involved examining the tooth under a strong light source in a darkened space and measuring the distance from the root apex to the highest point of visible transparency within the root [Figure-1]. The age was estimated using the following formula:

$$Age = (0.18 \times P) + (0.42 \times T) + 25.53,$$

where P and T are: P = (measured periodontal recession height × 100)/measured root height

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T = (measured root transparency height × 100)/measured root height

Kvaals Technique[11]: This is a radiographic technique, the analysis of the images was conducted using GIMP V 2.10 software, following the methodology described by Kvaal et al. The morphological measurements of the teeth were determined by calculating six measurements for each tooth, starting from the mesial aspect. Radiographs were taken using the Acteon X-mind DC X-ray machine with radiovisiography [Figure-2].

The additional analysis was performed by importing the quantitative data into Office Excel® 2007 (Microsoft®, Redmond, Washington, US). To calculate the age, the measured parameters were fed into Lamendin's formula and kvaals formula, a new regression formula was developed.

The obtained values were applied to the formula developed to estimate the age from mandibular premolars given by Kvaal's et al.

Age=133.0-318.3(M)-65.0(W-L)

W = Mean value of width ratios from level B and C

L = Mean value of length ratios P and R

W − L = Differences between W and L

Modified Kvaal's formula was made utilizing the ratios obtained from data sets

Age=123.22-141.2(M)-16.12(W-L)

Data analysis: Statistical analysis was done by using SPSS (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp. Released 2019). Descriptive statistics was done to assess the mean and standard deviation and to assess the gender difference unpaired t test was used and Pearson correlation was done between actual age and other parameters included in the study. P-value <0.05 was considered statistically significant.

## Results:

**Table 1: Pearson correlation between actual age and parameters in the study.**

| Parameters | Correlation coefficient | P-value |
|---|---|---|
| Root height | 0.023 | 0.281 |
| Periodontosis | 0.532 | 0.013* |
| Root translucency | 0.824 | <0.01* |
| P | 0.494 | <0.01* |
| T | 0.948 | <0.01* |
| Estimated age | 0.274 | <0.01* |

**Table 2: Comparison of estimated and chronological age.**

| Variables | Lamendin formula | | Newly derived formula | | P-value |
|---|---|---|---|---|---|
| | Chronological age | Estimated age | Chronological age | Estimated age | |
| Mean | 31.2250 | 33.2523 | 44.6800 | 43.6096 | |
| Std. Error of Mean | 1.51678 | 1.07562 | 2.74452 | 1.60290 | |
| Std. Deviation | 9.59297 | 6.80279 | 13.72261 | 8.01449 | 0.017* |
| Variance | 92.025 | 46.278 | 188.310 | 64.232 | |
| Range | 34.00 | 27.10 | 39.00 | 23.33 | |
| Minimum | 22.00 | 26.00 | 25.00 | 32.72 | |
| Maximum | 56.00 | 53.10 | 64.00 | 56.05 | |
| P-value | 0.092 | | 0.097 | | |

A significant correlation was seen between age and age-related indicators such as root transparency (r = 0.824, P < 0.001) and periodontosis (r = 0.532, P < 0.001). Nevertheless, there was no significant link observed between root length and age. [Table-1]. The mean age of the entire sample was 44.75 years with a standard deviation of 10.52. Lamendin's formula overestimated the chronological age of the research sample. Furthermore, a majority of the overestimated individuals were above the age of 40, The mean differences in Chronological age and estimated age between the age categories were statistically significant [Table-2]. A significant disparity was apparent within the age range of 50 to 65 years. Nevertheless, there was no notable disparity between genders in the measured and estimated values. Consequently, the regression equations were developed to estimate the age based on the root translucency and periodontosis characteristics for overall samples. The regression equation based on the data of the mandibular premolars is as follows: Age= (0.21 × P) + (0.49 × T) + 32.74. This equation was tested on a sample of 25 randomly selected mandibular premolars. The standard error estimation of ±5.5 Years in the modified lamendin's formula [Table 2].

Kvaal's technique revealed a significant correlation between chronological age and estimated age by using the parameters mentioned in the methodology [Table 3] with a P value < 0.01. The standard error of estimated age was (±11.5 years). The accuracy of the method for calculating age was assessed by comparing the estimated age to the recorded chronological age. When compared to the findings they obtained with the Norwegian population, it was discovered that the Kvaal's formula gave less accurate results in our population.

Based on the available data set modified Kvaal's formula for our population was derived.

Age=123.22-141.2(M)-16.12(W-L)

Modified kvaal's formula was tested in randomly selected 25 subjects and the same ratios were calculated and applied to the modified Kvaal's formula and age estimation was done. Standard error of estimated age by modified Kvaal's formula (±6.4 years).

The modified formula for both methods showed a significant reduction in standard error estimation of ±5.5 Years in the

**Table 3. Correlation coefficients between chronological age and ratios of measurements from dental radiographs and mean of the ratios from mandibular premolars.**

| Measurments | r-value |
|---|---|
| T | -0.21* |
| P | -0.365* |
| R | -0.112* |
| A | -0.499* |
| B | -0.630* |
| C | -0.585* |
| M | -0.681* |
| W | -0.523* |
| L | -0.309* |
| W-L | -0.516* |

P value: Level of significance <0.01 r: Correlation coefficient; B: Pulp and tooth width ratio at the midpoint between enamel cementum junction and mid root level; C: Pulp and root width ratio at the mid root level; W: Mean value of width ratios from level B and C; A: Pulp and root width at the enamel cement junction; P: Pulp length/root length; R: Pulp length/tooth length; L: Mean value of length ratios P and R; M: Mean value of all the ratios excluding T; T: Total length.

**Table 4. See comparison between lamendin's and kvaal's formula in south indian population and modified lamendin's and kvaal's formula.**

| Formula | SEE (years) in comparison with chronological age |
|---|---|
| Lamendin's formula<br>Age = (0.18 × P) + (0.42 × T) +25.53 | ±10.5 Years |
| Modified Lamendin's formula<br>Age= (0.21 × P) + (0.49 × T) + 32.74 | ±5.5 Years |
| Kvaal's formula<br>Age=133.0-318.3(M)-65.0(W-L) | ±11.5 Years |
| Modified Kvaal's formula<br>Age=123.22-141.2(M)-16.12(W-L) | ±6.4Years |

modified lamendin's formula and ±6.4 years in the modified kvaal's formula when compared to the original formula [Table 4].

**Discussion:**

Anthropologists, archaeologists, and forensic scientists have employed dental age estimation approaches worldwide. Accurate determination of dental age is crucial for identifying and reconstructing the biological characteristics of severely degraded, charred, or fractured remains. Even in advanced states, dental remains are regularly preserved and exhibit structural alterations that correlate to the individual's age.[12,13]

The Lamendin approach is a simple and basic method of age estimation that uses an extracted tooth. Due to the continuous formation of secondary dentin, it can be used as a dependable indicator to estimate age, even for individuals over the age of 21. The formation of secondary dentin follows a curved path instead of a straight path, and it is defined by chronological fluctuations.[14,15] Therefore, it is crucial to carry out research that can generate sufficient data to verify the dependability of this technique for calculating age. Premolars are preferred for these measures due to their single-root structure and large pulp canals. Lamendin technique was used on French people for the first time in 1992. Prince and Ubelaker carried out research in 2002 to devise a regression model to elucidate the morphological alterations in teeth, which were attributed to the impact of distinct populations in different geographical areas. The study group discovered a strong link between the projected age and the actual age. This study has developed a new regression equation primarily for the population of South India to ensure precise and reliable results. There was no noticeable difference between genders in the measured variables. This is consistent with the research by Lamendin et al. The level of root translucency demonstrated a significant positive connection with the chronological age of the overall sample, aligning with the results of Piyush et al. The study undertaken by Ackermann, Steyn, Piyush, et al., along with previous studies, produced consistent findings regarding periodontosis and root translucency. AB Acharya, Gupta, et al. exclusively employed the translucency measure in teeth that were sectioned on the ground and identified a strong positive correlation between dentinal translucency and chronological age. Martrille et al. (2007) did a study comparing four alternative approaches for calculating skeletal age in white and black individuals. The study concluded that Lamendin's method was the most accurate for those aged 41 to 60. Although there have been many studies investigating the accuracy of Lamendin's method in different age groups and communities, additional research is still required to ascertain its suitability in the field of forensic science.

Kvaal et al. devised a method to ascertain age by analysing six distinct teeth that are observable on an orthopantomogram (OPG) or periapical radiograph. The teeth mentioned are the maxillary central incisor, maxillary lateral incisor, maxillary second premolar, mandibular lateral incisor, mandibular canine, and first premolar.[16-19]

Gottlieb was the first to establish a correlation between alterations in dentition and the ageing process. In 1925, Bodecker presented evidence supporting the significance of secondary dentin's apposition in the context of the ageing process. Odontoblasts contribute to the development of secondary dentin over a person's lifetime, resulting in a reduction in the size of the tooth pulp cavity.[20,21] Secondary dentin deposition is currently recognrecognized as one of the contributing variables in the computation of dental age, along with attrition, cementum apposition, periodontal recession, apical translucency, and external root resorption.[22,23] A distinctive age estimation formula was developed using the ratios of length and width, as Kvaal's method demonstrated substantial mistakes in estimating age. The existing equation was subsequently assessed on a collective of 25 individual teeth.

Calculations were conducted to ascertain the ratios between tooth and pulp measurements, by Kvaal's approach, within the population of South India. The calculated age had a higher standard error of ± 11.5 years, in contrast to the ± 9.5 years standard error obtained in a study conducted by Kvaal and coauthors in the Norwegian population. The occurrence of this phenomenon can be attributed to ethnic inequalities and variances in the process of secondary dentin development among the population of South India. A recent study conducted by Babshet and his colleagues highlighted the imperative of formulating equations customized for certain populations, including ethnic variances. The absence of a substantial correlation between secondary dentin and age in the study can be attributed to the disparities in the formation of secondary dentin on the walls of the pulp chamber, which are influenced by factors such as race, ethnicity, nutrition, caries index, and lifestyle.

An evident correlation was found between the individuals' chronological age and the width ratios B, C, and W. The finding is consistent with the results documented by Bosmansa et al.[24]

Multiple studies have shown that the regression equations established by Kvaal et al are less significant in younger populations.[25,26] In contrast to previous research, our data demonstrate that we successfully determined the age of people in a group ranging from 21 to 75 years old, with an overall precision of ± 11.32 years. Regression models have been developed to estimate the age of individuals in the South Indian population using the results of this study.

The constraints of this study encompass the assessment of the newly formulated regression equation with a limited sample size. To strengthen the reliability of this technique for estimating the age of an adult using a single tooth, it is essential to validate the equation on a more extensive sample size that is tailored to both

the tooth type and the population being studied. Taphonomic and archaeological processes like burial can affect the accuracy of this method.

**Conclusion:**

Kvaal's and Lamendin's techniques are reliable in dental age estimation with Lamendin's method showing the nearest results. Future research complemented with multicentric analysis and a larger study population can validate its applicability in real-life forensic cases.

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CASE STUDY

# Modified Differential Extraction Protocol for the Identification of Suspect: A Case of Sexual Assault

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**Abstract:**

DNA fingerprinting is a standard recognized technology for individualization of suspect in criminal justice system. The identification of male contributors from high female and low male ratios through different body fluid mix's is still a major issue to address in forensic DNA laboratories. Traditional methods of separation of the male-female fraction are time-consuming and labour intensive and might give variable results. Currently, there remains scope to refine the method of differential extraction for better results. In the present case study, differential extraction was modified and it was noted that total male DNA yield was 1.561 ng/µl and 2.675 ng/µl in the spermic fraction of the vaginal slide and underwear of the victim, respectively. Although the underwear of the suspect contains female DNA in the non-spermic fraction was 7.864 ng/µl from the underwear of the suspect. Therefore, complete autosomal STR DNA profile of suspect was obtained from the victim vaginal slide and underwear due to significantly reducing the excessive quantity of female DNA using modified differential DNA extraction process. Thus, a modified method is recommended for a better male autosomal STR DNA profile in sexual assault cases.

**Keywords:** Sexual assault; Differential extraction; Spermic fraction; Non-spermic fraction.

## Introduction:

According to the National Crime Record Bureau (NCRB) sexual assault cases increased from 2005 to 2021 in India.[1,2] This data does not involve many sexual assault cases that were not reported or registered.[3] Moreover, there remains a huge backlog of such cases for processing in forensic and crime labs all over the country.[4,5] It is challenging to develop a robust and efficient method for producing full STR profiles of male DNA from a sexual assault sample with an excess of female epithelial cells.[6] Typically, the samples (swab, vaginal smear and clothes of the victim) recovered from sexual assault cases contain huge amounts of female DNA; hence the removal of female DNA from the male portion is very important in order to enhance the recovery of male sperm cells.[7,8] Traditional methods of separation of the male-female fraction are time-consuming and labour intensive and might give variable results.[9,10] Earlier, attempts were made to separate the male and female portions with a high reduction of female DNA carryover in the male DNA portion and minimizing male DNA loss[11,12] Y-STR or autosomal analysis is useful for the detection of the male component in a mixture of male and female DNA. The analysis of autosomal or Y-STR profiling depends on the quantity of DNA in the samples[13,14] Y-STR can confirm the presence of the Y chromosome, while an autosomal STR profile can be used to establish the identity of a male suspect.[15] Basically, the analysis of autosomal or Y-STR DNA depends on the male/female proportion of DNA in the mixed samples of rape cases.[16] Therefore, a comparative study was carried out to evaluate three different buffers with modifications in their incubation times to recover the maximum male DNA percentage.

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**Case history and samples:** A case was reported in which a 19-years-old victim was sexually assaulted when her parents had gone to work. A person who was living near her barged into her house and asked for some money but the girl denied it and said she did not have any money. The person was aggressive and he dragged the girl forcefully and raped her. During the medico-legal examination of the victim it is a duty of medical practitioner to collect important forensic evidence with standard protocol that may lead to justice.[17] In this case, vaginal slide, underwear and blood sample of the victim were collected by a medical officer. Two samples were collected from the suspect i.e., underwear and a blood sample during the medico legal examination and sent to a forensic science laboratory for investigation. Vaginal slides, underwear and blood of the victim were also collected for the present study in order to confirm the presence of the suspect's DNA and underwear of suspect for the analysis of female DNA. Suspect's blood sample was preferred as a reference sample for matching the suspect's DNA in all samples.

## Methodology:

3.1 Direct lysis: Single-step lysis and differential lysis were performed with all three samples, i.e., vaginal slide, underwear of

**Table 1. STR Profile of all processed samples with the recovered amount of DNA through a modified differential extraction procedure.**

| Exhibits | Direct lysis/ Differential lysis | Y-STR DNA Profile | Autosomal STRDNA Profile |
|---|---|---|---|
| Vaginal Slide of Victim | Direct Lysis | Complete Profile | Female Profile |
| | Spermic Fraction | Complete Profile | Male Profile |
| | Non-Spermic Fraction | Partial Profile | Female Profile |
| Underwear of Victim | Direct Lysis | Complete Profile | Female Profile |
| | Spermic Fraction | Complete Profile | Male Profile |
| | Non-Spermic Fraction | Partial Profile | Female Profile |
| Underwear of Suspect | Direct Lysis | Not Done | Mixed Profile |
| | Spermic Fraction | Not Done | Male Profile |
| | Non-Spermic Fraction | Not Done | Female Profile |

the victim and underwear of the suspect. In direct lysis, suspect stains were taken in a 2ml microcentrifuge tube. Lysis was performed in 500 µl of: *buffer C (Modified Differential Buffer), 50 µl of 20% SDS, 20 µl proteinase K of 20 mg/µl and 20 µl DTT of 1M. All samples were Incubated at 56°C for 1 hour.

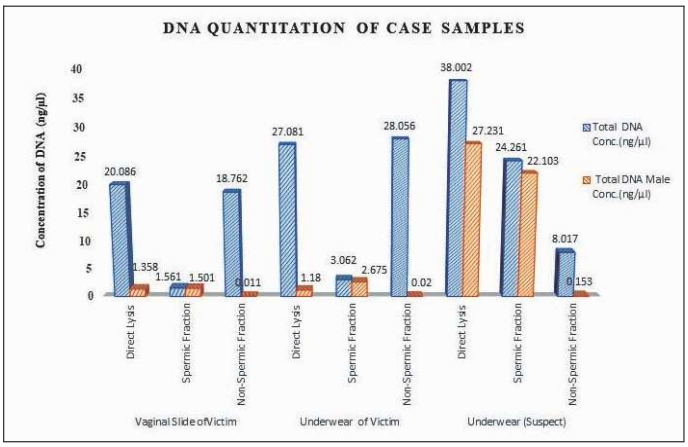
*Buffer composition will be disclosed later, as some studies are pending with this buffer.

3.2 Differential Lysis: Differential extraction was performed for the separation of male and female from the vaginal slide and clothing of the victim. Stains of the suspect were taken in a 2ml microcentrifuge tube. Preliminary lysis was performed in 500µl of buffer C (Modified Differential Buffer), 50µl of 20% SDS and 20 µl proteinase K of 20mg/µl. Both samples were incubated at 56°C for 30 min. Subsequently, samples were placed in spin basket for centrifugation at 7500 rpm for 3 mins. Spin baskets were then discarded and the samples were centrifuged again for male pellets. The remaining portion called female supernatant, was transferred into a new 1.5 ml microcentrifuge tube. The male portion was further lysed in a 400µl C buffer solution, 50µl of 20% SDS, 20 µl proteinase k of 20 mg/ µl and 20µl 1M DTT which was incubated at 56 °C for 30 min. DNA purification was done using automated DNA extraction system with Profiler™ Forensic DNA Extraction Kit as per manufactured protocol (Thermo Fisher, USA).

3.3 Quantification and Amplification: Isolated DNA was quantited by 7500 Real time PCR system (Thermo Fisher, USA) with the Promega Power Quant System kit as per manufacturer.[18] Autosomal STR and Y-STR marker amplification was performed using PowerPlex Fusion 6c multiplex system (Promega, USA) and PowerPlex Y23 multiplex system (Promega, USA), respectively as per manufacturing protocol. Amplification was done on VeritiTM 96-Well Fast Thermal Cycler (Applied BiosystemsTM).[19,20]

3.4 Genotyping: Amplified DNA fragment were analyzed on the Genetic Analyzer 3500 XL (Applied BiosystemsTM) using size standards and an allelic ladder provided by the manufacturer with the respective multiplex systems.[21,22] Data was analyzed through gene mapper software IDX 1.5 (Applied Biosystems TM).

3.5 Ethical clearance: This study ethical clearance was approved by the Institutional ethical clearance committee of Amity University, Haryana, vide latter No. IEC-AIB/AUH/2022-6, Date: 6th June, 2022.




**Results:** The selectivecase was examined through the standard differential extraction protocol with some modification. The RT-PCR data was obtained as described in Figure 1.

In the vaginal slide of the victim, the total DNA was found 20.086 ng/µl from which male DNA was only 1.358 ng/µl through the direct lysis process, whereas in the modified differential lysis procedure, the spermic fraction contains 1.561ng/µl total DNA from which the male DNA was found 1.501 ng/µl. Non-spermic fraction contains 18.762ng DNA and male DNA quantity was 0.011ng/µl.

In sample 2, underwear of victim the total DNA was found 27.081 ng/µl from which male DNA was only 1.18 ng/µl through the direct lysis process, whereas in the modified differential lysis procedure,the spermic fraction contains 3.062 ng/µl total DNA from which the male DNA was found 2.675 ng. Non-spermic fraction contains 28.056ng/µl DNA and male DNA concentration was 0.02ng/µl.

In sample 3, underwear of the suspect the total DNA was found 38.002 ng/µl from which male DNA was only 27.231 ng through the direct lysis process, whereas in the modified differential lysis procedure,the spermic fraction contains 24.261 ng total DNA from which the male DNA was found 22.103 ng. Non-spermic fraction contains 8.017ng DNA and male DNA content was 0.153ng.

STR profiles were obtained through all exhibits described in Table1.

**Discussion and Conclusion:**

The recovery of total DNA and male DNA concentrations with direct lysis and differential lysis, spermic fraction and non-spermic fraction were checked for quantity with two methods. Consequently, the reference blood sample of the suspect was analyzed to match the sample with the source of victim.

In sample 1,the direct lysis method was applied in the vaginal slide; DNA quantity of the female was found to be higher (18.728ng/µl) as compared to the quantity of male DNA (1.358ng/µl). The male to female DNA ratio was observed 1:13.79. Thus, we obtain a female autosomal STR profile due to the higher carryover of female DNA on male DNA. Consequently, differential extraction method was applied in

another replicate and two fractions were analysed i.e., the spermic fraction (MF) that contains1.501ng/µl male DNAand female DNA was reduced and foundin less quantity (0.06ng/µl). In non-spermic fraction the male loss was very minimal (0.011ng/µl). Due to differential extraction method, we obtained autosomal male DNA profile in the spermic fraction.

In sample 2 (underwear of victim)was processed with direct lysis and the female DNA quantity was found to be high quantity(25.901ng/µl)and the male was found to be low (1.18 ng/µl), where the male to female ratio was 1: 21.95. So, we are not able to obtain a male autosomal STR profile due to the excess amount of female DNA. In differential extraction method, the spermic fraction (MF) contains 2.675 ng/µl male DNA and the non-spermic fraction contains 28.036 ng/µl female DNA. The female carryover was reduced maximum and found to be only 0.387ng/µl in the spermic fraction through the modified differential method with lysis buffer C. Besides, the non-spermic fraction contains minimum loss of male DNA i.e., 0.021ng/µl.

In sample 3 (underwear of suspect) contains 27.231ng/µl male DNA and 10.771ng/µl female DNA through the direct lysis method, whereas in the differential extraction method, the spermic fraction contains 2.158ng/µl female DNA and in the non-spermic fraction the female DNA was 7.864ng/µl. So autosomal male profile was obtained in the spermic fraction and female autosomal profile was obtained in the non-spermic fraction.

The male DNA recovery was maximum with less female DNA carryover in the spermic fraction, whereas the female DNA quantity was higher in the direct lysis process. Although, minimum quantity male DNA loss in the non-spermic fraction. Thus, male autosomal profiling was not obtained through direct lysis of sample due to the high carryover of female DNA. The result of any DNA fingerprinting case depends on the type and condition of the samples which should be collected through standard procedure and proper precautions should be taken by the medicolegal officer. Otherwise, it is hard to get information from samples and the case could be reported as having inconclusive results.

Modified differential extraction was successful applied in sexual assault to identify suspect on victim source and victim DNA profile from successfully obtained from suspect source. Modified differential DNA extraction method will be play significant role in DNA analysis of sexual assault.

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**Conflicts of interest:** The Author(s) declare(s) that there is no conflict of interest'.

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CASE REPORT

# Stripped of Dignity and Murdered: A case report

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**Abstract:**
India has shown utter disregard and disrespect for women - rape, marital rape, sexual assault, harassment, female infanticide and dowry death are the best examples to cite this. These issues have been on debate for years after years with no definite result. Nearly 31,000 complaints of crimes committed against women were received by the National Commission for Women (NCW) in 2022, the highest since 2014.This is a case of an unidentified woman of about 24 years approx. who was found dead in the Jungles, Shillong. She was referred for post mortem examination to the department of Forensic Medicine in a tertiary hospital in North-East India. Autopsy findings revealed abrasions and bruises on the head and neck region with a ligature mark on the front and right side of neck. Internal organs were congested. Uterus and ovaries showed contusions. Fresh hymenal and perineal tear seen. There was evidence of spermatozoa in vaginal smear on microscopic examination. Assault against women is related with harmful health consequences and is regarded as a major public health problem. It is also a barrier for sustainable development goal of women on gender equality empowerment. The women facing brutality are more likely to view health workers as trustworthy for disclosure of abuse, hence it should be properly structured.

**Keywords:** Assault against women; Rape; Murder.

## Introduction:

India is the land where the feminine entity is being worshiped since ages in different forms and shapes, yet it is the same land where the violence against women is a major concern. Women irrespective of age, class, caste, education status, marital status, race and culture are still facing physical, sexual, emotional, psychological and economic abuse which is a barrier for women to acquire a sustainable development goal on gender equality and women's empowerment. This paper reports a case of murder involving rape. The word rape is derived from the Latin word “rapio” which means to snatch or, seize. The definition is different in different countries. In western countries a person of either sex can commit rape, whereas in India, legally only male can rape a female. Charlemagne, the Roman emperor (742-814 AD), first introduce medical evidence in case of rape. The issues of violence against women have been on debate for years after years, with no definite results. Even the stringent punishments introduced by “CLAA” could not change the stereotypic mindset of the mass. As per NCRB data, India lodges average 86 rape cases every day. Number of reported cases in 2020 were 28,046 and in 2021 were 31,677. Nearly “31,000 complaints of crimes committed against women were received by the National Commission for Women” (NCW) in 2022, “the highest since 2014”. Some of the tertiary hospitals in NE receive nearly 1200 cases of sexual abuse per annum that reveals the burden of it on health sector.

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## Case Report:

An unidentified woman of about 24 years was found dead in the jungles, around Shillong in October 2022 in the evening time. The body was found in half naked condition with only a floral top on. She was sent for conducting post mortem examination to the tertiary hospital of the area by the concerned Police Station. She was of average built having weight 45 kg and length 152 cm. Autopsy findings revealed crescentic abrasions on the lower border of right jaw, and on the right side of neck, 4cm below chin. Bruises were appreciated on the right side of chin along the lower border of jaw. Bruising over right eyelid with subconjunctival haemorrhage of both eyes was observed. Insect bite marks were found on the lower abdomen and thighs which were yellowish in colour and parchmentized. A dark brown ligature mark measuring 22cm in length and 0.6cm in width was seen in the front and right side of the neck that was transversely placed at a distance of 6cm below chin, 10cm above suprasternal notch. On dissection, bruising of neck muscles and subcutaneous tissues was observed which was more on the right side. Hyoid bone and thyroid cartilage were found to be intact. A religious string (Tabiz) was recovered near the body by the police, breadth of which is approximately equal to that of the ligature mark. This might have been used as ligature which could be either of the assailant or of the victim. Sub scalp and subdural hematoma seen on fronto-parietal area on both sides. Uterus and both ovaries showed patchy reddish and contused areas. Genital examination showed fresh tears in the hymen in 3 and 6 o'clock position which is mucosa deep with reddish margins. Perineal tear of skin deep situated 4mm in front of anal orifice noticed. Vaginal swabs collected and send for microscopic examination reveals presence of spermatozoa in vaginal smear. Histopathological examination

of uterus revealed presence of haemorrhagic areas and congestion with no evidence of pregnancy. Cause of death was given as death due to asphyxia resulting from ligature strangulation, homicidal in nature with evidence of recent sexual intercourse. Injuries sustained on the body were found to be antemortem in nature.

**Discussion:**

The case scenario is highly suggestive of brutality, violence and sexual abuse. Rape is a legal term, whereby the allegations need to be proved by evidence and facts. Sadly, the victim in this case isn't alive to put forward the facts, and hence the DNA from the accused can't be derived to come to a confirmatory conclusion. She came to the world with beautiful dreams but left the world as "unknown" in agony and pain. Rape is associated with harmful health consequences and is a major public health concern, like any other disease. It is silently prevailing in the society and is responsible for physical and phycological ill health of the


**Figure 1. Crescentic abrasions on the lower border of right jaw and on right side of neck.**


**Figure 2. Dark brown ligature mark on the right side of neck.**

survivor. "Researchers have distinguished the perpetrators of rape as sexual offenders and sexual killers".[1] Karakasi MV et al. have mentioned in their studies that "most offenders were in late 20's-30's". They are "non-psychotic at time of attack", however "the most notable characteristics seen in sexual killers is the lifelong social isolation". They also mentioned that "27.1% were in living in relationship" and these incidents include intense violence.[1] Meloy JR mentioned that "sexual behaviour may occur


**Figure 3. Religious string (tabiz).**

**Figure 4. Bruising of neck muscles and subcutaneous tissues on the right side of neck.**


**Figure 5. Fresh tears in the hymen.**

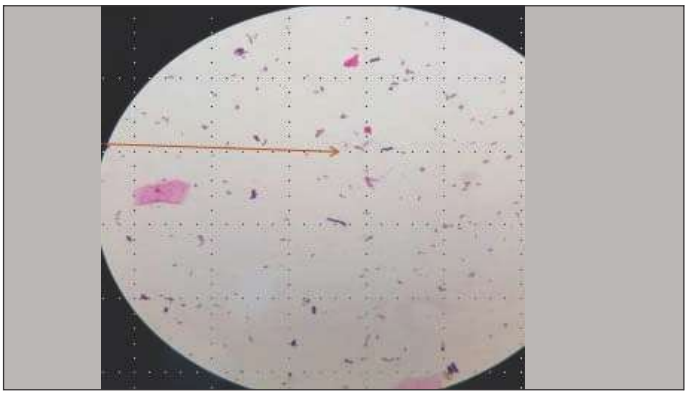

**Figure 6. Spermatozoa in vaginal smear on microscopic examination.**

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prior to, during or after the homicide".[2] Chan HCO have mentioned that "strangulation is the most common method of committing the homicidal act" in sexual offenders.[3] Grubin D conducted a study on 21 sexual murders and 121 men who only committed rape without attempting murder and he came to the conclusion that the most common factor responsible is "lifelong isolation and lack of heterosexual relationship amongst the sexual murderers".[4] Rape in India is covered under IPC 1860 which had little changes since the British colonial era. It was only after Nirbhaya case 2012, the Criminal Law Amendment Act 2013 came into enforcement that widened the scope and definition of rape. The punishments were made more stringent yet with little impact and no definite results. The Supreme Court of India has termed examination of a rape survivor as a "medicolegal emergency".[5] In spite of all the acts and laws, "rape is the fourth most common crime against women in India" as per NCRB data.[6] Memchoubi Ph et al have mentioned in their studies the incidence to be relatively high and "self-consumption of poison is the main cause of death" that isn't depicted in other studies.[7] Women encountering assault, more likely look upon health workers as trustworthy for disclosure of abuse, therefore the health system should ever be ready to support these women without being bias. In this context 'One Stop Centre' (OSC) have emerged over the years years that provide services in mental health, emergency department and primary care services to abused women since they are vulnerable, unsafe, and deprived of agency, which is a welcoming step.

**Conclusion:**

Rape is a heinous crime. The demand for equality by women creates insecurity in a patriarchal society. Only when the stereotype mindset of society is changed, maybe we can hope for a safe India for its women.

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BRIEF RESEARCH

# An Unconventional Method of Suicide by Corrosive Ingestion vis-à-vis Medicolegal Aspects – Autopsy based Brief Research

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**Abstract:**

Defining the word suicide is just misconstruing the gravity, essence and biology behind the mood, thought and behaviour of developing it. Suicide is not an act but a complex behaviour. As per literal meaning, it is just killing of oneself by himself. The method of suicide chosen by the victim depends on their availability of method and intensity of impending impulse of suicide. The authors here are discussing various autopsy cases of fatal ingestion of corrosives. The autopsy findings over the body, proper history and pattern-distribution of injuries over the body are correlated to each other to know the cause and manner of death. The injuries sustained over the gastrointestinal tract due to corrosive ingestion are compared with the findings observed by the authors in different cases. The legal aspect of the acid related injuries are also discussed. This method of suicide by corrosive ingestion is quite rare. The clinical symptoms, investigative observation and treatment outcome varies widely with case to case depending upon the patient profile, tissue affected and concentration of corrosive. However, detailed history taking, psychological profile of patient and medical expert's eye can diagnose the case on time which can save the patient with better prognosis.

**Keywords:** Corrosive poisoning; Suicide; Autopsy; Vitriolage; Caustics.

## Introduction:

Corrosives (strong acid and alkali) are substances that have a corroding and destructive effect on the human body. They are almost exclusively local acting and have very few systemic effects with the exception of generalised shock. Acids like sulphuric, nitric, hydrochloric etc. are potent desiccants with the ability to produce a coagulation necrosis and eschar formation of injured tissue. The extent and severity of chemical injury to the GIT depends upon the corrosive nature of the ingested substance, the quantity, concentration of the ingested substance and duration of contact.[1] Aqua regia (from Latin, literally "regal water" or "royal water") is a mixture of nitric acid and hydrochloric acid, optimally in a molar ratio of 1:3. It was named by alchemists because it can dissolve the noble metals like gold and platinum, though not all metals. It is used by the gold smith in diluted form to glisten the old ornaments made up of gold, silver and platinum due to its corrosive nature.[2] All caustics (The term caustic is often mistakenly presumed to denote an alkali, while actually it has a much broader meaning and refers to any substance which is corrosive and burning in nature. Obviously, this would include apart from alkalis, the more important group comprising acids both inorganic and organic) are highly injurious locally and produce burns of varying severity and intensity. Three phases of corrosive-tissue interaction have been recognised as Acute inflammatory phase, latent granulation phase and chronic cicatrisation phase.[3] Keeping the physical and chemical actions of the corrosive aside, this method of choice of suicide using acid ingestion is obviously unconventional and there must be enough factors to precipitate that leads one to ingest any corrosive. Not only that, the availability of acid restricted and scrutinised by the statute under the Corrosive And Explosive Substances and Offensive Weapons Act 1958. However, the acid though in the diluted form are still available for domestic purpose and in the concentrated form for the industrial use.

We are presenting herewith a case series of suicide by corrosive ingestion, discussing rarity of this mode of suicide, factors influencing the mode of suicide and legal issues concerning suicide in mental illness.

## Case Studies:

Case no. 1- An 18-year-old, unmarried male gold smith was brought to psychiatry outpatient department of hospital by his relatives. The patient had strong ideas of suicide and had made repeated attempts of suicide. On further enquiry he was found to have symptoms of sadness, easy fatigability, lack of concentration, sleeplessness, lack of appetite, loss of interest in work and daily activities of three weeks duration. Physical examination was unremarkable. Thus, on clinical evaluation a diagnosis of severe Major Depressive Disorder was made. During his follow-up days, he was brought to the emergency with pungent odour emanating from the patient. Patient became increasingly restless and was clutching his upper abdomen. On enquiry he complained of burning pain in the chest and upper abdomen. After history and general examination, a tentative

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diagnosis of acid poisoning was made. As the patient developed difficulty in breathing and became semiconscious, he was put on assisted breathing. The patient's condition gradually deteriorated and he died after 2 hours. The autopsy was performed 6 hours after the death. At autopsy, blackish discoloration of dorsal aspect of great toes and second toes of both feet eroding the nails with puckering of edges of the wound suggestive of corrosive acid burn (Fig. 1). They were due to the spillage of the ingested corrosive. Tongue was found swollen. The mucosa of esophagus was blackish discolored. The stomach contained about 30 cc of brownish mucoid material. Mucosa was thinned out with loss of rugosities and multiple erosions with base of ulcers greenish discolored (Fig. 5). The mucosa was deeply congested and haemorrhagic. All other internal organs were intact and congested. The stomach, loops of intestine, portion of liver with gall bladder, half of each kidney and spleen were preserved in rectified spirit and sent for toxicological analysis along with blood sample. The chemical examiners report was positive for hydrochloric acid and Nitric Acid in the viscera.

**Figure 1. Showing yellowish discolouration of mucosa due to xanthoproteic reaction after ingestion of nitric acid.**

**Figure 2. Showing localised oedema of base of tongue and oropharyngeal structures confroming the mode of intake i.e., ingestion of irritant substance not the inhalation.**

**Figure 3 & 4. Showing burns over the feet due to spillage effect of the corrosive ingested.**

Case no. 2 - We received a dead body of a male individual in the mortuary for medicolegal autopsy. On examination, the shirt was found bleached and decolorized from the right upper aspect. On further examination, Lips showed brownish discoloration at places. Base of tongue, pharynx and esophagus showed congestion, swollen and blackish discoloration over mucosal layer. (Figure 2). Larynx and trachea showed congestion. On dissection of abdomen, the peritoneal cavity was blackish discoloured and a perforation of size 1 x 1 cm was present over the anterior aspect of the upper part of the body of stomach along the lesser curvature. The whole stomach was pulpy and blackish in color. Mucosa was deeply congested and hemorrhagic with blackish discoloration at places. The viscera were preserved for detection of corrosive and the report came positive for hydrochloric acid. The opinion as to the cause of death was given as stomach perforation and its complications due to acid ingestion.

**Figure 5. Showing gastric ulcers with greenish base due to localised effect of sulfuric acid ingestion.**

**Figure 6. Velvety congestion of gastric mucosa after corrosive ingestion.**

Case no. 3- An old aged female was brought to the casualty with alleged history of assault under unknown circumstances. Patient was stabilized with initial resuscitative measures and was medicolegally examined and multiple blunt force injuries along

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with some burn injuries were noted. She succumbed to death within 3 hours of admission and the body was brought to the mortuary for medicolegal autopsy. After taking detailed history and initial external examination, the deceased was 84 years old female, a follow up patient of chronic insomnia and was on drug alprazolam. On external examination, the clothes worn by the deceased were brownish stained.

Chemical burns over an area of size 53 × 42 cm were present involving the anterior aspect of lower part of left side of chest including left breast, anterolateral aspect of left side of abdominal wall, lateral aspect of left gluteal region and upper part of left thigh. Burns were blackish with reddish discoloration at places and leathery touch. It was muscle deep at places under anterior aspect of abdominal wall. Superficial chemical burns were also present over the top of bilateral shoulder region, chin, focally at anterior aspect of neck and chest region more so over the left side suggestive of spillage burns. Reddish abrasions were present over the anterior aspect of right knee joint, medial aspect of left knee joint, anterior aspect of left leg, anterior aspect of left leg, medial malleolus of right ankle joint. Lips and tongue were blackish and eroded. Mucosa of the oral cavity including hard palate was blackish and eroded. Mucosa of the esophagus was blackish and eroded all over the length. Stomach contained about 50 cc of blackish mucoid material. Mucosa was eroded. Preserved for chemical analysis along with its contents the report came positive for sulfuric acid. The cause of death was given as corrosive acid burn and its complication.

Case No. 4- A dead body of an adult male individual was received for medicolegal autopsy after ingestion of some unknown corrosive substance. On examination, Lower incisor teeth shows brownish discoloration in their base. Esophagus mucosa was hyperemic and black in color with sloughing of mucosa at places. Esophagus was adhered to posterior surface of trachea. Mucosa of Larynx was congested and sloughing was present at places. Trachea was Intact. On dissection and opening of the abdominal cavity, peritoneal cavity contained dark brown fluid. Peritoneum was sloughed and perforated at places. The stomach was blackened and the mucosa along the lesser curvature was sloughed and perforated at places. It was preserved for chemical analysis. The report for the chemical analysis came positive for Phenolic Acid.

**Discussion:**

We discuss here different types of caustics ingestion and find caustic as a cause of death a rare and unconventional method of suicide. Unconventionality of this method of suicide can be explained by offensive smell, risk of getting burned and fear of delayed death. Suicidal deaths by acid are though rare but more commonly related with homicidal death like vitriolage. Ingestion of acid is the only method associated with suicidal tendency but throwing acid over someone's face is the method found with homicidal cases. The mental status of a person, his intent to commit suicide and easy availability of methods are the various factors that play role in choosing this method as suicide. Though acid market is strictly under scrutiny by the regulating authorities but still it's easy to avail the acid by a person who is linked to the industry which uses strong acid. Acute corrosive poisonings are a serious social-medical issue, both from the sense of clinical presentation and the therapeutical approach as well. Such poisonings cause severe chemical injuries of the upper gastrointestinal tract, most commonly localized to the esophagus and the stomach, presented as difficult clinical signs, in which the clinical investigations are hard to perform, so the treatment and the outcome are often uncertain. The findings on physical examination of an acid ingested patient as reported by Kim N et al.[4] are localised erythema and erosions in the oropharynx. They reported the CT based tracheobronchial injury caused after acid ingestion. In the autopsy conducted by author, the findings were localised swelling of tongue and oral mucosa with multiple erosions of stomach mucosa with base of ulcers greenish discolored. However, the extent of GI tract injury following ingestion of a corrosive substance depends on a number of factors, including: ingested product formulation, concentration, ingested volume, pH, viscosity, mucosal surface contact duration, and the absence or presence of food in the stomach as stated by Hall A H et al.[5] Three of the corrosive acids are discussed here.

According to the literature, Nitric acid (aqua fortis; red spirit of nitre) is a clear, colourless, fuming, heavy liquid, and has a peculiar and choking odour. In concentrated form it combines with organic matter and produces a yellow discolouration of tissue due to the production of picric acid (xanthoproteic reaction)[6]. We have also observed yellowish tinge of the gums and teeth in the case no. 1. Nitric acid releases oxides of nitrogen into the air upon exposure to light. Therefore, exposure to nitric acid potentially involves exposure to oxides of nitrogen, especially nitrogen dioxide. Nitric acid is formed in photochemical smog from the reaction between nitric oxide and hydrocarbons. Individuals living in heavily polluted areas may receive chronic inhalation exposure to nitric acid. Usual fatal dose is about 20 to 30 ml. Zargar et al.[7] in a retrospective study, stated that grade 3b lesion was the most common type found on endoscopy. In the case no. 3 of sulfuric acid ingestion reported by author, the findings were as follows; lips and tongue were blackish and eroded, mucosa of the oral cavity including hard palate was blackish and eroded, mucosa of the esophagus was blackish and eroded all over the length. Stomach contained about 50 cc of blackish mucoid material. Mucosa was eroded.

Sulfuric acid is probably the most widely used industrial chemical in most parts of the world including India. It is used as a feedstock in the manufacture of a number of chemicals. About 20 to 30 ml of concentrate sulfuric acid. Deaths have been reported with ingestion of as little as 3.5 ml. If the amount ingested is significant, there will be signs of shock, with collapse, a weak and rapid pulse, hypotension and possibly death, even if treatment is available straightaway.[8] In a case reported by Aouad R et al.,[9] a person with ingestion of sulfuric acid presented with decompensated hemodynamics and developed acute respiratory distress syndrome, acute renal failure, disseminated intravenous coagulation, bilateral pneumothorax, and cardiac arrest. In literature the systemic effects of sulfuric acid ingestion are metabolic acidosis, particularly following ingestion. Acidosis may be due to severe tissue burns and shock, as well as absorption of acid.[3] The systemic effects of sulfuric acid also causes death of

person however, the localised effect on gastrointestinal system leading to peritonitis was cause of death in the sulphuric acid ingestion case reported by the author.

Carbolic acid when pure consists of short, colourless, prismatic, needle-like crystals, which have a burning sweetish taste, which turn pink and liquefy when exposed to air. The commercial carbolic acid is a dark-brown liquid 10 to 15 g. The accidental ingestion of carbolic acid by paediatric age group is common due to its use in households. The property of getting absorbed via stomach mucosa is the unique property which differentiates it from other caustics. This is the reason of recommending gastric lavage in cases of carbolic acid ingestion though being of it a corrosive. Phenol is readily absorbed through multiple routes of exposure (ingestion, dermal, inhalational) and distributes widely through the body within minutes. The systemic complications of severe phenol toxicity are myriad. Mental status depression or seizures may result in airway compromise and respiratory failure. Acute respiratory distress syndrome (ARDS) may necessitate mechanical ventilation. Ventricular arrhythmias and/or cardiovascular collapse may occur. Acute kidney injury requiring dialysis may result from extensive rhabdomyolysis or haemoglobinuria due to intravascular haemolysis.[10]

As we have discussed medical implications of corrosive ingestion thoroughly now coming to legal implications related to manner of deaths in cases of corrosives. Legal implications related to suicidal deaths in cases of corrosives: Whoever attempts to commit suicide and does any act towards the commission of such offence, shall he punished with simple imprisonment for a term which may extend to one year [or with fine, or with both]. In P Rathnam v. Union of India held section 309 was unconstitutional and void for it violates Article 21. The court also observed that the provision is cruel as it once again punishes a person who had already suffered agony and as a result of which that person attempted suicide. Recently, an attempt to partially decriminalize this section has been made by the government through the Mental Healthcare Act 2017, which says that "any person who attempts to commit suicide shall be thought to suffering through heavy stress and thus not guilty unless proven otherwise". The most important question that takes place is; what is the limit of severe stress while deciding the case of an attempt to suicide?[11]

Legal implications related to homicidal deaths in cases of corrosives[12]: Vitriolage or vitriol throwing - It consists of throwing of strong sulphuric acid or as a matter of fact, throwing of any concentrated mineral acid, Corrosive alkalies, Carbolic acid or the acrid juice of Semicarpus Anacardium over the face or body of the victim. The purpose or motive is to disfigure the face, destroy the vision or to cause bodily injury or disfigurement of body or even destroy the costly garments or to take revenge.

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|---|---|---|---|---|---|
| 326 A | Voluntarily causing grievous hurt by use of acid, etc. | Imprisonment for not less than 10 years but which may extend to imprisonment for life and fine to be paid to the victim | Cognizable | Non-Bailable | Court of Sessions |
| 326B | Voluntarily throwing or attempting to throw acid | Imprisonment for 5 years but which may be extended to 7 years and with fine | Cognizable | Non-Bailable | Court of Sessions |

**Conclusion:**

Deaths by corrosives are being reported in developing countries. However, suicidal deaths using corrosive ingestion are quite rare and unconventional. The clinical symptoms, investigative observation and treatment outcome varies widely with case to case depending upon the patient profile, tissue affected and concentration of corrosive. However, detailed history taking, psychological profile of patient and medical expert's eye can diagnose the case on time which can save the patient with better prognosis.

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**Authors contribution:** All the authors contributed significantly in this case series.

**Conflict of interest:** None

**Ethical clearance:** In Indian legal system, consent of the relatives is not necessary for autopsy performed in medicolegal cases. As these are medicolegal autopsies, case series the particulars of the deceased are not revealed and kept confidential with the authors, so ethical clearance is not required in this present case series.

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LETTER TO EDITOR

# Silent Trauma: Unraveling the Legal Silence on Marital Rape in India

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Dear Editors,

This article sheds light on the severe mental trauma caused by marital rape, emphasizing the continued silence of the law on this issue, indicative of entrenched patriarchal norms. Despite the Justice J. S. Verma Committee's recommendation to amend the Rape Law and include Marital Rape as a crime under Section 375 of the IPC, no such changes have been made, neither in the Bharatiya Nyaya Sanhita, 2023. The only alteration introduced by the BNS is the age-related provision in Exception 2 of Section 63, stating that sexual acts with a wife not under eighteen years of age will not be considered rape. Marital rape is not a crime in India. The consent of a wife is not required by her husband if her age is over 18 years. This implies that forced sexual intercourse by a husband is considered a legal right. However, the law is silent on three crucial aspects: 1) the legal rights and remedies available to a wife, 2) her free consent for sexual intercourse with her husband, and 3) the mental or physical trauma experienced by a wife who has suffered from such acts within the four walls of the bedroom.

Around 14% of married women in the United States face marital rape, with 77% of these cases going unreported. The aftermath includes post-traumatic stress disorder (PTSD), depression, heightened anger, fear, and guilt, leading to a negative impact on self-esteem and resentment towards their bodies. Despite the belief that prior consent in marriage lessens the impact, victims of marital rape experience more profound and enduring psychological consequences than those assaulted by strangers.[1] The majority of sexual violence in India takes place within marital relationships; however, it is believed that only around 10% of individuals who experience spousal sexual abuse come forward to report such incidents.[2]

Moreover, women who fall victim to spousal sexual abuse frequently endure various forms of Intimate Partner Violence, encompassing physical, emotional, and psychological abuse. Consequently, they bear a notably heavy burden of exposure and psychiatric risk. This aspect has been disregarded by lawmakers for an extended period. Numerous studies indicate that the absence of appropriate laws often deters women from reporting these crimes occurring within the confines of their homes. As per the second exemption in Section 63 of The Bharatiya Nyaya Sanhita, 2023 states that sexual intercourse or sexual acts between a man and his wife, provided that the wife is not under eighteen years of age, are not considered rape. Thus law makers have left no scope for women above 18 years to file case against her husband.

Several married women reported experiencing sexual violence, encompassing forced acts, threats, and, in rare instances, forced prostitution. Instances of sexual harassment were prevalent in both their family and marital homes, involving vulgar language, marital rape, and incest. The impact of domestic violence on their health was substantial, with some women exhibiting signs of severe depression. Additionally, a few women reported sleeping disorders due to the fear of sexual assault by their partners. Suicidal thoughts were reported by some victims.[2]

One can observe a noticeable increase in cases of wife swapping in India, representing another form of crime against marriage. However, it's important to note that not all instances are reported and brought to public attention. Only a few cases have been reported and highlighted. As for these cases also directly, we don't have any provisions in our law.[3] Many women stay silent about sexual violence due to societal judgment and financial dependence on their husbands. It's crucial to address this medico-legal issue promptly, by involving legal and medical experts to provide remedies for victims.

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