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"From Bones to Years: Unlocking Age through Ossification Secrets"

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ABSTRACT
Age assessment in forensic sciences is crucial for identifying unidentified remains and addressing legal issues, particularly in cases of crimes, civil cases and mass tragedies. Thisneed for age estimation of living individuals has also increased significantly in recent decades due to various civil and criminal cases as well asglobal migration trends which influence legal outcomes. This case study examines a unique scenario involving a female petitioner asserting she is over 18 years old, while her parents claim she is only 14, seeking to annulate her marriage under the Prohibition of Child Marriage Act, 2006. This case illustrates the vital role of modern forensic medicine in age estimation in legal contexts and underscores the ethical and legal implications of age determination in resolving disputes surrounding age, identity and marital status.

Keywords: Age Estimation, Ossification test, Legal issues, Bone Age

INTRODUCTION

The age assessment of unidentified corpses and bones for purpose of identification has been a long practice in forensic sciences. Finding the identity of a deceased is crucial from an ethical, legal and criminal aspect. It has not been only necessary to formally declare someone dead, but it has also served as foundation for investigations into crimes, mass tragedies, and war crimes.[1]On the contrast, age estimation of living individuals is a relatively new and growing field of forensic research and is in greater demand as a result of the recent global surge in migration movements, criminal and civil cases[2] Due to social and legal constraints, it is now more important than ever to have professional opinions regarding an individual's age. This is particularly true for young adults and adolescents, for whom precise age assessment can influence a number of legal issues and social classifications[3]

For age assessments, aphysical examination is performed first, followed by dental and X-ray examination in accordance with the guidelines set forth by the AGFAD (Study Group on Forensic Age Diagnostics of the German Association of Forensic Medicine).[4] CT imaging of the clavicles actsas a yardstick to determine whether hand bones have ossified. [5] Besides, there are other laid down directives by American Academy of Forensic Sciences, International Association of Forensic Sciences, European Network of Forensic Science Institutesand Society of Forensic Toxicologist practiced for forensic guidelines. In the Indian scenario, besides modern techniques ones general physical examination, secondary sexual characters and radiology investigation are often used for medical assessments related to age estimation.[6]Although variations are found in developmental milestones among masses from region to region, yet legal parameters of age estimation remains uniform acrossthe Indian sub-continent. Generally, an ossification test is a medical procedure used to determine age by studying fusion ofbones and its maturityby examining the x-ray of few bones. Its importance has risen significantly in medicolegal and civil cases in recent decades. The process of bone formation is called osteogenesis which is based on bone fusion from birth to 25 years age of an individual. [7-9]

The present case study aims to bring out the uniqueness of the case related to age estimation of an female petitioner, who is claiming to be above 18 years, while her parents have filed a case stating her to be of 14 years age to void the marriage under the prohibition of Child Marriage Act, 2006. [10]

Case report

The Institute received a requisition from theHon'ble High Court to conduct an ossification test of the female petitioner to assess her exact age. As per directions of the Hon'ble court, acommittee was constituted of members from stakeholder departments;Forensic Medicine, Anatomy, Oral Health Sciences, Orthopaedics, Radiodiagnosis & Imaging and Hospital Administration to determine the age of the female individual with the help of ossification test.

The documented age of petitioner as per one of the acceptable legal document attachedwas 18 years,7 months and 26 days on the day of examination, whereas, female petitioner claimed that her date of birth has been recorded erroneously by her parents claiming her of 13 year, 3 months and 21 days. There was no other supporting document showing her age. Furthermore, as per the history given by the petitioner, she has married against the wishes of her parents after which her parents had filed a case to annulate the marriage stating petitioner is minor, under 18 years of age. In response to this, female petitioner filed counterclaim for protecting her life and liberty from the hand of respondents (parents). It is pertinent to mention here that, as per the Child marriage Act, 2006 the minimum age of marriage is 21 years for male, and 18 years for female and a marriage is null and void if a minor child is abducted or lured away from their legal guardian. [10]

On the day of examination,the constituted board examined the female petitioner, who has reported with her husband and mother-in-law. The consent for the examination was taken along with identification marks and finger prints. She asserted that she has not been examined medically earlier for the same. Pros and cons of the procedures were explained in her easily understandable language. The examination commenced with history taking, wherein she mentioned being18 years of age on the day of examination. A thorough physical examination was conducted to assess the overall growth and development features of the petitioner, whichprovided the insights on the age based on the physical characteristics and maturity level.In general physical examination, height, weight, BP and pulse were noted and were found to be in normal limits. Consequently, on secondary sexual characters examination, menstrual history was taken along with examining the growth of breast, axial hair and pubic hair. Her menstrual history onset was reported to be five years earlier, breast development is in stage 3 (breasts are slightly larger, with glandular breast tissue), presence of pubic hair and axillary hair. Acne is present (1-2 in number) andare at healing stage.

On dental Examination, there were 28 permanent teeth and an unerupted third molar. The dental expert recommended Orthopantomogram (OPG)forassessingthedentaldevelopment (Table-1). Radiological evaluation was done to evaluate the skeletal maturity which further provided significant clues on the individual age. The mentioned X-ray were done to find out the results of ossification test (Table-1). The inference of age as per the X-ray elbow and Xray wrist, is minimum 16 to 17 years . The inference of age as per Xray hand, X-ray shoulder, Xray knee and OPG is minimum 17 to 18 years. The inference of age as per x-ray pelvis is 17 to 20 years. Additionally, CT Scan of chestwas done for providing additional information on skeletal maturity of clavicle bone. The inference of age as per CT chest, after studying the ossification of clavicle is 14 to 20 years as per stages of Schmeling and sub stages of Kelling Haus. After reviewing all the parameters, board members were of the opinion that age of the female petitioner is between 17 to 20 years.

Table 1: Age estimation findings of female petitioner

Sr No.	Investigation undertaken	Observations	Inference about Age
1.	X-ray Elbow	All the epiphysis around the elbow joint including medial epiphysis, upper end of radius and Ulna are fused [11] (Image I)	Minimum 16 to 17 years
2.	X-ray left wrist and hand	All the epiphysis around the wrist joint including lower end of radius and ulna, base of first metacarpal and head of 2^{nd} to 5^{th} metacarpals are fused [11] (Image I)	Minimum 16 to 17 years for hand Minimum 17 to 18 years for wrist
3.	X-ray shoulder	All the epiphysis around the shoulder joint including upper end of humerus, lateral end of clavicle, acromion, coracoid and sub-coracoid are fused [11] (Image II)	Minimum 17 to 18 years
4.	X-rayknee	All the epiphysis around the knee joint including lower end of femur, upper end of tibia and fibula are fused [11] Image II)	Minimum 17 to 18 years
5.	X-ray pelvis	All the epiphysis around the upper end of femur	17 to 20 years

		including head, greater and lesser trochanter are fused. The epiphysis of iliac crest is complete but not fused. The epiphysis of ischial tuberosity and pubic symphysis is unfused [11] (Image III)	
6.	CT chest	Medial end of epiphysis of clavicle shows visible ossification centre but epiphyseal plates are not fused. Stage 2A as per stages of maturation described by Schmeling and sub- stages of Kelling Haus [12] (Image IV)	14 to 20 years
7.	OPG	Second molar root development completed and third molar crown completed using modified Demirjian method [13]	About 17 to 18 years

DISCUSSION

The age assessment in forensic sciences has always remained a very crucial aspect for identifying the age and addressing various civil and medicolegal issues, specifically in crimes. With the recent technological developments, there has been use of x-ray scans of hands, ischial tuberosity and iliac Crest epiphyses for age estimation [14].Even a number of grading schemes have been developed to assess the iliac crest ossification timeline in order to estimate the age.[15]The iliac crest epiphysis has provided an excellent subject for the application of forensic age diagnostics in living, particularly for determining age thresholds of 14, 16, and 18 years. [16] andsimilar technique was followed for age estimation in the present case. In another study conducted in University of Freiburg by Vamberszky in the year 2023 has shown that at stage 2 of ossification stage of clavicle studied with the help of computed tomography was seen to be 18 to 20 years of 32 subjects. [17]study by Nisha Veluchamy in 2023 stated that demirjian's modified method is widely accepted method for scoring the developmental stage of third molar as opted in the present case report. [18] In a study conducted by Leonie Vamberszky, test method with specificity of thin section of CT imaging for age estimation is 99%.[19]Similarly, in another study conducted by Harsh in year 2023, the fusion of medial end of clavicle began at 19 years and completed at 23 years in both males and in females and is vital link in age estimations.[20]

These technological advancements and future directions aim to improve the accuracy, reliability and ethical considerations of forensic age estimation, ultimately benefiting legal processes and individual rights. Future research should focus on integrating advanced imaging techniques to improve the accuracy of skeletal age assessments.Furthermore, studies have been conducted showing how deep learning can evaluate radiograph automatically for determining bone age. [21-22] In clinical practices, deep learning technique for autonomously determining bone age have shown remarkable accuracy to human practitioners. [23-20] The topic "in question" may be fascinating or ambiguous to many medical graduatesas there are very lesser studies, especially in North India,specifically for age estimation and it will enhance their knowledge and early resolution of legal and civil processes. It is also crucial for professionals, who are especially enrolled to offer knowledgeable viewpoints on such relevant legal and criminal subjects.

Declaration of patient consent

The authors certify that consent of the petitioner was sought. The petitioner has also consented for the clinical information to be reported in the journal. Due efforts have been made to conceal identity and privacy.

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Nil

Conflict of Interest

There are no conflict of Interest.

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