

Pattern of Epiphyseal Union at Knee in the Children & Young Adults of Peshawar

Ahmad Saeed, Inayat ur Rehman Khalil, Zahid Hussain Khalil

ABSTRACT

Objectives: Objectives of the study were to:

1. Determine the age of epiphyseal union at distal end of femur & proximal end of tibia and fibula in the children & young adults of Peshawar.
2. Compare the pattern of epiphyseal union at knee among males and females.

Study Design: Non-interventional descriptive.

Settings: Department of Forensic Medicine, Khyber Medical College Peshawar.

Subjects and Methods: In the study 120 healthy, young volunteer students of both sexes and original residents of NWFP were included. Males were 15-19 years and females were 13-17 years of age. Age was certified by means of birth record, school certificates and interview with the parents. Radiographs of right knee were taken using conventional x-rays apparatus. Non-probability purposive sampling technique was used.

Radiological findings regarding epiphyseal union were classified as follow;

- a. Stage of non-union
- b. Stage of partial union
- c. Stage of complete Union

Data was compiled and significance of results was evaluated through statistical analysis of the data using Chi-square and t-test.

Results: In males average age of epiphyseal union of femur, tibia and fibula is 16.5, 17 and 17.5 years respectively. In comparison, in females epiphyseal union of femur and tibia takes place at the age of 14 years while that of fibula at the age of 15 years. Epiphyseal union is 2.5 to 3 years earlier in females as compared to males.

Conclusion: Epiphyseal union occurs earlier in Pakistan than in European countries. Europeans norms and standards of skeletal growth used for age estimation are not valid for Pakistani children. Further studies on pattern of epiphyseal union must be conducted to develop local reference standard that may be used for age estimation.

Key Words: Epiphyseal union, knee, skeletal age, Chronological age.

INTRODUCTION

Union and length of the long bones are the principal criteria for estimating age in pre-adults[2].

X-rays of the elbow, wrist and shoulder joints in case of upper extremity and of the hip, knee and ankle joint in case of lower extremity are usually recommended for this purpose[3]. Stage of epiphyseal union observed in the X-rays is then compared with the norms of different radiographic atlases published for this purpose.

The study of epiphyseal union of bones is considered a reasonable scientific and accepted method for estimation of age by the court of law all over the world. Therefore, it is necessary to follow the latest data available for a particular place for estimation of the age of the population of that place [4].

A number of studies were conducted on specific populations in different countries of the world like Turkey [5] Ireland [6] Portugal [7], Canada [8], India [4, 9, 10, 11, 12] & Pakistan [13, 14, 15] to know the pattern of epiphyseal union with different results.

Variation in timings of epiphyseal union in the long bones shown in different studies is suggestive that pattern of epiphyseal union need to be assessed in Pakistan. Though a few studies have been conducted on the pattern of skeletal maturity in Pakistani children using the X-rays of wrist and elbow [13,14,15], yet knee radiography, as diagnostic tool for establishing the age could not get proper attention in Pakistan leading to lack of dependable scientific data in this

respect. Due to non-availability of local ones, commonly used X-ray standards for age estimation are those for white US Americans, North and Central Europeans as well as for Indians. The applicability of these standards to members of ethnic groups different from the reference populations has been the subject of controversial discussion. So it is need of the time to develop our own standard by radiological study of the pattern of epiphyseal union in different racial samples in Pakistan. This study will contribute in achieving this goal. (Insha'Allah)

Purpose of the study was to develop local standard of developmental growth by the radiological examination of knee that may be used as frame of reference for the estimation of age.

Objectives of the study were to:

1. Determine the age of epiphyseal union at distal end of femur & proximal end of tibia and fibula in the children & young adults of Peshawar.
2. Compare the pattern of epiphyseal union at knee among males and females.

SUBJECTS AND METHODS

This was a cross sectional, non-interventional descriptive study.

Study was conducted at the department of forensic medicine Khyber Medical College Peshawar.

120 Healthy, young Volunteer students, 60 boys and 60 girls belonging to different educational institutions of Peshawar and original residents of NWFP were included in the study. Non-probability purposive sampling technique was used. Males having age range of 15-19 years and females 13-17 years were selected for the study.

Volunteers not originally belonging to NWFP, having bony deformity or diseases or suffering from a hormonal abnormality such as gigantism and dwarfism were not included in the study.

Chronological age was certified by means of birth record or school certificate and was verified by the parents. Informed consent of the parents / guardian regarding radiological examination was taken explaining them the purpose and details of the procedure. Radiographs of right knee (AP view) were taken using conventional X-ray apparatus at radiology section of forensic medicine department. Radiological findings regarding epiphyseal union were classified as follow;

A - Stage of non-union (N)

B - Stage of partial union (P)

C - Stage of complete Union (C)

Stage of non-union is the stage where epiphyseal growth plate was clearly visible on the X-ray film throughout the width of the bone.

Stage of partial union is the stage where growth plate was partially replaced by bony tissue at one or more places and epiphyseal line on X-rays was partially visible.

Complete union is the stage where growth plate was replaced by solid bone and therefore was not visible on X- ray film.

Mean age of union in each bone of knee was calculated by totaling all the cases of complete epiphyseal union from the age of the earliest union (where first union in the sample occurred) to the age of the latest union (age at which complete union in 100% of the cases occurs) and dividing by total number of these cases. For the purpose of age calculations, while converting days into months more than 15 days was counted as one month while period up to 15 days was not counted. Whereas while converting month into years period of less than 3 months was not counted while more than 3 months was counted as half year (0.5 year). While making year-wise age groups of the subjects, period up to 6 months was not counted and period of more than this was counted as one year.

Data was compiled and results were prepared after analysis of the data. Chi-square was applied to test the association between the age and stage of epiphyseal union. t-test was used as test of significance for comparing the ages of complete epiphyseal union between males and females.

RESULTS

There were two groups of subjects, males and females in our study. Average age of complete epiphyseal union in the males is 16.5 (Standard deviation 0.71) for femur, 17.0 years (Standard deviation 1.26) for tibia and 17.5 (Standard deviation 1.16) for fibula. While in the females it is 14 years (Standard deviation 0.52) for femur, 14 years (Standard deviation 0.71) for tibia and 15 years (Standard deviation 0.41) for fibula.

The study revealed that epiphyseal union occurs 2.5 to 3 years earlier in females than males. The difference between the ages of epiphyseal union in two genders is statistically significant.

Table 1
Age of Epiphyseal union-Distal end of femur

Sex	Age Group	Number of cases			
		Non Union	Partial Union	Complete Union	Total
Male	15Years	09	05	02	16
	16Years	04	03	09	16
	17Years	00	05	06	11
	18Years	01	00	06	07
	19Years	00	00	10	10
Female	13Years	03	12	01	16
	14Years	00	10	01	11
	15Years	00	01	06	07
	16Years	00	00	11	11
	17Years	00	00	15	15

Table 2
Age of Epiphyseal union-Proximal end of tibia

Sex	Age Group	Number of cases			
		Non Union	Partial Union	Complete Union	Total
Male	15Years	09	05	02	16
	16Years	05	02	09	16
	17Years	00	04	07	11
	18Years	01	00	06	07
	19Years	00	01	09	10
Female	13Years	05	09	02	16
	14Years	01	09	01	11
	15Years	00	01	06	07
	16Years	00	00	11	11
	17Years	00	00	15	15

Table 3
Age of Epiphyseal union—Proximal end of fibula

Sex	Age Group	Number of cases			
		Non Union	Partial Union	Complete Union	Total
Male	15Years	13	03	00	16
	16Years	07	00	07	16
	17Years	04	02	05	11
	18Years	01	00	06	07
	19Years	00	01	09	10
Female	13Years	09	07	00	16
	14Years	04	07	00	11
	15Years	01	00	06	07
	16Years	00	01	10	11
	17Years	00	00	15	15

Year-wise changes in the pattern of skeletal maturity / status of epiphyseal union in the bones of the knee that is femur, tibia and fibula are given in table 1, 2 & 3 respectively.

DISCUSSION

In our study average age of complete epiphyseal union in the males is 16.5 for femur, 17.0 years for tibia and 17.5 years for fibula. While in the females it is 14 years for femur and tibia and 15 years for fibula.

Multiple authors in different parts of the world conducted a number of similar studies. Findings of some important studies are tabulated below for convenience of comparison.

Table 4
Comparison of age of epiphyseal union at knee in different countries

Country / Race	Sex	Age of epiphyseal union		
		Femur	Tibia	Fibula
American Whites (16)		20	20	25
Englanders(9)		19	19-20	18-19
Australians (17)	F	17	15	17
	M	19	18	19
Bengalis (10) India	F	14-17	14-15	14-16
	M	14-17	15-17	14-16
Punjabis (Indian)(10)		16.5-17.5	16.5-17.5	16.5-17.5
Delhi (18) India	F	16-17	-	-
	M	18-19	-	-
Peshawar (Pakistan)	F	14	14	15
	M	16.5	17	17.5

Similar radiographic studies such as Todd (Child Dev, 1, 1930) have placed commencement of union of all three epiphyses at knee at 17.5 years with fusion being complete by 18.5 years. Subsequently, Flecker (J. Anat. 67, 1932; Am. J. Roentgen. 47, 1942) indicated that for each of the three epiphyses at knee, fusion begins at 16 years and reaches completion by 19 years [19].

It is evident from the above- cited studies that pattern of skeletal maturity in Peshawar is different from that of Western countries. Epiphyseal union in the bones of the knee takes place two to three years earlier in Peshawar (Pakistan) as compared to Western countries. It has been observed by many authors that in the people of subcontinent, union of epiphysis takes place about 2 to 3 years in advance of the age incidence in Europeans [9, 20].

Two different studies conducted at Larkana, Pakistan on determination of skeletal age in children

revealed that Pakistani children are advanced in their skeletal age indicating earlier maturity as compared to western children [13, 14].

One of the important reasons for early epiphyseal union is difference in the climatic conditions. Many observers have showed that in tropical climates ossification takes place earlier than in Temperate Zone [21]. Other factors responsible for this variation are difference of dietary status and hereditary background [22].

Results of our study are comparable with those of different studies conducted in the various parts of India particularly of Bengal, Punjab and South India. The reason is likely the same geographical condition in these regions. However few variations in ages of epiphyseal union may be due to widely differing diets in these areas.

Our study revealed that there is a marked sex difference in the timing of epiphyseal union at knee. In females, epiphyseal union take place 2.5 years earlier in femur and fibula as compared to males while 3 years earlier in tibia. (Table 1,2,3) This sex difference of 2.5 to 3 years is in agreement with the findings of H. Flecker who studied skeletal maturity in Australians where epiphyseal union in females is 2-3 years earlier than that in males [22].

Several other studies have shown that union of most epiphyses occurs about one to two years earlier in females than in males [4, 6, 7, 8, 9, 23, 24]. This is due to the fact that process of ossification and epiphyseal union begins earlier in females than in males. The average is about two years in advance to males. This subsequently leads to a shorter period of growth in females and is responsible for their smaller adult size [2].

CONCLUSIONS AND RECOMMENDATIONS

Ages of epiphyseal union in the bones of knee at Peshawar are 2 to 3 years earlier than those in western countries. So norms and standards used for determination of age in these countries are not applicable for Peshawar, Pakistan. It is recommended that for the proper evaluation of skeletal age in local population, a large-scale longitudinal study on individuals in this region to establish normal standards should be conducted.

REFERENCES

1. Awan NR. Principle and practice of forensic medicine. 1st ed Lahore: Sublime Arts; 2002. 36.

2. Rinehart D. Excavations of skeletal remains from an anthropological point of view. [online] 2003 [cited 2003 Oct 1] available from <http://www.crime-scene-nvestigator.net/index.html>.
3. Vij K. Text book of forensic medicine. 3rd ed. New Delhi: B.I Churchill Livingstone; 2005. 58-9.
4. Banerjee KK, Aggarwal BBL. Estimation of age from epiphyseal union at the wrist and ankle joints in the capital city of India. *Forensic Sci Int.* 1998 30; 98:31-9.
5. Koc A, Karaoglanoglu M, Erdogan M, Kosecik M, Cesur Y. Assessment of bone ages: is the Greulich-Pyle method sufficient for Turkish boys? *Pediatr Int* 2001 ;43:662-5.
6. O'Connor JE, Bogue C, Spence LD, Last J. A method to establish the relationship between chronological age and stage of union from radiographic assessment of epiphyseal fusion at the knee: and Irish population study. *J Anat.* 2008; 212:198-209.
7. Cardoso HF. Age estimation of adolescent and young adult male and female skeletons II, epiphyseal union at the upper limb and scapular girdle in a modern Portuguese skeletal sample. *Am J Phys Anthropol.* 2008; 137:97-105.
8. Crowder C, Austin D. Age ranges of epiphyseal fusion in the distal tibia and fibula of contemporary males and females. *J Forensic Sci.* 2005; 50:1001-7.
9. Modi NJ, Mmodi, s textbook of medical jurisprudence and toxicology. 19th ed. Bombay: A.S Pandya. 1977;31-6.
10. Galstaun G. A study of ossification as observed in Indian subjects. *Indian journal of Medical Research.* 1937;25:1.
11. Saksena JS and Vyas SK. Epiphyseal union at wrist, knee and iliac crest in the residents of Madhya Pradesh. *Journal of Indian Medical Association .* 1974; 63:8-16.
12. Dasgupta SM, Prasad V and Singh S: A roentgenologic study of epiphyseal union around elbow, knee, wrist and pelvis in boys and girls of Utar Pradesh, *JIMA.* 1974; 62: 10-12.
13. Rikhasor RM, Qureshi AM, Rathi SL, Channa NA. Skeletal maturity in Pakistani children. *J Anat* 1999;195:305-8.
14. Shaikh AH, Rikhasor RM, Qureshi AM. Determination of skeletal age in children aged 8-18 years. *J Pak Med Assoc* 1998 ;48:104-6.

-
15. Kaheri GQ, Rikhasor RM, Khichi ZH. Age of fusion for epiphysis; elbow and wrist in normal children. *The Professional* 2001;08:85-9.
16. Sutton D. A textbook of radiology and imaging. 5th ed. London: Churchill Livingstone; 1993. 1579-81.
17. Evans KT, Knight B, Whittaker DK. Forensic radiology. London: Blackwell Scientific Publications; 1981. 25-46.
18. Johnston FE. Sequence of epiphyseal union in a prehistoric Kentucky population, Indian Knoll. *Human Biol* 1961; 33. 66-81.
19. Connor JEO, Lewis ME, Last J and Spence L. A method to establish chronological age from radiographic assessment of epiphyseal union at the knee *J Anat.* 2004; 205: 543.
20. Hussain SS. A text book of forensic medicine and toxicology. 20th ed. Lahore: The Carvan Book House. 1991; 18-28.
21. Mant AK. Taylor's principles and practice of medicinal jurisprudence. 13th ed. Edinburgh: Churchill Livingstone; 1984. 174.
22. Krogman, WM, ISCAN MY. The human skeleton in forensic medicine. 2nd ed. Illinois: Charles.C.Thomas; 1986. 68.
23. Krogman WM. The human skeleton in forensic medicine. *Postgrad Med* 1955; 17: 48-62.
24. Cardoso HF. Epiphyseal union at the innominate and lower limb in a modern portuguese skeletal sample, and age estimation in adolescent and young adult male and female skeletons. *Am J. Phys Anthropol*, 2008 ;135:161-70.

AUTHORS

- **Prof. Dr. Ahmad Saeed**
Head of Forensic Medicine Department
Punjab Medical College, Faisalabad.
- **Prof. Dr. Inayat ur Rehman Khalil**
Head of Forensic Medicine Department,
Peshawar Medical College, Peshawar
- **Prof. Dr Zahid Hussain Khalil**
Head of Forensic Medicine Department,
Khyber Medical College, Peshawar