Review Article

Ossification Centres and their Validity for the Assessment of Age in India

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Abstract
The subject of Forensic Medicine & Toxicology is an integral part of teaching in medical curriculum prescribed by Medical council of India. Since the evolution of this subject & separation of the subject from the Pathology / Community Medicine, in early 20th century no much scientific additions / developments have been taken place. At the same time the subject experts have adhered to what the subject had in beginning, only teaching under graduates in medical colleges without much medico legal work (which is present only in government medical colleges) often within college campus. Hence most of the references mentioned in common Forensic Medicine text books in India are inherited from western literature. Are these data reliable to be applied in Indian population? If yes, to what extent these references are applicable to Indian population? More and more researches are necessary in this regard.
Key words: Forensic Medicine & Toxicology; Reliable data; Indian population

Introduction

Age of the either victim or accused has legal bearing upon the outcome of the given crime case under investigation. Hence estimation/assessment of age of the subject under question by the medical practitioner is of paramount importance in the outcome of the given case. Age estimation is essential to establish the identity of a person at the time of admission in school/college/ institute, sports meet, employment & marriage[1].

The process of assessment of age by traditional methods like General Physical Examination and Dental examination are in practice. Among these methods the assessment of age by Dental examination is reliable tool as proved by the experts in the medical field and the same are accepted in Honorable courts of law. However if estimated / assessed age is of more wider range then the use of ossification centres by radiological examination is employed upon to reduce or narrow the range of assessed age. The reference criteria for estimation of age by appearance of primary or secondary centers of ossification for the various parts of ossifying bone are at different age. These ossification centers are subjected to variations in their age of appearance in respect to nutritional, infectious, endocrinal disorders or diseases that the person suffering or suffered earlier. Extensive work on determination of age from the epiphyseal union has been carried out abroad. In India, different states revealed the difference in the ages of epiphysial union. The difference may be on account of varying sexual dimorphism, dietetic, geographic, hereditary and other factors keeping in mind that very less literature is available relevant to the population of this particular region of India[2]. But still assessment of age by radiography is one of the handy tools in need of hour in certain age. The references available in the medical literature as to appearance or fusion of these ossification centres vary from book to book. How reliable are they? Do they

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have scientific valid references? Because most of the text books of Forensic Medicine & Toxicology don't mention references for the data given. Hence this review article is presented to throw some light upon existing literature. It also points out arriving at conclusions as to what to be done, to create scientific reliable reference criteria, either for regional or national level. For instance different modalities of bone age estimation provide different results and their applicability differs in different ethnicities[3]. The need is to study in order to compare them and select the method best suited to our population.

Objective:

The main objective of the study is to look at the various text books and their contents as to the assessment of age by ossification centres. There are lot of differences of opinions amongst the authors as to age of appearance as well as fusion of various ossification centres. Nature of research, done by whom, when, where and study done on which population are the questions which remain un-answered in most of the references. Hence this study was under taken to throw some light upon existing literature and pave the new way for development of authenticated references for local population.

Materials & Methods:

The five forensic Medicine and Toxicology textbooks of the authors belonging to different regions of India were considered for the review. The age of appearance and age of fusion of various ossification centres which are used in undergraduate teaching and age estimation of medico-legal cases mentioned in these textbooks were tabulated and the values compared.

When values for both sexes were given by the authors, the range with minimum and maximum ages was recorded.

Observations:

The data derived from radiography based on appearance and fusion of ossification centres used to estimate the age of an individual available in various text books of Forensic Medicine & Toxicology is shown in Table 1 (Upper limb joints) and in Table 2 (Lower limb joints).

Discussion:

The bones of the human skeleton are preformed in hyaline cartilage. This soft tissue is gradually converted into hard osseous tissue by osteogenesis from which the process of transformation spreads until whole skeleton is ossified.[4] The appearance of these ossification centres is spread over a long period starting from embryonic life to few years after birth. The process of appearance and fusion of these centres follow a sequence and a time. This process is used in forensic investigations for estimation of age. The age ages of appearance and fusion differ in different populations. The possible reason is the geographical distribution, and associated influence of climate, race, sex, dietary habits, physical habits, presence of diseases in that region, hormonal & metabolic disorders religious practices and heredity.[6,8] Similar opinion was expressed by Srivastav Ashutosh et al[9] in their study and other studies done in Bengal and Mumbai.[10] There may be maturity imbalance between bones from different parts of the same individual.[4]The ossification centres in females generally appear and fuse earlier when compared to males.[6,8]In Bengali study, the ossification centres in Hindu females fused one to two years earlier compared to Mumbai region females.[10] Hepworth study showed that the skeletal maturity in Panjabi region was 6 months to 1 year earlier compared to Mumbai region.[10]

Our review of textbooks also reveals the similar findings. The studies done in different parts of India or the values coted in textbooks selected in the study belonging to different parts of India have clearly shown the discrepancies in the ages of appearance and ages of fusion for many ossification centres. The following observations can be derived from the tables:

Table 1: Details of Ossification centres of Upper Limb mentioned in various textbooks

Ossification centre	KSN[4]		Apoorba Nandy[5]		Krishan Vij[6]		Rajesh Bardale[7]		Balachandran[8]	
	A	F	A	F	A	F	A	F	A	F
Acromian Process	14-15 y	17-18 y	12-15 y	13-16 y	14- 15 y	17-18 y			14.2-15.6 y	16.3-18.7
Head of Humerus	½ -1 y	18-19 y	1 y	15-17 y	1 y	18-19 y*	1 y	14-18 y	--	--
Greater tubercle	3 y	--	4 y	--	3	18-19 y*	7 m	5-7 y*	--	--
Lesser tubercle	5 y	--	5 y	--	5	18-19 y*	--	--	--	--
Capitulum	1 y	14-16 y	1 y	14-16 y*	1 y	14-16 y	5-10.5 m	--	--	--
Trochlea	9-11 y	14-16 y	9-11 y	13-15 y*	9 – 11 y	16-17 y	7-11 y		11.1-13	--
Lateral epicondyle	11 y	16-17 y	10-13 y	14-15 y*	11 y	16-17 y	10-12 y	10-16 y	11.1-12.7	--
Medical epicondyle	6-7y	16-17 y	5-7 y		5 – 6 y	16-17 y	5-7 y	14-16 y	--	15.7-18.3
Upper end of Ulna	9 y	16-17 y	9-12 y	13-16 y	9 y	16-17 y	9-13y	15-17 y	--	--
Upper end of Radius	5 y	16-17 y	5-7	13-16 y	5 y	16-17 y	6-8 y	14-16 y	--	15.3-18.1
Lower end of Radius	2y	18-19 y	1 y	16-18 y	2y	18-19 y	1 y	16-17 y	--	16-18.9 y
Lower end of Ulna	5-6 y	17-18 y	5-7 y	17-18 y	5-6 y	17-18 y	8-11y	17-18 y	--	16.1-18.8 y
Capitate	2 m	--	1 y	--	2m	--	6 m	--	--	--
Hamate	2 y	--	1 y	--	3m	--	8-14 m	--	--	--
Triquetral	3 y	--	3 y	--	2-3 y	--	2-4 y	--	--	--
Lunate	4 y	--	4 y	--	3-4 y	--	5 y	--	--	--
Trapezium	6 y	--	4-5 y	--	5-6 y	--	5-7 y	--	--	--
Trapezoid	5 y	--	4-5 y	--	5-6 y	--	4-7 y	--	--	--
Scaphoid	5 y	--	6 y	--	5-6 y	--	6-11y	--	--	--
Pisiform	11-12 y	--	9-12 y	--	10-12 y	--	9-17 y	--	10.4 – 12.4 y	--
Base of 1st Metacarpal	2-3 y	15-17 y			2-3 y	15-17 y	3-4 y	14-18 y	--	--

*Fusion afterComposite epiphysis formation; y – years;m - months

1. For the given centre of ossification, different authors have presented different age of appearance.
2. The under graduates reading these text books will be under confusion, regarding which textbook (reference) to be followed and to be written in exams.
3. Examiners from various parts of country are appointed by universities to evaluate theory answer scripts and to conduct

practical examinations. The students reading one text book of Forensic Medicine & toxicology written by one particular author will be wrong if the examiners follow different reference book in their area and may wrongly evaluate the answers.

4. Post graduate students reading various text books of Forensic Medicine & Toxicology face difficult while referencing the topic under discussion. Even the guide shall be in doubt as to the origin of these references.
5. Ultimately these references shall create doubt in the minds of reader or the person referring these citations.
6. The days are not far where we may have to face difficult defense examination in the honorable court of law & court questions too as to reliability of these references.

Table 2: Details of Ossification centres of Lower limb mentioned in various textbooks

Ossification centre	KSN[4]		Apoorba Nandy[5]		Krishan Vij[6]		Rajesh Bardale[7]		Balachandran[8]	
	A	F	A	F	A	F	A	F	A	F
Iliac crest	14 y	20-21 y	16 y	19-20 y	14 y	18-20 y	14-17 y	17-20 y	14-14.9 y	18-18.9 y
Ischial tuberosity	16 y	20-21 y	15-17 y	20 y	15-17 y	19-21 y	14-18 y	20 y	15.6-18.9 y	16.9-18.7 y
Triradiate cartilage	-	15 y	-	14-15 y	-	11-14 y	-	13-16 y	-	13.5-15.8
Ischipubic rami	-	6 y	-	8-9 y	-	6 y	-	8 ½ y	-	-
Head of femur	½ -1 y	17-18 y	1 y	14-17* y	½ -1 y	17-18 y	1 y	14- 19 y	-	-
Greater trochanter	4 y	17-18 y	4 y	14-17* y	4 y	17-18 y	5 y	14-17 y	-	15.6-17.1 y
Lesser trochanter	12-14 y	17-18 y	14 y	14-17* y	12-14 y	17-18 y	12-14 y	15-17 y	-	-
Lower end femur	9 month IUL	18-19 y	9-10 month IUL	16-17 y	9th month IUL	18-20 y	9th month IUL	14-17 y	-	16.5/ 14.4
Upper end tibia	Birth	18-19 y	Around Birth	16-17 y	Birth	18-19 y	Before birth	14-17 y	-	-
Upper end fibula	4 y	18-19 y	2-5 y	14-16 y	4 Y	18-19 y	3-5 y	14-16 y	-	-
Lower end tibia	1y	16-17 y	1 y	14.1-16 y	1y	16-17 y	1y	14.1-16 y	-	-
Lower end fibula	1y	16-17 y	1 y	13-16 y	1y	16-17 y	1 y	13-16 y	-	-
Calcaneal tuberosity	6-8 y	14-16 y	5-6 IU months	--	6-8 y	14-16 y	At birth		-	-

*Fusion afterComposite epiphysis formation; y – years; m - months

Looking at the regional problems of social, employment & administration, in the recent past the Indian citizens started moving from one region to another of the country in search of livelihood. This created mixed group of people living together. In such case, how can authors claim that the reference coted in their textbooks is authentic to that population under

question unless the researchers had standardised the methods keeping these factors in mind? Hence the selection criteria for 'research subjects' has to be specific to those who are inhabitants of given region for considerable period so that the uniformity is maintained in selection of subjects and it gives authenticity to the data obtained.

The researchers should work towards the development of national reference criteria for age assessment by ossification centres, which can become standard reference for medico legal purposes. The following steps could be kept in mind while developing national reference criteria.

1. Form group of Forensic Medicine & Toxicology experts representing all parts of country, at least two persons from each state at national level.
2. All the members of this forum meet, to form common agenda & meeting at convenient place to decide the objectives, available literature collection etc.
3. Frame common objectives material methods & guidelines to conduct research in every state across India in a stipulated period.
4. Publication of the research works in regional, national & international indexed journals. And then inclusion in text books by authors as an authentic reference.

Conclusion:

The ossification centres and their appearance and fusion age are being used for estimation of age in forensic investigations to establish the identity of the persons. However as evident from various references available in textbooks and other sources, the ages of appearance and fusion differ from region to region of the country. Hence these data cannot be generalised to all the cases throughout the country. The region wise data needs to be generated by carrying out researches under uniform standards and such data should be published before applying for forensic investigations.

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