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## Indian Journal of Forensic Medicine and Pathology

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## Awareness of Medical Ethics and Medico-Legal Issues amongst Medical Professionals

C.S. Makhani\* Madhusudan R. Petkar\* K.D. Chavan\*\* T.V. Rao\*\*\*

### ABSTRACT

**Background:** Over the years, medical professionals who once enjoyed the immunity from litigations and accountability in the court of law have found themselves in the crosshairs of the judicial system. The doctors have become service providers and their patients consumers. Medical Council of India, the statutory body governing the medical profession in India, has laid down certain guidelines for the medical professionals to follow. This study endeavored to assess the level of awareness of various ethical and legal issues and code of conduct amongst medical professionals (including general practitioners to various specialists) **Material and Method:** The study was conducted in the geographical region of Indore city for a period of one month from 1 Nov 2009- 30 Nov 2009. A total of 75 physicians, including general practitioners, specialists of various specialities practicing in Indore were selected using Radiant Medical Directory and were given a standardized questionnaire to answer. **Results:** 52.91% subjects answered correctly in the range of 65-80%, whereas 33.82% answered 45-60% answers correctly. A need was felt to enhance the awareness of finer aspects of medicolegal issues.

Key Words: Ethics; Medical Council of India; Code of Conduct; Medico-legal.

"Life is short and the Art long; the occasion fleeting; experience fallacious, and judgment difficult."

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### INTRODUCTION

Medicine is one of the most respected and revered professions the world over. Doctors are regarded as saviors who deliver the people from their afflictions. However, to prevent those who practice this profession from faltering in delivering their duties, code of medical ethics, etiquette and professional conduct were formulated as guidelines.

Egypt, Babylon, India and China had some of the oldest civilizations in the world, and evidence of existence of laws in relation to medicine during those times has been found. Medico-legal code practiced around 2200 BC, during the rule of the King of Babylon is the oldest known code of medico-legal conduct[1]. Hippocrates (460-377 B.C.) is the father of modern medicine. His guidelines known as the 'Hippocrates oath' have been, by far, the most revered and practiced principles of medical ethics the world over[2, 8]. In the present day, the *Geneva declaration* formulated by the World Health Association is a rephrased version of the Hippocrates oath practiced the world over [2, 8]. Under the provisions of the Act (No. MCI-211 (2) 2001-Regn) read with section 33 (m) of the Indian Medical Council Act 1956 (102 of 1956), the Medical Council of India, with the previous approval of the Central Govt. has made detailed regulations relating to the professional conduct, etiquette and ethics for registered medical practitioners and these have been published in the Gazette of India dated 06 April, 2002 (part III – Section 4) and are in force from the said date[9].

As per the Medical Council of India amendment act no.24 of 1964, the Council has specified a warning notice that violation of this code shall constitute "infamous conduct in a professional sense; i.e. it will be Professional Misconduct[9].

With the development of medical science, newer modalities of treatment are being invented everyday and with them newer medico-legal issues are cropping up. Growing commercialization in the society has also pervaded this noble profession, and a few doctors have resorted to unethical practices for financial gains. Use of touts, advertisements to lure patients, commissions for referrals and investigations, irrational prescriptions, prenatal sex determination, illegal organ transplants and growing instances of medical malpractice are just some of the glaring examples of the degradation of moral values and ethics in this once revered profession [10, 14]. Medical ethical problems that once were no more than entertaining speculations about the future are now a reality and medical ethics can no longer be regarded as a mere formality in the medical education [2, 8].

Control of medical profession by the legislative actions of the government through various legal provisions like MTP act, PNDT, CPA were enacted to curb the growing malpractice in medical profession.

Numerous verdicts of the courts on cases between doctors and patients have frequently been in favor of the patients which have proved the guilt of the faltering physicians [15, 17]. Reacting to these, the physicians have raised their concerns and have cautioned about the fear of prosecution which would compel the medical fraternity to attend the patients and do research with a guarded approach[18].

This project is a sincere effort to highlight the awareness of the various principles of medical ethics and codes of conduct amongst the medical professionals and to assess their approach in dealing with various issues confronting them and to invite opinion and suggestions from them.

### MATERIALS AND METHODS

The study was conducted in the geographical region of Indore city for a period of one month from 01 Nov 2009- 30 Nov 2009. A total of 75 physicians holding MCI recognized qualification, practicing allopathic medicine, including general practitioners, specialists of various specialties such as General Medicine, General Surgery, Pediatrics, Obstetrics & Gynecology, Dermatology, Ophthalmology, Otolaryngology practicing in the mini metropolitan town of Indore were approached to participate in the study. The names of the doctors were randomly selected from the 'Radiant Medical Directory' [19]. Of the selected doctors, 68 consented to participate and were given a standardized questionnaire of 20 multiple choice questions based on ethical and medico-legal issues a doctor would encounter in day- to-day practice. They were asked to choose the most appropriate answer. Percentage of correct response was calculated and the results were tabulated.

### RESULTS

Of the 75 medical professionals 68 consented to participate in the study. Of the 68 medical professionals, 21 were general practitioners, 15 were medical specialists including six super specialists, 14 were surgeons including five super-specialists, six pediatricians, five Obstetric and Gynecology specialists, three Ophthalmologists, two ENT specialists and two Dermatologists. (Table 1)

Of the 68 doctors who participated in the study, the majority of them- 49- (72 %) were in the age group of 35 to 45 yrs, 14 (20.5 %) were in the age group of 45- 55 years and 05 (7.3 %) were in the age group of 25 -35 years.(Table 2)

To tabulate the results easily, the respondents were divided into five groups based on the number of correct responses. Group A contained those whose response included 17-20 correct answers, Group B contained those whose response included 13-16 correct answers, Group C contained those whose response included 9-12 correct answers, Group D contained those whose response included 5-8 correct answers and Group E contained those whose response included 1-4 correct answers.

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Majority of the respondents 36(52.91%), based on the number of correct responses were placed in Group 'B', followed by 23 (33.82 %) in Group C, 06 (8.82%) in Group D and 02 (2.9%) in Group A.one (1.4 %) did not complete the questionnaire due to busy schedule. (Table 3)

### DISCUSSION

Majority of doctors had knowledge of the basic concepts of medical ethics and medicolegal issues; however, they lacked the knowledge of finer details of the subject.

S. No.	Specialty	Number
1	General Practitioner	21
2.	Medical specialist	15
3.	Surgeon	14
4.	Pediatrician	06
5.	OBGY	05
6.	Ophthalmologist	03
7.	ENT specialist	02
8.	Dermatologist	02
	Total	68

Table 1. Doctors of various specialties participating in the study

### Table 2. Age group of doctors participating in the study

S No.	Age group (yrs)	Number
1	25-35 yrs	05
2	35-45 yrs	49
3	45-50 yrs	14

Majority of them faltered in answering the following questions related to the following aspects:

1. Maintenance of Medical Records.

2. Difference between Infringement of Law and Code of Conduct.

3. Conduct of Drug Trials.

One hundred percent of respondents faltered in correctly answering questions from related to above topics. These topics as evident deal with the finer facts and details of the medical ethics and medico-legal issues.

As evident majority of the respondents 36(52.91 %) based on the number of correct responses, were placed in Group B, followed by 23 (33.82 %) in Group C, 06 (8.82%) in group

D and 02 (2.9%) in group A. one (1.4%) did not complete the questionnaire. The findings of the study are similar to the findings observed by Mohite et al[20].

The respondents were also asked to give their opinion about the reasons for lack of awareness amongst the medical community about the ethical and legal issues in medical practice. Lack of regular CMEs on medical ethics and medico-legal issues, over-confidence, less significance to medical jurisprudence during undergraduate curricula, near zero exposure to these issues during post graduation were some of the commonly cited reasons. The participating medical personnel acknowledged this as a need of the hour and felt that concrete steps were needed to upgrade their knowledge to keep themselves from faltering.

S.No.	Group	No. of respondents	Percentage %
1	A (17-20 ans/85-100% correct)	02	02.9%
2	B (13-16 ans / 65-80% correct)	36	52.91%
3	C (9-12 ans/ 45-60% correct)	23	33.82%
4	D (5-8 ans/ 25-40% correct)	06	8.82%
5	E (1-4 ans/5-20% correct)	00	00%
6	Not submitted*	01	1.4%

### Table 3. Grouping of participants as per the number of correct responses

\*Questionnaire was not completed, hence not submitted to the investigator.



Grouping of participants as per no. of correct responses

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Another fact which emerged from the study was that the rising instance of doctors being taken to court for medical negligence, despite being sincere in their efforts, is forcing the doctors to take a guarded approach in patient treatment. A fallout of the same is the rising cost of medical treatment, asinstead of relying just on their clinical acumen, the attending doctors are forced to get all the investigations of the patient done to protect themselves from future litigation.

### CONCLUSION AND RECOMMENDATIONS

This study was a sincere effort to assess the knowledge of medical professionals about medical ethics and medico-legal issues. The participating medical personnel were knowledgeable about the basic issues but lacked knowledge about the finer facts.

Thought the investigator broadly covered all the specialties the sample size was small. Subsequent studies using larger sample and bigger questionnaire would give better perspective of awareness of the issues under consideration. However, one of the recommendations which could be made from the present study is increased participation of local bodies and medical associations in holding seminars, CMEs for the doctors to increase awareness of newer ethical and medico-legal issues in medical practice.

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# Evaluation of preoperative informed consent procedure in obstetrics and gynaecological surgeries

Saubhagya Kumar Jena\* Basanta Kumar Behera\*\* Soumya Samal\*\*\* Mousumi Sen\*\*\*\* Manoj Kumar Mohanty\*\*\*\*\* Anugya Aparajita Behera\*\*\*\*\*

### ABSTRACT

**Background:** Informed consent is a two-way communication process by which the patients/parents/ guardians are provided the relevant and necessary information regarding the diagnosis and treatment. In the present study an attempt was made to find out the process (How, Who, Where & When) of obtaining informed consent in Obstetrical & Gynaecological surgeries. **Materials & Methods:** This crosssectional observational study was carried out in the Department of Obstetrics and Gynaecology at SVMCH & RC, Ariyur, Puducherry. Randomly, 132 post-operative cases were interviewed by a predesigned, pre-tested and structured questionnaire from 1st October 2011 to 31<sup>st</sup> December 2011. **Results:** In 21.2% of cases consent was not given by the patient and in majority (72.7%) of cases consent was taken by the nurse. In 75.8% of cases consent was taken on previous day or prior to it, consent was taken in ward in 92.5% of cases and duration of explanation was from more than five to fifteen minutes in 65.2% of cases. In 48.5% of cases nurses witnessed the consent process, but in 24.2% of cases consent was not taken in patients' own language. All the components of informed consent were explained to the patients in majority of cases. **Conclusion:** The process of obtaining informed consent still has to be improved.

Keywords: Informed consent; Gynaecological Surgery; Operative procedures.

### INTRODUCTION

At the start of their career, medical professionals are bound by an Oath to promote and safeguard the health of the patients. As go the words of 'Declaration of Geneva' of the

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World Medical Association - "The health of my patient will be my first consideration" [1]. With increasing awareness among the consumers regarding their rights, the medical fraternity needs to be more vigilant while dealing with patient care. Respecting the well being of the patient in clinical practice is the need of the hour.

The decision as to what has to be done with his/her body is in the complete autonomy of the patient[2]. The physician has to negotiate rather than dictate what has to be done with the patient's body. It is at the patient's complete discretion whether he/she agrees to or rejects the physician's advice. For centuries, doctors have been granted with the right to decide in the best interest of the people through the Hippocratic Oath[3]. During the twentieth century, because of increasing consumer awareness, this right of doctors has been conflicted. So, it in the best interest of the

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physicians to avoid non-consensual medical treatment.

'Informed consent' is the basic essence of consensual medical treatment. The Indian scenario of doctor-patient relationship is governed more by trust. Here, the physician is given authoritative position which is due to the huge proportion of illiterate population who are less aware about consumer rights. Notion of informed consent was practically nonexistent until COPRA (Consumer Protection Act) came to the forefront to safeguard consumer rights in health services[4].

Like all other surgical procedures, informed consent should be taken in both major and minor obstetrics and gynaecological surgeries. As all patients are female, while taking consent specific care must be taken. Consent given by the lady is rarely real. Many a times, owing to the dominant role played by the husband during decision-making in household matters, he or his family members take the upper hand in deciding what is best for the female patient. She merely puts a signature on the consent form obliging to her husband. "Consent", as per section 13 of Indian Contract Act, is defined as 'two or more persons are said to consent when they agree upon the same thing in the same sense'[5]. Consent taken is valid when its essential components are practiced/ considered, which includes voluntariness (willingness of a patient to undergo treatment), capacity (patient is able to understand the nature of treatment), knowledge (sufficient information as to the nature of treatment disclosed to patient) and decision making.

A doctor examining or treating a patient without *valid consent* can be liable for 'battery' or 'assault'[6]. Even now, taking informed consent is more of a legal necessity than an ethical moral obligation seen on the part of a doctor towards his patient[7 & 8]. Improper method of taking consent and withholding complete information from the patient are the important aspects of several medical consumer litigations which need to be addressed.

However, there are limited studies on this issue in the literature despite the importance of the subject to the health care providers.

### The present study was conducted

1. To find out the processes by which patients/parents are given information about their complaint, treatment and treatment options.

2. To determine whether the decision is informed or not.

3. To find out whether the patient knows and understands details of the procedure, its complications, risks and possible alternatives to the treatment.

### **MATERIALS & METHODS**

This hospital based cross-sectional observational study was carried out in the Department of Obstetrics and Gynaecology at Sri Venkateshwara Medical College Hospital and Research Centre, Ariyur, Pondicherry. The study period was from 1st October 2011 to 31st December 2011. The study population consisted of post operative cases of Obstetrics and Gynaecological surgeries. A total of 132 cases were selected for the study by systematic random sampling. Study tool was a predesigned, pre-tested and structured questionnaire. Participants were interviewed face-to-face on the day of discharge. During interview data was collected about informed consent. Emphasis was given on type of operation which they had undergone, how and where the informed consent was taken, who had taken, whether adequate time was given to the patient before taking consent. The anonymity of the responses was maintained. Permission from the institutional ethical committee was obtained. All post operative cases that underwent elective or emergency surgeries in the Department of Obstetrics & Gynaecology were included in the study after taking their consent. The patients who were operated by the investigator, who were not in a condition to give consent, or who had delegated the power of consent to another person were excluded from the study. Patients were interviewed by the investigators personally to collect the information. The data

collected were entered in MS-Excel spread sheet, analyzed and interpreted.

### RESULTS

In the present study all 132 cases were above 18 years of age. Total of 106 cases undergone elective surgery and remaining 26 cases had undergone emergency surgeries. Out of 132 cases, 54 had undergone obstetrical surgery and 78 cases gynaecological surgery. In 21.2% of cases, consent was not given by the patient and in majority of cases the consent was taken by the nurse (Table 1). The concerned surgeon had taken consent in 15.09% of cases in elective surgery and 30.76% of cases in emergency surgery. In most of the cases, the duration of explanation was 5 to 15 minutes and consent was taken more than one day prior to surgery (Table 2). In 3% of cases consent was taken in and around operation theatre (Table 3). In 91% of cases nurse and patient attendants witnessed the consent procedure (Table 4). Out of all the components of informed consent, the consent was not taken in patient's own language in onefourth of cases (24.2%), whereas the diagnosis of the disease was explained in almost all cases (98.5%). All other components of informed consent were explained to the patients in more than 80% of cases (Table 5). Only two (1.5%) patients were not able to identify or name the operating surgeon when asked to give the identity of the operating surgeon. Paternalism was found in 14 out of 132 (10.6%) cases.

Consent Consent Taken By Given By					Total
j	Surgeon	Assistant	Resident	Nurse	_
Patient	20	08	02	70	100 (75.8%)
Husband	0	0	0	04	04 (3%)
Relative	02	02	0	20	24 (18.2%)
Both Patient & Relative	02	0	0	02	04 (3%)
Total	24 (18.2%)	10 (7.6%)	02 (1.5%)	96 (72.7%)	132

Table 2.	Time of	Consent	(n=132)
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Time between consent & surgery		Total			
	= 5 minutes	>5 to 15 minutes	>15 to 30 minutes	Not sure	
>One day	04	60	14	02	80 (60.6%)
Previous Day	02	10	08	0	20 (15.2%)
Same Day	0	08	10	0	18 (13.6%)
Just Before Surgery	02	08	02	02	14 (10.6%)
Total	08 (6%)	86 (65.2%)	34 (25.8%)	04 (3%)	132

Place	Number (n=132)	Percentage	Witness	Number (n=132)	Percentage
Ward	122	92.5	Patient's Attendant	56	42.4
OPD	06	4.5	Another Doctor	02	1.5
Pre Operative Room	02	1.5	Nurse	64	48.5
Operation Theatre	02	1.5	Attendant & Nurse	08	6.1
			Not Sure	02	1.5

		(	- /	
Questionnaire	Yes	3	No	
	Number	%	Number	%
Whether diagnosis of the disease has been	130	98.5	02	1.5
Whether operative procedure has been explained?	124	94	08	6
Whether alternative modalities of treatment have been explained?	110	83.3	22	16.7
Whether explanation about type of anesthesia eiven?	116	87.9	16	12.1
Whether risks/complications of the procedure explained?	110	83.3	22	16.7
Whether potential benefits of the procedure explained?	128	97	04	3
Whether prognosis with or without the proposed procedure explained?	114	86.4	18	13.6
Whether costs of the proposed procedure approximate explained?	116	87.9	16	12.1
Whether the success & failure rate of the	108	81.8	24	18.2
proposed procedure explained? Whether consent was taken in patient's own	100	75.8	32	24.2
language? Whether consent was explained in patient's own language?	130	98.5	02	1.5

### Table 5. Components of Informed Consent (n=132)

### DISCUSSION

Table 3. Place of Consent

Improper consent and withholding complete information from the patient is an important medico-legal concern. The Supreme Court of India has given the following guidelines on informed consent: "A doctor must seek and secure the consent of the patient before starting treatment. The consent so obtained should be real and valid. The information should include the nature and procedure of the treatment and its purpose, benefits and effect, alternative treatment if any available, an outline of the substantial risks and the adverse consequences of refusing treatment". The Supreme Court judgment emphasized the need for specificity of consent. Consent given for a specific procedure will not be valid for conducting another procedure. The nature and extent of

Table 4. Witness & Consent (n=132)

information to be furnished by the doctor to the patient to secure the consent should be acceptable as normal and proper by a body of medical men skilled and experienced in the particular field[9].

Empowering the patient will mean that the patient is part of the team in control of his medical health. This will make it much easier for the doctor to communicate risk information to him. Informed consent is not simply the patient signing a consent form, but, more importantly, is a process of detailed discussion between the doctor and his patient. Informed consent is enforced by both medial ethics and the common law. The common law places a medical duty on doctors to inform and warn. Failure to communicate is a failure in duty thus resulting in a breach of the medical standard of care. But in an emergency situation where a patient is unable to give consent due to unconsciousness, a doctor may perform emergency treatment based on the doctrine of necessity or implied consent to save life.

A person who has the capacity and competence can consent to her treatment. A person is said to have 'capacity' when she can understand the necessary information, retain that information, use it for decision making and communicate the decision by appropriate means[10]. It also depends on what is being consented; more the risk of the treatment offered, greater the capacity required to understand and comprehend[11]. There are fixed guidelines outlining the exact age of consent for medical or surgical treatment. In India, 'majority' is achieved at an age of 18 years and considered a legal age for giving a valid consent for treatment as per Indian Majority Act, Guardian and Wards Act, and Indian Contract Act[12]. In the present study, all 132 cases were above 18 years, but in nearly onefifth of the cases surgeries were done without consent, the patient being a major & mentally sound person. Other studies have reported that around 26.7% of patients had not signed the consent form[13].

Ideally, consent may be obtained by a person who is capable of communicating all the necessary information required to make a decision regarding their health care. The physician rendering the care may obtain the consent himself/herself[14]. It remains unclear whether a house surgeon/intern can obtain an informed consent or not[15]. Staff nurses or other health care providers are not entitled to obtain the consent although they can bridge the communication gap between the surgeon and the patient. Nursing staff that has been trained in a particular speciality can educate, empathize and prepare the patients before the anticipated formal meeting of doctor and patient. This may improve the communication between the physician and patient and allay the fears and barrier pertaining to the desired procedure/ treatment[16]. In this study only in 18.2% of cases the concerned surgeon had taken the consent. Different studies in literature show different results in this regard. In the study by Dharmanada V[13] the surgeon explained the consent form in 23.4% of cases, whereas in studies by Andrea A et al[17] & SA Shittu et al[18] consent was taken by the concerned surgeon in 47% & 48% of cases respectively. In the study by Dharmanada V[13] the nurse explained the consent form in 3.3% of patients whereas in this study nurses explained the consent form in about 72.2% of cases. Consent is a contract between the doctor and the patient, and the doctor himself must give the information to the patient. In the study by Dharmanda V[13] 23.3% of cases were not sure about who had explained the consent, and almost similar finding (26.8%) was reported by Andrea A et al[17] but in our study such findings were not observed.

The literature is little regarding timing of consent and, in fact, some believe there is no right answer about ideal time and place to sign consent; each unit should determine the best local practice. However, it is important that patient be given sufficient chance to absorb the information necessary for them to make the decision. Also, if significant time has elapsed between time of consent and the time of the procedure, it is important to reaffirm that the patient has not changed her mind[19,20].

Consent was taken in ward in 92.5% cases in this study; but a study in Australia reported consent was taken in the ward in 60% of cases[13]. In 75.8% of cases the consent was taken previous day or prior to it in this study. However, this is in contrast to the other studies[13,17]. The present study reveals that in 32 cases, patients gave consent either on the day of operation or just before surgery. During this time patients may not have a right frame of mind to take decision. Another study in district hospital shows 81.5% of patients consented within 24 hours of surgery [18]. The duration of explanation was more than 5 to 15 minutes in majority of cases, but it was 10 to 15 minutes in 40% of cases in other study[13]. Many controversies or legal complications can be reduced by adequate communication and proper dialogue at proper timing.

Obtaining an informed consent must be considered a process rather than a point which ends once the patient signs the consent form. It is a continuous two-way communication and must proceed as frequently as possible during the entire treatment of the patient. In general, the consent process provides an opportunity for the treating surgeon to create a good patientdoctor relationship by communicating with the patient regarding the details of the treatment, tailoring the information to the specific needs and understanding of the patient. It also allows for the patient to express her opinion and concerns. This can build patients trust and confidence in the doctors as they feel that they are in control of the decisions in their treatment. In the present study all the components of informed consent were explained to the patients properly in majority of cases. Similar findings were also observed by other studies[11,21].

In the present study, in 48.5 % of cases the nurses witnessed at the process of consent but in the study by Dharmananda V[13] it was 23.4% cases only. Duly witnessed and signed by uninterested third parties are more

dependable legally, as the parties concerned cannot subsequently deny execution. There is no conclusive judgment mandating a witness by an uninterested third person while consenting to medical treatment. However, it is realized that the importance of a third person witness improves, especially when the consenting patients are illiterate and have consented by placing a thumb impression[22]. In our study 98.5% of patients were able to identify the operating surgeon whereas only 40% of patients could do so in other study[13]. In 24.2% of cases the consent was not taken in patient's own language.

A consent form in developed nations is expected to be readable by 8<sup>th</sup> grade level, but there are no guidelines developed in India[23]. It was observed that the consent form given to the patients often has plenty of tough medical terminology and often is not legible and scribbled in a poor handwriting[24,25]. The consent forms need to be comprehensible and written/typed legibly. It would be advisable to use short sentences with simple vocabulary and use of non-medical terminology as far as possible. The consent forms written in patients might improve own language the comprehension and understanding[26]. In cases where the same language is not possible a good interpreter should be provided. The consent form should be signed by all parties concerned (Patients/guardian/doctor/ witness) to make it a valid document[22]. India is a multilingual country where every state has its own language. So people of one area cannot communicate with others in local languages. English is a universal language for Indians; however, most patients from rural India know only the local language. Urban patients may know both English and local language as schools in these areas teach both the languages. If consent is not taken in the language with which the patient is familiar, it becomes difficult to communicate. Though, till date, no literature is available regarding paternalism, this study recorded 14 cases (10.6%) of paternalism. Doctor should avoid abusing his/ her power at all cost & should respect the choice

of patient which she wishes to follow while undergoing any form of treatment.

### Limitations

The conclusions of this study cannot be generalized to other surgical specialities as it was done for the Department of Obstetrics & Gynaecolgy.

### CONCLUSION

The importance of consent before obstetrics & gynaecological surgery cannot be over emphasized. It is believed that the best arguments in favour of informed consent are moral rather than legal. In the present study, though all the components of informed consent were explained to the patients in their own language, it was not done by the concerned surgeon. In some cases the consent was not written in patient's own language. To overcome these problems, the use of operation - specific consent form or proforma in patient's own language will ensure accurate and comprehensive discussion and documentation of serious and frequently occurring risks of surgical procedures, particularly the operationspecific ones. Also, emphasis must be given in undergraduate & postgraduate training on legal jurisprudence and legal medicine. Future studies can also be carried out in other specialities and comparison of elective and emergency procedures can be made. The effective procurement of informed consent promotes patient autonomy, engenders trust and confidence in medical professionals and reduces the risk of unnecessary legal claims premised on incorrect assumptions regarding appropriate medical care.

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## Study of Foeto-Placental Ratio in Normal and Low Birth Weight Cases

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### ABSTRACT

Birth weight is one of the simplest measurements that can be made with reasonable accuracy under different conditions. It is a reliable indicator of foetal well- being and maturity. In the present study, the average birth weight in Marathwada region, the incidence of low birth weight, the foeto-placental ratio in normal and in low birth weight cases was studied in 296 newborns and placentae. It was observed that the foeto-placental ratio in low birth weight cases is statistically significantly low (6.72) as compared with the normal (7.08). The significantly low foeto placental ratio in low birth weight cases indicates that though there is decrease in both birth weight and placental weight, the decrease in birth weight is more as compared with the decrease in placental weight.

Key words: Low birthweight; Foeto-placental ratio; Marathwada region.

### INTRODUCTION

Birth weight is a reliable indicator of foetal well- being and maturity. It is also one of the simplest measurements that can be made with reasonable accuracy under different conditions[1]. Studies indicate that babies born with adequate birth weight have a relatively low mortality even in poor environmental conditions.

Birth weight depends upon numerous factors: genetic, maternal nutrition, height and age of mother, parity, duration of gestation, birth spacing, sex of child, smoking in pregnancy, obstetrical history, placental weight, etc. Most of these factors are interrelated interact and it is difficult to point out any one main factor[2]. Some of the above mentioned factors also affect the placental weight. The placental weight in tern affects the birth weight.

So far, a number of studies have been conducted by different authors in different regions. Rath et al (2000)[3], Udania & Jain(2001)[4] and Rath & Jain (2001). They have studied the mean birth weight, the mean placental weight and the foeto placental ratio. It was observed that the mean birth weight, the mean placental weight and also the foeto placental ratio showed regional variations.

The present study was carried out to study the average birth weight, the incidence of low birth weight and the foeto-placental ratio in normal and in low birth weight cases in Marathwada region.

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### **MATERIAL & METHODS**

The present study was undertaken at Swami Ramanand Teerth Rural Medical College and Hospital, Ambajogai. Being the Rural Medical College, study population was mainly from rural area. The data collected included the weights of 296 newborns and placentae, excluding the anemic, hypertensive, diabetic mothers and twins & stillbirths.

The chart was prepared containing a serial number, birth weigth and placental weight. Serial number was given to each case. The birth weight was recorded as early as possible after delivery. The placentae were collected and the membranes were removed. The serial number was written and tagged to the placenta. The cord was cut leaving proximal 2 cm attached to the foetal surface. Then the placentae were dried between the blotting papers and weighed with a standard weighing machine. Cases with birth weight of 2500 gm or above were considered normal and below 2500 gm labeled as low birth weight.

The data obtained was tabulated and statistically analyzed separately for the normal and low birth weight cases.

### RESULTS

Table I shows birth weights in normal and low birth weight cases.

Out of 296 total cases studied, 210 were having normal birth weight (mean 2775 gm) and 86 were of low birth weight (mean 2174 gm). The mean placental weight in all 296 cases studied was 2600.385gm.

It was observed that the mean placental weight in normal cases was 408 gm while the mean placental weight in low birth weight cases was 343 gm. The difference between the means was statistically highly significant.

The foeto-placental ratio in normal and low birth weight cases is shown in Table I. The foeto-placental ratio in normal cases was 7.08 while in low birth weight cases the foetoplacental ratio was 6.72. The value of Z = 5.422at p>0.001. Hence, the foeto-placental ratio in low birth weight cases was significantly low.

Table II shows the comparison of present and previous studies.

The mean birth weight observed by Rath, Garg & Sood[3] was 2718gm, Udania & Jain[4] observed 2640gm and Rath & Jain stated 2710gm, while in the present study it was 2600gm.

The mean placental weight observed by Rath, Garg & Sood[3] was 382gm, Udania & Jain[4] observed 495gm and Rath & Jain observed 438gm while in the present study it was 388gm.

The foeto-placental ratio observed by Rath, Garg & Sood<sup>3</sup> was 7.11, Udania & Jain<sup>4</sup> stated

# Table I. Comparison of birth weight, placenta weight & feto-placental ratio among normal & low birth weight cases

Parameter	Normal Birth Weight (n=210)	Low Birth Weight (n=86)	Z Value	P Value
Mean Birth Weight in kg	2775±251	2174±378		
Mean Placental Weight in kg	408±83.75	343±86.63	6.058	<0.001
Mean Feto- placental ratio	7.08±1.69	6.72±1.42	5.442	<0.001

Mean ±SD

	Mean birth weight (gm)	Mean placental Weight (gm)	Mean foeto-placental ratio
Rath, Garg & Sood (2000)	2718	382	7.11
Udania & Jain (2001)	2640	495	5.33
Rath & Jain (2001)	2710	438	6.18
Present Study (2004)	2600	388	6.95

### Table II. Table showing comparison of present and previous studies

5.33 and Rath & Jain stated 6.18 while in the present study it was 6.95.

### DISCUSSION AND CONCLUSION

The mean birth weight in a total of 296 babies studied was 2600 gm. Out of 296 babies, 86 had a birth weight below 2500 gm. Hence, the incidence of low birth weight in this region is 29.05%, which is slightly lower than the incidence of low birth weight in India, which is 30%.

The mean placental weight was 388 gm. The mean foeto-placental ratio was 6.95. The mean placental weight in low birth weight cases was low (343 gm) as compared with mean placental weight in normal (408 gm). The difference between the means was statistically highly significant (z = 6.058). Hence, the placental weight decreases significantly in low birth weight cases.

The mean foeto-placental ratio in normal was 7.08 while in low birth cases it was 6.72. The Z value is 5.422 at p<0.001. Hence, the foeto-placental ratio in low birth weight cases is statistically significantly low.

The significantly low foeto-placental ratio in low birth weight cases indicates that, though there is decrease in both birth weight and placental weight, the decrease in birth weight is more as compared with the decrease in placental weight. Hence, it can be concluded that some additional factors contribute to birth weight other than those contributing for the placental weight.

Also, the foeto-placental ratio, as observed in the present study and compared with the other workers, differs regionwise. The foetoplacental ratio, once determined in a region in normal cases cannot be applied as it is for the low birth weight cases because it is observed in the present study that the foetoplacental ratio decreases significantly in low birth weight cases. So, in low birth weight cases, the decrease in the placental weight is not in proportion with the decrease in the foetal weight but decrease in the foetal weight is significantly more than the decrease in the placental weight.

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## Ocular Manifestations in Patients with Snakebite in Rural Western Maharashtra

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### ABSTRACT

This study was conducted in Pravara Rural Hospital, Loni, Tah-Rahata, Dist.-Ahemadnagar (Maharashtra) during January 2010 to December 2010. A large number of cases occur in this area because of agriculture and agriculture-related occupation. This study was aimed to know the ocular changes in snake bite. Patients admitted in intensive care unit (ICU) due to snake bite were considered for the study. Detailed ocular examination of these patients was carried out by torch, ophthalmoscope and other ophthalmic instruments. For this study, a total 78 patients were examined. Out of 78, cases 38 (48.78%) cases were having bilateral ptosis. Out of 38 cases of bilateral ptosis, 13 (34.21%) were of Krait, 15 (39.47%) cases were of Cobra. In 10 (26.35%) cases of ptosis, type of snake could not be identified. In 30 (38.46%) cases visual acuity was reduced.

Key words: Snake bite; Ocular manifestation; Western Maharashtra.

### INTRODUCTION

Snake bite is a major problem in the world. It is a neglected problem in tropics due to lack of antisnake venom. Snake bite is a bigger problem in rural India. It is one of the main causes for morbidity and mortality. There are 2500 species of snakes in the world. Out of that 216 species are present in India. Common poisonous snakes seen in India are Cobra, Krait and Viper. Snake bites cause two types of effects- 1) vasculotoxic and 2) neurotoxic. Both these kinds cause ocular manifestations. The institute where this study was conducted is located in a rural area, so large numbers of cases occur in this area due to agriculture and agriculture-related occupation. This study aimed to know the ophthalmic changes in snake bite. Patients admitted in intensive care unit (ICU) due to snake bite were considered for the study. Detailed ocular examination of these patients was done. A total of 78 patients were studied of which 44 were male. Maximum cases of snake bites were seen between 20 to 40 years of age. In majority of cases snake bite was in the evening time. Maximum cases of bite were in the lower limb and occurred when people were working on farms. Near about equal no. of cases occurred during January to March and July to September. During the study ocular manifestations observed were bilateral ptosis and reduction in visual acuity.

### MATERIALS AND METHOD

Patients admitted in intensive care unit of Rural Medical College, Loni, due to snake bite were considered for the study. Detailed history

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of each patient was taken which included name, age, sex, occupation, time of bite, date and time of admission in hospital, information about snake, location of bite, presence of fangs of snakebite, general examination. Detail ophthalmic examination included recording of visual acuity with the help of Snellen's distant vision chart, head posture, facial symmetry, position of lids, ocular movements, size and reaction of pupil (direct and consensual), appearance of conjunctiva, transparency of cornea, fundus examination with ophthalmoscope to see retinal hemorrhages, disc oedema, recording intraocular pressure with digital tonometry or schiotz tonometer. The type of snakes were identified by showing pictures of snakes to patients. Statistical test applied for bilateral ptosis was Z test of difference between two proportions at 5% and 1% level of significance (i.e. p<0.05 p<0.01) There was significant difference between proportion of cobra and krait as compared to other type of snakes

### RESULTS

According to Table 1 out of total 78 cases 44(56.41%) were male and 34 (43.8%) were female. Maximum cases 48 (61.43%) were between age group of 20 to 40 years of age group followed by 18 (23.07%) cases of age group above 40 years while less cases 12 (15.38%) were below 20 years of age. Hence median age was 38 years. Near about 60 (89.7%) cases of snake bite occurred in agricultural workers where as 18 (23.03%) cases were in nonagricultural persons. As regards timing of bite, more cases 42 (53.84%) were during evening as compared to 36 (46.15%) cases during daytime. More bites 58 (74.35%) were on lower limb as compared to 20 (25.64%) in upper limb. About equal number of cases, 28, (35.8%) occurred in January to March and 29 (37.17%) cases during July to September followed by 15 (19.23%) cases during April to June, followed by 6 (7.69%) cases during October .to December. In relation to place of bite, 52 (66.66%) cases occurred in field as

compared to 26 (33.33%) in home. In 30 (38.43%) cases of snake bite, type of snake was identified in which 2 (6.66%) were viper, 13 (43.33%) were Krait and 15 (50%) were Cobra. Out of 78 cases in 38 (48.73%) cases there was bilateral ptosis. Out of 38 cases of bilateral ptosis, 13 (34.21%) cases were of Krait.15 (39.47%) cases were of Cobra. In 10 (26.31%) cases of ptosis type of snake could not identified. In 30 (38.46%) cases visual acuity was reduced.

# Table 1. Sociodemographic profile ofstudy population

Age	Study population
below 20 Years	12 (15.18 % )
20–40 years Above 40	48(61.53%)
years age	18(23.07%)
Sex	44(46 41%)
Male	34(40.41%)
Female	54 (45.0070)
Terrare	
Occupation	60(76.92%)
Agriculture	18(23.07%)
Nonagricultural	
Timing of bite	42(53.84%)
Evening time	36(46.15%)
Day time	
Site of bite	58(74.03%)
Lower limb	20(25.06%)
Upper limb	
Season	28(35.86%)
January to March	15(19.23%)
April to June	29(37.17%)
July to September	06(7.69%)
October to December	( )
	26(33.33%)
Place of bite	52(66.66%)
Bite in home	
Bite in &around field	
Type of snake	
Vipers	02(6.66%)
Krait	13(43,33%)
Cobra	15(50.06%)

Table 2. Distribution of cases according to ocular manifestation

Type of snake	Bilateral ptosis (48.78% cases)	Extra ocular muscle paralysis	Optic Neuritis	Optic atrophy	Retinal hemorrhages	Acute angle closure glaucoma
Viper	0	0	0	0	0	0
Krait	13(34.21%)	0	0	0	0	0
Cobra	15(39.47%)	0	0	0	0	0
Unidentified	10(26.35%)	0	0	0	0	0
Cases						



Z test of difference between two proportions at 5% and 1% level of significance (i.e. p<0.05 and p<0.01) there is a significant difference between proportions of Cobra and Krait as compared to other types of snake.

# Table 3. Distribution of cases according to visual acuity (N=78)

Visual acuity	No.	%
Normal visual acuity	48	61.53
Reduced visual acuity	30	38.41

### DISCUSSION

In the present study 56.2% of participants were male while 43.8% were female, showing male dominance. This may be due to more

involvement of males in agriculture work as compare to females. This observation is consistent with observation of Nuchhiudaykumar et al[1].

High incidence (61.43%) of snake bite was seen in age group of 20 to 40 years of age as this is active age for involvement in agriculture work. This observation matches with the observation of JS Whitehall et al[2].

Maximum numbers of cases (89.7%) were seen in agricultural workers. Farming community is increasingly prone to accidental contact with the snakes while working in field. This observation is similar to that of Francis N P Monteiro et al[3]. Maximum cases (53.84%) of snake bite occurred during evening time because of nocturnal nature of snakes. Same observation was made by Hung H.T., Hojer.J[4].

As far as site of bite is concerned more cases (74.34%) were found in lower leg as agricultural workers do not wear legging and boots while working in fields. Same observation was made by Swamy and Banerjee[5]. Almost equal number of cases occurred during January to March (35.8%) and July to September (37.17%). July to September is rainy season and sowing season while Janwary.to March is harvesting season. This observation is similar to JS Whitehall et al[2].

Only in 38.43% cases the type of snake could be identified .Out of that, 50.0% were cobra, 43.3% were Krait and 6.66% were Viper. JS Whitehall et al[2] could identify 32% cases of which 43% were Saw Scaled Viper, 14% were Russell Viper 6% Cobra and 6% Krait White 68% snakes were not identified .This variation may be due to the fact that one variety of snake may be more in population in a particular area.

In 38.46% cases visual acuity was reduced. There was no obvious cause for reduction of visual acuity. This reduction might be due to psychological disturbance of patients due to snake bite. Jasjit Singh et al[6] observed blurred vision in 72% case This difference is because in this study only venomous snake bites were considered.

Ptosis was the only ocular manifestation observed. It was present in 48.78% cases. JSWhitehall et al observed ptosis in 15% cases; Jasjit Singh et al[6]. found ptosis in 77% cases. This high percentage is because only venomous snake bites were considered. In total cases of ptosis, 39.47% were due to Cobra, 34.21% were due to Krait and 26.3% were due to unidentified snakes. Statistically, there is significant difference between proportion of Cobra and Krait as compared to other type. JS Whitehall et al[2] observed ptosis in 7% cases of saw Scale Viper, 21% cases of Russell Viper, 24% cases of unidentified Viper, 17% cases of Krait, 17% cases of Cobra. This difference is due to more cases of snake bite by viper (57%). In this study, not a single case was of extraocular muscle paresis, but Mesuji Takeshita et al[7] noted one case of extraocular muscle paresis in which there was paresis of medial rectus and inferior oblique. There was no case having optic neuritis. Guttmann-Friedmann[8] noted bilateral optic neuritis as a result of severe hemorrhage following snake bite. In this study there was no severe hemorrhage in any case after a bite. In no case there was optic atrophy. Davenport and Budden[9] noted bilateral secondary optic atrophy after snake bite. In no case there was subconjuctival hemorrhage or retinal hemorrhage. According to R.C. Davenport and F.H. Budden[9] some snake venom contains anticoagulants, haemolysins, and after bite there are multiple hemorrhages in the body. There can be subconjuctival, retinal and vitreous hemorrhage. There was no case having acute angle closure glaucoma.Dr Mohd Haneef and DrVeena VA[10] noted a case of Viper bite in which patient developed acute congestive glaucoma which is a rare complication.

## CONCLUSION

In rural western Maharashtra snake bite cases are more due to Cobra bite and Krait bite. Sites of bite are more in lower leg. People should be advised to wear boots while working on farms. Only neurotoxic ocular manifestation observed in venomous snake bite is ptosis. Statistically, there is significant difference between proportions of Cobra and Kraits compared to other type of snakes in regarding bilateral ptosis.

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## Sudden Death Due to Tuberculosis: An Enigma

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### ABSTRACT

Sudden natural un-witnessed death of a previously apparently healthy person raises issues related to the manner of death. This issue can be appropriately answered with the expertise of a forensic pathologist, who has the means to help in these circumstances through his knowledge which is supplemented by the investigation of the police officer. Here, a case of sudden natural death of an apparently healthy individual construed to be unnatural by the kin of the deceased is highlighted.

Keywords : Death; Forensic pathologist.

### INTRODUCTION

The primary component of forensic pathology is the ability to recognize and interpret injury and determine its role in causing death, but majority of cases investigated by the forensic pathologist are sudden deaths [1]. Of the cases of sudden deaths investigated by the forensic pathologist,

**Reprints requests: Dr. Y.P. Raghavendra Babu**, Assistant Professor, Department of Forensic Medicine, Kasturba Medical College, Manipal University, Mangalore, Karnataka. about 75% will be found to be deaths from natural causes [2]. Unfortunately, majority of these cases present without antemortem documentation of significant pathology, which poses a challenge to both the investigating officer and the forensic expert [1]. Although a sudden natural death may be due to a disease process in almost any organ, the majority are due to some affliction either of the heart, lungs, and brain [3]. One-fourth of sudden deaths are caused by diseases of the respiratory system [4]. The main cause of death due to respiratory cause is hemoptysis [5]. Hemoptysis may be secondary to tuberculosis, bronchogenic carcinoma, lung abscess or bronchiectasis [6]. The most massive hemoptysis of respiratory cause leading to death is tuberculosis [7]. Here, we present a case of sudden death due to complications of tuberculosis.

### Case report

A 50-year-old male was brought to the mortuary with a history of vomiting of blood

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& sudden death at workplace. The co-workers and relatives of the deceased suspected foul play and a medico-legal autopsy was requisitioned to ascertain the matter of fact. On external examination, the clothes were found to be blood stained with passive oozing of blood from nostrils and mouth. On internal examination, the trachea and the esophagus were flooded with blood clots, both lungs were

# Fig 1. Left lung with nodular cavitated lesion in its upper lobe



adhered to the chest wall with bilateral nodular cavitatory lesions in the upper lobe.(Fig1). The stomach contained 1500 ml of blood admixed with clots (Fig2). Histopathological examination of the lung showed caseating epitheloid granulomas with giant (Langhan's) cells (Fig3) and Ziehl Neelsen stain was positive for acid-fast bacilli (Fig4), which were suggestive of tuberculosis of the lung.

# Fig 2. Blood admixed with clots in stomach



Fig 3. Caseating epitheloid granulomas with giant (Langhan's) cells (H & E stain)



### DISCUSSION

Tuberculosis is the leading infectious cause of death in the world next to HIV [8]. Current

Fig 4. Ziehl neelsen stain with positive acid fast bacilli



estimates suggest that nearly 4.56 million people in India are infected with HIV and that approximately 1.4 million of these individuals are also infected with tuberculosis[9]. Tuberculosis remains a worldwide public health problem despite the fact that the causative organism was discovered more than 100 years ago[9] [10] [11]. India accounts for nearly one-third of global burden of tuberculosis. Eight out of ten of all those struck by tuberculosis are in the economically productive age group of 15-49 years [11]. Tuberculosis is caused by infection with mycobacterium tuberculosis, which is a part of complex of organisms including а Mycobacterium bovis and Mycobacterium africanum[12]. Acute death due to tuberculosis is a consequence of the erosion of a fully patent vessel located in the wall of a cavity. Hemoptysis, however, may result from rupture of a dilated vessel in a cavity (Rasmussen's aneurysm) or from aspergilloma formation in an old cavity [13]. Majority of these cases occur in the world's poorest and developing countries, who struggle to cover the cost associated with the management and control programmes[14,15,16]. There is also an

increasing incidence of tuberculosis in developed nations due to factor such as immigration from high prevalence areas, HIV, increased proportion of elderly, and drug resistance[12].

About one-third of the current global population is infected asymptomatically with tuberculosis, of which 5-10 percent will develop clinical disease during their life[11]. In the present case, the deceased was apparently healthy, asymptomatic who died after massive hemoptysis at workplace which aroused doubt as to the nature of death. Autopsy with histopathological examination confirmed it as natural death due to tuberculosis. So However medicolegal issues do arise in sudden, unwitnessed natural deaths and the absence of external signs of injury does not preclude death from physical violence. The very purpose of medicolegal autopsies is to determine whether violence or poisoning has been in any way responsible for the death. Histological examination of selected material should be an integral part of any postmortem examination, including chemical analysis for poisoning [2].

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## Postpartum Hemorrhagic Death Due to Retained Placenta in Uterus

Chormunge Vijay\* Kadu Sandip\*\* Asawa Shrikant \*\*\*

### ABSTRACT

A 27 year old female was admitted in Pravara Rural Hospital, Loni, in shock condition with history of full term normal delivery. The delivery was conducted in a private hospital, but due to postpartum hemorrhage the patient was shifted to PRH, Loni. The patient died immediately after admission and relatives of the patient filed a complaint against the private hospital which had conducted the delivery. Postmortem was conducted which showed bleeding from genitalia and uterus with 7cm circumference mass of retained placenta at posterolateral region. The clinical and autopsy findings revealed mismanagement after delivery leading to death of the patient, and the doctor who conducted the delivery was held responsible for the death.

Key words: Placenta; Delivery; Postpartum hemorrhage; Negligence.

### INTRODUCTION

Worldwide, more than half a million women die every year as a result of pregnancy and childbirth, and 99% of these deaths occur in developing countries[1]. About 25 % of maternal deaths in Asian countries are due to hemorrhage during pregnancy, birth or postpartum. Out of these, almost 30% are due to post partum hemorrhage and further 15-25% of these are maternal deaths due to retained

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placenta[2]. The incidence of retained placenta is 0.8-1.2% of birth[2].

Placenta is said to be retained when it is not expelled even 30 minutes after the birth of the baby[3].There are three main types of retained placenta following the vaginal delivery- (1) Placenta adherans - which is due to failed contraction of the myometrium behind the placenta[2]. Trapped placenta- a detached placenta trapped behind a closed cervix[3]. Partial accreta- when there is a small area of accrete preventing detachment. All can be treated by manual removal of placenta, which should be carried out at 30-60 minutes post partum[4].

### *Case History*

A 27 year old female body was received for ostmortem in the Department of Forensic Medicine and Toxicology at Rural Medical College, Loni, A'Nagar, Maharashtra. The Police panchanama showed that the patient had been admitted in Medical College Hospital

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with a history of bleeding after delivery and died within one hour of hospitalization. The relatives of deceased filed a complaint against the doctor who had conducted the delivery.

### Autopsy Report

The body was pale, well built and there was oozing of blood stained fluid from the mouth. Faint postmortem lividity was present on the back portion of the body with well marked rigor mortis. There were no any signs of decomposition present on the body. The clothes were blood stained and blood soaked cotton pad was seen at the vaginal orifice. Also stitched episiotomy wound was seen on forchute, 3 cm in length. There were no bodily injuries except injection marks.

### Fig 1. Pale and flabby uterus



Fig 3. Dissected uterus with blood clots and placenta



On internal examination all the organs were pale and stomach was empty. Genital examination showed labia minora contused, stitched episiotomy wound and active bleeding from the vagina. The uterus was flabby, pale and few blood clots were seen inside it. On the poster lateral region, a dull red color spongy mass of retained placenta was seen 7cm in circumference. The uterus, with other organs, was sent for histopathology examination in the Department of Pathology at PRH Loni.

The histopathological report confirmed gravid uterus with placental remnants.It also revealed shock lung syndrome and intense vascular stasis in brain, lungs, liver, and kidney. After postmortem and histopath examination, the cause of death was given as severe postpartum hemorrhagic shock as a result of retained placenta in the uterus.

# Fig 2. Enblock dissection of reproductive organs and bleeding from genitals



### Fig 4. Retained placental remnants in uterus



### DISCUSSION

Retained placenta is associated with morbidity and mortality when left untreated[3]. A patient with retained placenta often has postpartum hemorrhagic[6]. Adequate resuscitation is mandatory before attempting manual removal[6]. This should include giving blood if the patient is bleeding and the administration of a second dose of oxytocin to encourage uterine contraction and placental separation<sup>6</sup>. Failure to deliver the placenta despite these measures indicates transfer of the patient to operation theatre[6]. In the present case, the patient was admitted for labour at a private hospital where she was given a trial with episiotomy. The patient was exhausted by labour pains without any progress and then shifted to a gynecologist. The gynecologist conducted the delivery and a 3 kg live baby was born. After the delivery there was profuse bleeding for several hours. The placenta was taken out by manual method but the bleeding could not be stopped, as per the case sheet of the doctor. Then the patient was shifted to Rural Medical College Hospital, Loni, in a shocked condition.

The doctor, who conducted the delivery, did not see the placenta after delivery. The retained placenta was the cause for profuse postpartum hemorrhage. If the retained placenta had been removed in time or at least suspected this could

### Fig 5. Pale liver, spleen and kidneys



have saved the life of the patient. The doctor was held responsible for mismanagement after delivery; though it was a rare complication, he failed in his duty. The doctor was unable to prove his innocence. The court passed a verdict against the doctor and held him responsible for the death of patient under sec 304 (A) IPC.

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## Teeth: Important Forensic Tools in Dentistry

Vipin Ahuja\* Annapurna V. Ahuja\*\*

### ABSTRACT

Teeth are highly mineralized appendages found in the entrance of the alimentary canal of both invertebrates and vertebrates. They are associated mainly with prehension and processing of food, but they also frequently serve other functions, such as defense, display of dominance and phonetic articulation in humans. Inspection of teeth and jaws has also been used for centuries to identify humans and is an important aspect of forensic odontology. This review article throws a light on those properties of teeth which make then useful as a forensic tool.

Key words: Teeth; Forensic; Forensic Odontology; Dentists; Dental records.

### INTRODUCTION

Forensic science is the application of a broad spectrum of sciences to answer questions of interest to a legal system. This may be in relation to a crime or a civil action. The word "forensic" comes from a Latin word, "forum" which means pertaining to the courts of law[1]. Forensic medicine is a branch of medicine that deals with legal aspects of health care, and forensic dentistry is a branch of dentistry that deals with the legal aspects of professional dental practice and treatment, with particular emphasis on the use of dental records to identify victims of crimes or accidents [1].According to Pederson, forensic odontology is a branch of odontology which deals with proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings in the interest of justice[2]. The British Association for Forensic Odontology (BAFO) notes that forensic odontology is a branch of forensic medicine and, in the interests of justice, deals with the proper examination, handling and presentation of dental evidence in a court of law[2].

The earliest dental identification was made by Agrippina in 49 AD. Agrippina, the wife of Emperor Claudius, ordered the killing of Lollia Paulina; soldiers were instructed to bring back her head. However, Agrippina was unable to recognize Lollia Paulina face by looking at the severed head. She parted the lips and looked for one front discolored tooth to recognize Lollia Paulina. Paul Revere became the first dentist to make a dental identification. He indentified his friend's; Dr. Joseph Warren's body in April 1776 by observing a silverwirefixed bridge which he had delivered to him in 1775. He is also known as the forerunner of forensic odontology. Dr. Oscar Amoedo is

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known as the Father of forensic odontology. He played a major role in the mass identification in the famous disaster of Paris, The "Bazar de la Charite" disaster on 4<sup>th</sup> May, 1897. He wrote the 1<sup>st</sup> texbook on Forensic Odontology of 600 pages – L' Art Dentaire en Medecine Legale-in 1899, which include chapters on dental anatomy, bite-marks, chemical effects on teeth, traumatic lesions, teeth after death[3].

Forensic dentistry is a multidisciplinary team effort by forensic pathologist, forensic anthropologist, forensic dentist, serologists, criminalists, co-operation and co-ordination of law enforcement officials. It is an interdependent science where all of the above mentioned branches have their responsibilities to share.

### Why teeth are an important forensic tool?

Skeletal tissues have a very ancient ancestry in the evolutionary record. The basic chemistry of the calcified tissues like bone, antler and tooth (including ivory) is fundamentally the same, although they differ in their mode of growth and microstructure. Tooth enamel is rather specialized and differs from the other calcified tissues in that it is more crystalline and has a negligible organic content. Healthy enamel has zero porosity, apart from occasional growth defects. Although there has been little or no investigation of the porosity of tooth dentine, it is clear that its porosity is low compared with that of bone. Because of the absence of a vascular network in tooth dentine, its relatively low porosity, and the hard shell of impervious enamel that covers the exposed crown, it is generally accepted that teeth are less susceptible to diagenesis (changes undergone by skeletal tissues in burial environment) than bones and, therefore, they represent a more reliable source of ancient DNA and other biomolecular information. Recent evidence supports the view that the potential for post-mortem and post-excavation contamination of teeth is much lower than for bones[4].

*Reasons why teeth are known as a valuable in forensic dentistry* 

1. Teeth endure post/mortem degradation and extreme changes in ambient temperature and pressure better than most human tissues. They form an inert mineralized structure that resists deterioration and hence set up an important method of establishing identity. In a situation involving fire or severe trauma, physical features are often destroyed. Because teeth are heavily calcified, they can resist fire as well as a great majority of traumas[5]. Sweet D, Hildebrand D et al., in 1998, proposed that teeth can survive postmortem circumstances, decomposition, and immersion in water, burial, and fires reaching a temperature of 1100°c[6]. Sweet D, Sweet CH, in 1995, had presented a case report where a victim is burnt body was found in a garbage dumpster. The body seemed to be burnt in gasoline at 200°F for 30-40 minutes. All the physical evidences were destroyed and the body found was 25% of the original volume and weight. Surprisingly, most of the teeth and dental restorations remained infact [7].

2. As a source of DNA – Dental pulps are a rich source of DNA; hence, DNA-PCR can be carried out to identify a persons identity. Sweet D, Hildebrand D et al., in 1998, concluded that the neurovascular bundle in pulp is a rich source of DNA. They collected 20 human molars from an oral surgeon and cryogenic grinding was done. The average weight of tooth powder obtained was 1.77gm, i.e 97% yield; average yield of DNA was 30.9 µg. According to them, more recently the extracted tooth, more the yield.<sup>6</sup> Sweet D, Sweet CH in 1995 presented a case report where a victim body was burnt in gasoline at 200°F for 30-40 minutes. After four days, the bone was surgically removed and teeth were extracted. Pliable dental pulps were found in two wisdom teeth and DNA-PCR was done to identify the person[7].

3. As a growth predictor - Liverside HM, Molleson TI, in 1999, studied the skeletal remains of 76 individuals from an 18<sup>th</sup> century coffin-burried population from Christ Church, Spitalfields, London. The exact age was recorded from parish records Selected age range was from 1-19yrs. Radiographs were taken and developing teeth were dissected from jaws using dental burs; 354 teeth were isolated, and the tooth length was defined as the distance from cusp tip to developing crown or root. Growth curve was plotted as follows: Most of the growth follows 'S' shaped curve in the pattern of initial fast growth and a mid-root growth spurt [8]. Reddy V.R. (1985) studied the eruption of deciduous teeth in different Indian populations. It was inferred that the order of eruption of teeth in Gulbarga (Karnataka, South India) children was similar to that of Bengali children (West Bengal, Eastern India),except that the mandibular central incisors and second molars erupted earlier in Gulbarga male children [9].

4. As race estimator - Burris BG, Harris EF in 1998, studied the size of palate in 332 half white and half black Americans. It was concluded that in the blacks palate is broader and 'U' shaped especially in canine and 1<sup>st</sup> premolar region, whereas in whites it is typically convergent shape, elliptical curve in canine and 1st premolar region[10]. Hsu et al ,in 1997, reported two important teeth features: Shovel-shaped teeth and Cusp of Carabelli. The study included 329 Taiwan Chineese and 244 Bunun aborignes children of 12-15 years age. Two typical features of Mongloid races found were more shovel shaped incisors and less incidence of cusp of Carabelli, This pattern was seen more in Taiwan Chinese group. This condition is also seen in Chinese, Japanese, Eskimos, North/ South American Indians. Carabelli's tubercle or cusp is an anomalous cuspule on the mesiolingual surface of maxillary molars, appearing in 50% of American whites, 34% of Afro-Americans, and 5 to 20% of American Indains Taurodontism or "bull toothness", especially in maxillary molars, enamel pearls on premolars, and the frequent congenital lack of upper third molars, are commonly noted features in Mongoloids[11].

5. As sex estimator- Lewis A.B. and Garn S.M., in 1960, studied tooth eruption in males and females. Tooth eruption was found accelerated in early maturing girls and the significant correlation between certain stages of tooth formation or movement and menarche was found[12]. Fanning E.A., in 1961, also

reported that the completion of tooth crown calcification occurred earlier in females than in males for both deciduous and permanent dentition [13]. Seno and Ishizu in 1973 observed that male teeth are larger than female teeth; canines in females are more pointed with narrow buccolingual width[14].

6. As a Dental age estimator- Dental age is estimated by comparing the dental development status in a person of unknown age with published dental developmental surveys.

### Dental age assessment

## Principal methods

• Conventional method of counting number of teeth or the last tooth erupted

- Schour And Masseler Method
- Stages By Kraus And Jordan
- Demirjian's method
- Nolla's method
- Moorees method
- Gustafson's method
- Gustafson and Koch method
- Attrition ratio method
- Kvaal et al age estimation criteria

## Ancillary methods

- Amino acid racemization studies
- Incremental line and other histology studies
- Dentinal structure identification
- Metal ratio analysis in bone and teeth

## • Stages by kraus and jordan

Kraus and Jordan studied the early mineralization in various deciduous teeth as well as in the permanent first molar in the intrauterine life. The development is described in ten stages, denoted by Roman numerals I to X; the IXth stage includes three stages and the Xth stage includes five stages[15].

# • Conventional method of counting number of teeth or the last tooth erupted

It is one of the most commonly implied clinical methods to determine dental age. It is indeed commonly accepted that tooth eruption as an evaluation method for dental age estimation has some limitations. The limitations are: a) they are susceptible to environmental influences such as available space in the dental arch, extraction of deciduous, predecessors, tipping, or impaction of teeth b) they cannot be applied between the ages of three to six years, or past the age of thirteen[16].

### Schour and masseler method

In 1941, Schour and Masseler studied the development of deciduous and permanent teeth, describing 21 chronological steps from 4 months to 21 years of age and published the numerical development charts for them. The American Dental Association (ADA) has periodically updated these charts and published them in 1982, making it possible to directly compare the calcification stages of teeth on radiographs with the standards[17].

### Demirjian's method of age assessment

The method by Demirjian et al. is useful in estimating the chronological age of children based on their dental age, i.e., of children with unknown birth data, which is often true for adopted children or of children committing legal offenses. The technique may also be used to estimate the age of unidentified skeletons belonging to children. It states eight defined stages in tooth development giving them a score from 'A' through 'H'. This method has been developed from a large random sample of French-Canadian children and is confined to first seven teeth of left lower quadrant. Adding these 8 scores results in the estimation of age[16].

Stages	Description
Stage A	Cusp tips are mineralized but have not yet coalesced
Stage B	Mineralized cusps are united so the mature coronal morphology is well
-	defined
Stage C	Crown is about half formed; the pulp chamber is evident;dentin
0	deposition is occurring
Stage D	Crown formation is complete to dentinoenamel junction; the pulp
	chamber has a trapezoidal form
Stage E	Formation of inter-radicular bifurcation has begun; root length is less
-	than crown length
Stage F	Root length is at least as great as crown length; roots have funnel -
-	shaped endings
Stage G	Root walls are parallel but apices remain open
Stage H	Apical ends of roots are completely closed and the periodontal
	membrane has uniform width around the tooth

### Advantages[18]

• Predicted dental age is relatively accurate since it is not based on the eruption process of teeth.

Satisfies most of the ideal requirements

•Based on development of seven or four teeth in mandible, making it quick, easy to use and accurate

•Simplest, most practical, widespread method

• It is based on clearly defined stages

### Limitations

Over-estimation of dental age

Liversidge et al. proved that the Demirjian method yields overestimated results and they consider this due to a positive trend in growth and development during the last 25 years[18]. Prabhakar AR, Raju OS, Panda AK also studied the applicability of Demirjian method in 151 Davangere children of 6-15 years. They also concluded that this technique shows overestimation of dental age[19].

Nollas stages of tooth eruption

This method of dental age assessment was proposed by CM Nolla in 1960. It is a type of gradation scale and is one of the dental ageing systems, which are useful for forensic, research and clinical purposes. Development of each tooth is divided into ten recognizable stages and categorically numbered 1 through 10. The sum of the scores of all the teeth is used to define the dental age[20].

### Indications

**1. Estimation of dental age -** Dental age may be assessed either by tooth eruption dates or by the progress of tooth calcification.

**2. Application in archaeology -** Degree of age-related change in a tooth may be used to estimate the age of human remains.

**3. Legal purposes -** Tooth calcification rapidly and accurately determines an individual's age for legal purposes.

Si	tages
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Stages	Description
Stage 0	Absence of crypt
Stage 1	Presence of crypt
Stage 2	Initial calcification
Stage 3	1/3 crown completed
Stage 4	2/3 crown completed
Stage 5	Crown almost completed
Stage 6	Crown completed
Stage 7	1/3 root completed
Stage 8	2/3 root completed
Stage 9	Root almost completed, open apex
Stage 10	Apical part of root completed

**4.** Formulating treatment plans - Dental age is one of the factors taken into account - having particular relevance to the timing of treatment.

**5.** Diagnosis of genetic anomalies - Certain genetic conditions are characterized by a delay in dental development, eg. Cleidocranial dysplasia.

### Advantages

**1. Most accurate way of estimating dental age** - Teeth progressively calcify in several, easily definable stages so that age can be reliably defined by stage of calcification. It is the least susceptible of these systems to change, both over the centuries and to environmental influences. It is also independent of the somatic growth. Kevin Briffa et al. studied panoramic radiographic records of 120 patients ( aged 11 to 14 years ), collected from records kept at the School Dental Clinic, Floriana and St Luke's Hospital. Records were matched for age and sex. Calcification of teeth was graded according to Nolla's method. Results obtained were compared to the Nolla's tables to determine how closely Maltese population conforms to these tables. A significant correlation between estimated (dental) age and the chronological age of male school children was found [21].

**2. Reliable -** Calcified teeth are extremely durable, often surviving conditions which consume all other human tissues, and may be used to age cadavers.

**3. Whole dentition analysis –** It is applied over the whole dentition leading towards more accuracy.

**4. Bolanos scale-** It is a modification of Nolla method. It is based on Nolla's tables applicable to three and four teeth. This scale is more practical for epidemiological studies [21].

5. Moorees cf method - This is a graphic method where dental maturation has been divided into 14 stages, ranging from initial crown formation to apical closure. It is a quantitative numerical method that performs very well in individuals from 4.7 to 20.7 years of age. For estimating dental age, mandibular teeth are generally used because the overlapping of osseous structures hinders analysis of maxillary teeth. The values of ages corresponding to the formation stages are averaged obtaining the dental age through the mean. This method presented the highest correlation coefficient between dental age and radiographic age with a tendency to overestimating the radiographic age [22].

**6. Gustafson's method** - An early age estimation technique was proposed by Gustafson. It is based on the measurement of regressive changes in the teeth such as amount of occlusal attrition, amount of coronary secondary dentin deposition etc. For each of these parameters, Gustafson has assigned scores from 0 to 3, and by adding these, an overall score was obtained which was linearly related to an estimated age[23].

• Gustafson linear regression formula for age estimation was:

Age = 11.43 + 4.56 X X = Overall score

Later on, Johanson modified the formula, evaluated six criterias and made it most widely accepted among forensic odontologists. The equation given was:

$$\label{eq:age} \begin{split} \mathbf{Age} &= 11.02 + (5.14 \ \mathrm{A}) + (2.3 \mathrm{S}) + (4.14 \mathrm{P}) + (3.71 \mathrm{C}) \\ &+ (5.57 \mathrm{R}) + (8.98 \mathrm{T}) \end{split}$$

Six criteria

- 1) Attrition, wearing down of incisal and occlusal surfaces (A)
- 2) Secondary dentin formation, filling of pulp canal with hard tissue **(S)**
- 3) Paradontosis, changes in supporting periodontium leading to loosening of teeth, abscess formation and tooth loss (**P**)
- 4) Cementum apposition especailly. at root apex **(C)**
- 5) Root resorption, delineated areas of cementum and dentin being resorbed by special cells **(R)**
- 6) Apical root transparency, transparent dentin seen in root **(T)**

### **Attrition Ratio Method**

Sumit Seth et al[21] from the Department of Forensic Medicine & Toxicology, L.H.M.C & Smt. Sucheta Kriplani Hospital, New Delhi, in the year 2001 – 2002 proposed a method to estimate the dental age. The central maxillary incisor teeth were extracted from the dead bodies of ages 25 to 75 years. The formula proposed was:

• Index value of attrition = 
$$\frac{aX100}{A}$$

• 'a' is width in mm of attrited teeth

• 'A' is the width in mm of teeth at the cervical margin

• The Inference was that in Group A (25 – 35 years), the index value of attrition ranged from 35.5 to 60.0. In Group B (35-45 yrs), the index value ranged from 34 to 86. In Group C & D the values ranged from 63 to 92 & 87 to 94.5.

On this basis, an equation was formulated to determine dental age,

Age = 0.606 x Index value of attrition – 0.474

Kvaal Age Estimation Criteria [25, 26]: In this method, pulp-to-tooth ratio was calculated for six mandibular and maxillary teeth. Teeth included were maxillary central and lateral incisors; maxillary second premolars; mandibular lateral incisor; mandibular canine; and the first premolar. The age is derived by using these pulp-to-tooth ratios in the formula for age determination given by Kvaal et al. Using intraoral periapical radiographs, pulproot length (R), pulp-tooth length (P), toothroot length(T), pulp-root width at cementoenamel junction (A), pulp-root width at midroot level (C) and pulp-root width at midpoint between levels C and A (B) for all six teeth were measured. Finally, mean value of all ratios excluding T (M), mean value of width ratio B and C (W) and mean value of length ratio P and R (L) were substituted in the given formula:

Age = 129.8 - (316.4 X M) (6.8 X (W-L))

### Ancillary techniques of dental age estimation

• Aspartic acid racemization - Racemization of aspartic acid in dentin protein during the human lifetime progresses with age. The extent of racemization of aspartic acid in coronal dentin of normal permanent teeth can be used in forensic odontology to estimate the age of an individual at the time of death. Amino acids which contain at least one asymmetric carbon atom in their molecules show optical activity [i.e., the D- and L-enantiomers of these molecules rotate the plane of polarized light to the right (D) or to the left (L)]. Optically active amino acids in most living organisms consist initially only of their L-enantiomers. In time, these L-amino acids are partly converted to the D-enantiomers until equilibrium mixtures of the D- and L-enantiomers are attained. The racemization of aspartic acid in bone is

generally faster than that of other amino acids (aspartic acid > alanine >glutamic acid > isoleucine - leucine). Studies have shown that D-aspartyl residues accumulate with aging throughout human life in the metabolically stable protein in tooth enamel, dentin, and lens. The accumulation rate of D-aspartyl residues (i.e., racemization rate) is temperaturedependent in vivo and post mortem. As post mortem temperatures of cadavers rapidly reach the temperatures of the preserving environment, the racemization rate decreases greatly. In 1976, Helfman and Bada used this information to study age estimation by comparing D/L aspartic acid dental ratios in 20 subjects. A high coronary D/L ratio was noted in the younger age group, decreasing with age presumptively due to environmental changes[27]. In 1985, Ogino et alreported this application in forensic odontology specimens for age determination at the time of death[28]. In 1990, Ritz et al studied the extent of aspartic acid racemization in dentin for age determination at the time of death, concluding it as a more accurate method for the determination of age than other aging parameters[29]. In 1991, Ohtani and Yamamoto studied this aspartic acid relationship in lower central incisors and first premolars and found good correlation between Asp D/L and actual age. It was concluded that better age estimations could be achieved with fractionating the total amino acid fraction (TAA) into an insoluble collagen fraction (IC) and a soluble peptide fraction (SP). Soluble peptide fraction contains higher aspartic acid and glutamine. SP appeared to provide the most reliable age estimation because of a high racemization rate - roughly three times that of TAA [27].

• Incremental line analysis: Dental development in humans begins prior to birth and continues throughout adolescence. Like many biological systems, hard tissue formation is characterized by a circadian rhythm. Developmental rate and time are permanently recorded by incremental lines in enamel and dentine, which remain unchanged in these

tissues for millions of years. Given that dental remains are the most common, well-preserved type of fossil evidence for extinct species of primates, examination of incremental growth processes sheds new light on the evolutionary developmental biology of early humans. Counts and measurements of these short- and long-period lines provide information on the rate and duration of enamel and dentine secretion, which may be combined to determine the total crown formation time and the rate and duration of root extension. The neonatal line is a particular band of incremental growth lines seen in histologic sections of deciduous teeth. It belongs to a series of a growth lines in tooth enamel known as the striae of Retzius. The neonatal line is darker and larger than the rest of the striae of Retzius. It is caused by the different physiologic changes at birth and is used to identify enamel formation before and after birth. These lines are formed in enamel and dentine at the point of birth. Therefore, only teeth that are developing at birth can exhibit neonatal lines. All the primary teeth are forming at birth; first permanent molar is just beginning calcification at or near birth. The enamel develops before dentine, so, depending on when the first permanent molars start their development, the enamel would probably have neonatal lines and the dentine may or may not have. Different teeth developing in one individual give the same pattern of incremental lines which is distinct from that of another individual. So, they are the "Fingerprints" of enamel development. Incremental line analysis is usually done on ground sections of longitudinally sectioned dentition. [29] [30]. Anders Retzius in 1837 described incremental brown striae in the enamel of teeth. In 1991, Skinner and Anderson studied the cranium of a missed native Indian child in British Columbia, Canada. They correlated these lines with stressors in life[30]. Thomas Cook DC also reported that incremental line analysis appears to complement dental eruption data. Lipsinic et al. studied correlation of age and incremental lines in cementum of human teeth. They found correlation between the number of lines and age[29]. Singh and Gunberg combined bone

section histology with dental histology and concluded the lalter as a valuable comparative age determination method[31].

• Dental structure identification: The microscopic age changes of dentin are characterized by the fact that an increasing number of dentinal tubules are obliterated by mineralized tissue with age. The occluding material is homogeneous and consists of non collagenous matrix and small hydroxyapatite crystals. The formation and pattern of agerelated intratubular dentin is important from the forensic point of view, which starts at the apex of teeth and continues towards the coronal direction with increasing age. In the coronal dentin, the intratubular mineralization will not lead to complete obliteration of the tubules until patient is in their 70s. Carrigon PJ et al (1984), in a SEM study, studied dentinal tubules in 30 freshly extracted human maxillary central incisors and concluded that the number of dentinal tubules decreased with increasing age[29]. Carr et al in 1986. confirmed dentition in recovered remains from burned wreckage of a gasoline truck involved in a transportation mishap. Identification of the specimens as dentition was based on the presence of dentinal tubules In addition to dentinal tubules. SEM provided profile of elements present within the dentinal tubules which identified particular type of dental material. [32]. Fairgrieve, in 1994, reported a similar case involving SEM on incinerated teeth to evaluate parallel striations in tooth enamel and dentine as evidence of previous dental restorations[33].

• Metal ratios: Under conditions of normal calcium metabolism, strontium/calcium ratios (Sr/Ca) have been shown to reflect the trophic level of contemporary and recent terrestrial fauna. These ratios, therefore, offer a potential means of studying fossil ecosystems in medicine. However, in dentistry, the literature is very sparse. LT Humphrey et al studied Sr/Ca ratio across neonatal line. Neonatal line separates enamel that initiate mineralization prior to birth and enamel that initiate

mineralization in early postnatal period. It was concluded that stronitium level decreases at birth in breastfed infants and the level increases in infant-fed formula from cow's milk[34].

### CONCLUSION

Teeth record information that remains throughout life and beyond. Teeth may also be used as weapons and, under certain circumstances, may leave information about many important things used in forensic odontology. It is because of this unique nature of this hard mineralized tissue that we can wind up this article by concluding that a tooth is indeed a very important forensic tool. So, dental professionals have a major role to play in keeping accurate dental records and providing all necessary information so that legal authorities may recognize malpractice, negligence, fraud or abuse, and identify unknown humans.

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## Gender Determination: A View of Forensic Odontologist

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### ABSTRACT

Forensic odontology is an investigative aspect of dentistry that analyzes dental evidence for human identification. Forensic odontology plays an important role in establishing sex, age, and race of victims. Many times, determination of sex / gender using skeletal remains presents a great problem to forensic experts, especially when only fragments of body are recovered. Forensic odontologist can assist other experts to determine sex of the remains by using teeth and skull traits. Various features of teeth, like morphology, crown size, root length etc are, characteristics differentiating male and female sexes. There are also differences in skull pattern and skull traits of two sexes. These help a forensic odontologis to identify the sex of the remains.

**Key words:** Forensic odontology; Sex determination; Canine dimorphism;, Polymerase Chain Reaction (PCR); Amelogenin.

### **INTRODUCTION**

The British Association for forensic odontology defined forensic odontology as branch of forensic medicine that, in the interests of justice, deals with the proper examination, handling and presentation of dental evidence in a court of law.

Forensic odontology is an investigative aspect of dentistry that analyzes dental evidence for human identification. Apart from assisting in the identification of an individual, it reveals the age and gender of the same. Determination of sex using skeletal remains

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presents a great problem for forensic experts, especially when only fragments of the body are recovered[1].

Forensic dentists can assist other experts in determining sex of the remains by using information of the dental and skeletal remains.

Dental remains as teeth are an excellent material in living and nonliving populations for anthropological, genetic, odontologic and forensic investigations. Being the hardest and chemically the most stable tissue in the body, they are selectively preserved and fossilized, thereby providing best records for evolutionary change. Their durability in the face of fire and bacterial decomposition makes them invaluable for identification[2].

Various features of teeth, like morphology, crown size, root length etc, are differentiating characteristic between males and females. There are also differences in the skull pattern. These help a forensic odontologist to identify the sex. New developments like PCR,

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amplification assist in accurately determination of the sex of the remains[3].

# Classification of methods used for sex determination

- Visual method or clinical method
- Microscopic methods
- Advanced methods

### Visual method or clinical methods

Differences between the sexes with respect to:

a. Tooth size

- b. Root length and crown diameter
- c. Using canine dimorphism
- d. Tooth morphology and sexing
- e. Dental index
- f. Odontometric differences

### Microscopic methods

a. Sex determination using Barr bodies

### Advanced methods

a. Sex determination using Polymerase Chain Reaction (PCR)

b. Sex determination using enamel protein

### Visual / Clinical methods

### Sex difference in tooth size

Teeth may be used for sex differentiation by measuring their mesiodistal and buccolingual dimensions[4]. Studies shows significant differences in crown dimensions of male and female teeth, and both deciduous and permanent. Mandibular canines show the greatest dimensional difference with large teeth in males than in females. Pre-molar, first and second molars and maxillary incisors are also known to have significant differences[5].

### Root length and crown diameter

Using optical scanner and radiogrammetric measurements on mandibular permanent teeth, sex determination can be done with 80% accuracy by measuring root length and crown diameters[3].

### Sex determination using canine diamorphism

In the field of forensic odontology, permanent canine teeth and their arch width (distance between the canine tip) contribute to sex identification through dimorphism. The dimensions of canine teeth have been studied by several methods, including Fourier analysis (Minzuno, 1990), Moire topography (Suzuki et al, 1984) and the measurement of linear dimensions such as mesiodistal width, buccolingual width and inciso-cervical height (Anderson and Thompson (1973)[7], Garn et al, (1967)[8]; Rao et al (1988a, b)[9& 11].

A study by Anderson and Thompson (1973)[7] showed that mandibular canine width and inter-canine distance was greater in males than in females and permitted accurate differentiation between the sexes in 74% of cases.

Garn et al (1973)[8] studied sexual dimorphism by measuring the mesiodistal width of canine teeth in different ethnic groups. Furthermore, the mandibular canine showed a greater degree of sexual dimorphism than the maxillary canine.

Rao et al (1988)[9] reported that the mesiodistal width of mandibular canines was significantly greater in males than in females.

### Tooth morphology and sexing

Distal accessory ridge, a non metric feature on the canine is the most sexually dimorphic crown trait in the human dentition, with males showing significantly higher frequencies and more pronounced expression than females[10].

### Dental index

In addition to absolute tooth size, tooth proportions have been suggested for Indian Journal of Forensic Medicine and Pathology differentiating the sexes. Mandibular canine index proposed by Rao[11] and associates has given an accurate indication of sex in an Indian population. Using the mesiodistal (m-d) dimension of the mandibular canines, these researchers obtained the formula:

[(Mean m-d canine dimension + (Mean m-d canine dimension in females + S.D) in males S.D)] / 2 (S.D- Standard Deviation)

The values obtained using this formula is 7.1mm and the maximum possible mesiodistal dimension of mandibular canines in females. The same dimension is greater in males than females. The success rate of determining sex using the above formula was close to 89%. However, relative to the near 100% accuracy using pelvis and skull, sexing by odontometrics is relatively poor[4].

### Odontometric differences

The odontometric differences between male and female are generally explained as a result of greater genetic expression in males[12].

### Microscopic methods

### Sex determination using Barr bodies

Sex can also be determined by the study of X &Y chromosomes in the cells which are not undergoing active division. Presence or absence of X chromosome can be studied from buccal smears, skin biopsy, blood, cartilage, hair root sheath, and tooth pulp. After death, it persists for variable periods depending upon the humidity and temperature of the ambient atmosphere. X chromatin and intra-nuclear structure is also known as Barr body as it was first discovered by Barr and Bertam (1949)[13]. It is present as a mass usually lying against the nuclear membrane in the females[13].

In a study done by Das et al (2004)[14] it has been shown that up to a period of four weeks after death we can determine the sex accurately from the study of X & Y chromosomes, keeping in view the variation of temperature and humidity. Whittaker and coworkers determined sex from necrotic pulp tissue stained by quinacrine mustard using fluorescent Y chromosome test for maleness and claimed that upto 5 weeks after death, sex determination can be done with high degree of accuracy[15].

Duffy et al[16] showed that Barr bodies and F bodies Y chromosomes are preserved in dehydrated pulp tissues upto one year and pulp tissues retain sex diagnostic characteristics when heated upto 100Úc for one hour.

### Advanced methods

### Sex determination using PCR

Polymerase Chain Reaction (PCR) is a method of amplifying small quantities of relatively short target sequences of DNA using sequence-specific oligonucleotide primers and thermostable Taq DNA polymerase[17].

The teeth can withstand high temperature and are used for personal identification in forensic medicine. In the case of few teeth or missing dental records, there is not enough information to identify the person. The dental pulp enclosed by the hard tissue is not influenced by temperature, unlike the buccal mucous membrane, saliva, and calculus[6].

In a study by Tsuchimochi T et al (2002), they used Chelex method to extract DNA from the dental pulp and amplified it with PCR and typing at Y-chromosomal loci to determine the effects of temperature on the sex determination of the teeth[17.

Hanaoka et al (1996) conducted a study to determine sex from blood and teeth by PCR amplification of the alphoid satellite family using amplification of X (131 bp ) and Y (172 bp) specific sequences in males and Y specific sequences in females. It was shown to be a useful method in determining the sex of an individual[18].

Sivagami and coworkers (2000) prepared DNA from teeth by ultrasonication, and subsequent PCR amplification, and obtained

Trait	Male	Female
General size	Large endocranial volume > 200 cc	Small, lighter with thin walls
Architecture	Rugged	Smooth
Glabella	More pronounced	Less pronounced
Orbits	Square, lower, smaller with rounded margins.	Rounded, higher, larger, sharp margins.
Supra-orbital ridges	Prominent	Less prominent
Forehead	Steeper & less rounded	Vertical, round & fantile
Check bones	Heavier, laterally arched	Lighter & more pronounced
Zygomatic arch	More pronounced	Less pronounced
Frontal eminence	Small	Large
Parietal eminence	Small	Large
Occipital area	Muscle lines & protuberance marked	Muscle lines & protuberance less marked
Mastoid process	Medium to large, round & blending	Small to medium smooth & pointed.
i. Base	Sites of muscle insertion are marked	Less marked
ii. Digastric groove	Deep	Less deep
iii. Condylar facet	Long and slender	Shorter and broad
Occipital Condyle	Larger	Small
Palate	Larger,broader, U-shaped	Small & parabola shaped
Frontal sinus	Well developed	Less developed
Nasal aperture	High & narrower margins & sharp	Lower & broader
Foramina	larger	Smaller
Foramen magnum	Large & long	Small and round

## Skull traits of two sexes (Krogman/Narayan Reddy)

-

100 % success in determining the sex the individual[19].

### Sex determination from enamel protein

Amelogenin or AMEL is a major matrix protein found in the human enamel. It has a different signature (or size and pattern of the nucleotide sequence) in males and females.

The AMEL gene that encodes for female amelogenin is located on the X chromosome amelogenin and AMEL gene that encodes for the male amelogenin is located on the Y chromosome. Females have two identical AMEL genes or alleles, where males have two different AMEL genes. This can be used to determine the sex of the remains with very small samples of DNA[3].

### CONCLUSION

Forensic odontologist assists in determination of gender where skeletal remains present a great problem to forensic experts, especially when only fragments of body are recovered. Thus, forensic odontologist plays a key role in identifying the gender.

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