

Determination of Age by Epiphyses Fusion at Knee Joint by Digital X-Ray Study in Age Group of 14 to 24 Years: A Bikaner Based Study

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ABSTRACT

Background: Determination of age is helpful in both civil and criminal cases. In the living age determination is the most important issue to the court and to the common citizens as well. The present study was carried out to study the determination of age by epiphyses fusion at knee joint by Digital X-Ray study in age group of 14 to 24 years. Subjects taken from various schools, from neighbourhood of various faculty members.

Materials & Methods: This study was carried out in the Department of Forensic-Medicine and Toxicology in association with Radio-diagnosis Department of S.P. Medical College and Associated Group of Hospitals, Bikaner; after institutional ethical clearance and informed written consent taken from all the subjects. The total number of subjects (n=100) was selected randomly from various schools, from neighbourhood of various faculty members and staff as well as cases. The age of subjects was determined by fusion of ossification centre of knee joint by Anteroposterior & lateral views of digital X- Rays.

Results: The present study showed Out of total 100 cases, 62 cases were male and 38 were female. Maximum number of cases belongs to 17-18 years of age group in both genders. The age of complete fusion between epiphysis and diaphysis in lower end of femur was observed at 17-19 years of age & above in male and 16-18 years of age & above in females in our study. The age of complete fusion between epiphysis and

diaphysis in upper end of tibia was observed at 16-19 years of age & above in both genders in our study and in upper end of Fibula in males was observed at 17-20 years of age & above, in females was observed at 16-19 years of age & above in our study.

Conclusion: In present study concluded that fusion of various epiphyses has been reported earlier in females (about 1year) in comparison to boys of present series except epiphyseal fusion of upper end of Tibia where no such difference was observed.

Keywords: Epiphysis, Age, Diaphysis, Fusion.

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INTRODUCTION

Determination of the age is important in murder cases, when attempts have already been made to dispose of the body by mutilation, by dismemberment, by the use of corrosives, by the action of fire, or in cases where murder was committed long ago, where only skeletal remains are available for examination. It is also necessary to identify the persons in accident cases including varying degree of bodily destruction by fire as in conflagrations, air crashes and auto accidents. With the increase in crime and criminals, the duty of a forensic expert does not end with the examination of dead bodies alone but also to give his opinion in living individuals in solving various medico legal problems by virtue of his knowledge and experience.¹

Human growth is continuous process which goes through, first a developmental stage and second, the maintenance of status. In the developmental stage, changes in skeletal and dental morphology occur in an age-age predictive sequence.²

Determination of age is helpful in both civil and criminal cases. In the living age determination is the most important issue to the court and to the common citizens as well. It is essential to establish the identity of the person at the time of admission to schools, colleges, institutes, or while competing in sports tournaments at regional, state or national levels. It is also important while taking consent or in cases relating to juvenile offenders, rape, kidnapping, employment in Govt. establishments, competency as a witness, attainment of majority, marriage, fixation of criminal responsibility, etc.³

There are hundreds of ossification centers in the bones of the body. The appearance and fusion of some centers in the bones with others of the same bones form the basis of estimation of age. The long bones of lower limb play a vital role in assessment of age both in living and dry remains.⁴ Age is an important parameter for medico-legal cases. Many times doctors are called upon to

give opinion about age of a person. For this objective methods of age determination are required. Age of epiphyseal union is an important objective method of age determination. But these ages varies with racial, geographic, climatic and various other factors. These variations have suggested need of separate standards of ossification for separate regions. The present study was carried out to study the determination of age by epiphyses fusion at knee joint by Digital X-Ray study in age group of 14 to 24 years. Subjects taken from various schools, from neighbourhood of various faculty members and staff as well as cases attending the OPD of P.B.M. & AG hospitals Bikaner, Rajasthan.

MATERIALS & METHODS

This study was carried out in the Department of Forensic-Medicine and Toxicology in association with Radio-diagnosis Department of S.P. Medical College and A.G. of Hospital, Bikaner; after institutional ethical clearance and informed written consent from all the subjects. The total number of subjects (n= 100) was selected randomly from various schools, from neighbourhood of various faculty members and staff as well as cases. The age of subjects was determined by fusion of ossification centre of knee joint by Anteroposterior & lateral views of digital X- Rays.

Inclusion Criteria

1. Subjects should be living in Bikaner region for more than 5 years.
2. Subjects should be free from any physical disability or endocrinal anomaly.
3. Person should have accurate record of their date of birth.

Exclusion Criteria

1. Subjects with musculo-skeletal disorder, fractures at the joint, nutritional disorders and chronic illness will be excluded from the study.
2. Age <14 years or>24 years will be excluded from the study.
3. Subject not willing to give consent.

The subjects selected for study was grouped as per their stated age, viz.-14-15years, 15-16years, 16-17years, 17-18years, 18-19years, 19-20years, 20-21years, 21-22years, 22-23years and 23-24 years.

Age as stated by them was further confirmed by secondary school certificate, any document reflecting their exact age viz Birth certificate, or entry in their school record. The persons belonging to the age group selected for the study of either gender are included in the study irrespective of their socioeconomic, religious and educational status, each person so chosen on the basis of criteria as mentioned above are evaluated clinically in details as per Performa .

Criteria For Data Analysis of Fusion of Ossification Centres Were

1. Stage I: Centre has appeared but there is no union: +
2. Stage II: Union has started but there is incomplete union: ++
- 3 Stage III: Recent union, here there is a complete union between the epiphysis and diaphysis. The diaphyseo-epiphyseal union is complete with persistence of white lines termed as epiphyseal scar at the site of fusion of epiphysis with diaphysis: +++
4. Stage IV: Old union, here there is a complete union between the epiphysis and diaphysis, with the disappearance of epiphyseal scar: ++++

Finally the details were analyzed and the conclusions were drawn after comparing and discussing with similar type of the work carried out by foreign and Indian authors.

Table 1: Age group wise distribution of male and female

Age groups in years	Male	Female
14-15	4	3
15-16	8	2
16-17	9	5
17-18	11	7
18-19	5	3
19-20	5	5
20-21	6	4
21-22	6	4
22-23	4	3
23-24	4	2
Total	62	38

Table 2: Age wise distribution of subjects according to fusion between epiphysis and diaphysis in lower end of femur in males & Female

Age group	Stage I		Stage II		Stage III		Stage IV	
	Male	Female	Male	Female	Male	Female	Male	Female
14-15 yrs	4	3	0	0	0	0	0	0
15-16 yrs	8	0	0	2	0	0	0	0
16-17 yrs	0	0	9	4	0	1	0	0
17-18 yrs	0	0	4	0	7	7	0	0
18-19 yrs	0	0	0	0	4	1	1	2
19-20 yrs	0	0	0	0	3	0	2	5
20-21 yrs	0	0	0	0	2	0	4	4
21-22 yrs	0	0	0	0	0	0	6	4
22-23 yrs	0	0	0	0	0	0	4	3
23-24 yrs	0	0	0	0	0	0	4	2
Total	12	3	13	6	16	9	21	20

Table 3: Age wise distribution of subjects according to fusion between epiphysis and diaphysis in Upper end of Tibia in Males & Females

Age group	Stage I		Stage II		Stage III		Stage IV	
	Male	Female	Male	Female	Male	Female	Male	Female
14-15 yrs	4	3	0	0	0	0	0	0
15-16 yrs	6	0	2	2	0	0	0	0
16-17 yrs	0	0	7	3	2	2	0	0
17-18 yrs	0	0	2	1	9	6	0	0
18-19 yrs	0	0	0	0	4	1	1	2
19-20 yrs	0	0	0	0	3	0	2	5
20-21 yrs	0	0	0	0	2	0	4	4
21-22 yrs	0	0	0	0	0	0	6	3
22-23 yrs	0	0	0	0	0	0	4	2
23-24 yrs	0	0	0	0	0	0	4	2
Total	10	3	11	6	20	9	21	20

Table 4: Age wise distribution of subjects according to fusion between epiphysis and diaphysis in Upper end of Fibula in Males & Females

Age group	Stage I		Stage II		Stage III		Stage IV	
	Male	Female	Male	Female	Male	Female	Male	Female
14-15 yrs	4	3	0	0	0	0	0	0
15-16 yrs	8	1	0	1	0	0	0	0
16-17 yrs	3	0	6	4	0	1	0	0
17-18 yrs	1	0	8	1	2	6	0	0
18-19 yrs	0	0	1	0	4	3	0	0
19-20 yrs	0	0	0	0	4	2	1	3
20-21 yrs	0	0	0	0	3	0	3	4
21-22 yrs	0	0	0	0	2	0	4	4
22-23 yrs	0	0	0	0	0	0	4	3
23-24 yrs	0	0	0	0	0	0	4	2
Total	16	4	15	6	15	12	16	16

RESULTS

The present study showed Out of total 100 cases, 62 cases were male and 38 were female. Maximum number of cases belongs to 17-18 years of age group in both genders (table 1). The age of complete fusion between epiphysis and diaphysis in lower end of femur was observed at 17-19 years of age & above in male and 16-18 years of age & above in females in our study (table 2). The age of complete fusion between epiphysis and diaphysis in upper end of tibia was observed at 16-19 years of age & above in both genders in our study (table 3) and in upper end of Fibula in males was observed at 17-20 years of age & above, in females was observed at 16-19 years of age & above in our study (table 4).

DISCUSSION

Age as stated by them was further confirmed by secondary school certificate, any document reflecting their exact age viz Birth certificate, or entry in their school record. The persons belonging to the age group selected for the study of either gender are included in the study irrespective of their socioeconomic, religious and educational status, each person so chosen were evaluated clinically in details as per Performa .

Our study showed the maximum number of cases belongs to 17-18 years of age group in both genders in urban residency and 16-17 & 20-21 years of age group in rural residency in both genders. Similar study done by Apurba Nandy⁵ (2010) stated that countable differences are noticed in the appearance and fusion activities of ossification centres depending on race, geographic distribution and sex. The process of ossification may also be influenced by food habit, nutritional status, infectious diseases, hormonal and metabolic disorders, and physical activities. The ages of union of epiphyses in females were found to be earlier by about a few months to two years on the whole by many workers and are quiet understandable taking in to consideration the earlier onset of puberty in the females.

FUSION BETWEEN EPIPHYSIS AND DIAPHYSIS IN LOWER END OF FEMUR

In Male: In present study average age of fusion between epiphysis and diaphysis in lower end of femur was observed at 17-19 years of age in male, which is consistent with the observation of the Todd (1930)⁶, Narayan & Bajaj (1957)⁷, Saxena

& Vyas (1967)⁸, Das Gupta et al (1974)⁹, Connor JE (2008)¹⁰, Bokariya et al (2009)⁴, Kausar Asma (2012)¹, S.S. Bhise (2015).¹¹ Stevenson (1924)¹², Davies & Parson (1927)¹³ and Flecker (1932)¹⁴ observed the fusion of lower end of femur at 19 years of age in their studies separately and Sangama William (2007)³ observed the fusion at 17 years of age. Their observations are also in accordance with our study.

The finding in our study is slightly higher than Peterson (1929)¹⁵, Pillai (1936)¹⁶ and Galstaun (1937)¹⁷, the fusion of lower end of femur at 14-17 years of age in male while Flecker (1942)¹⁸ observed it at 16 to 19 years of age in male.

The finding in our study is slightly lower than the Schaefer & Black (2005)¹⁹, Bipinchandra Tripude (2015)²⁰, they observed fusion at 18-20 years of age in male, Talwad R.V (2012)²¹ who observed fusion at 17-20 years of age in male and Mckern & Stewart (1957)²² who observed the fusion of lower end of femur at 22 years of age in male.

The finding in our study is in accordance with different authors of standard textbooks as K.S.N. Reddy²³, Krishna Vij²⁴, Rao G Nagesh Kumar²⁵, Sharma R.K²⁶, V. V. Pillai²⁷ stated that fusion occurs at 18-19 years of age. Anil Agarwal²⁸, Ajay Kumar²⁹, Krishnan MKR³⁰. Apurba Nandy⁵ stated that fusion occurs at 16-17 years of age in male.

In Female: In present study average age of fusion between epiphysis and diaphysis in lower end of femur was observed at 16-18 years of age in Female, which is consistent with the observation of the Kausar Asma (2012)¹, Sangama William (2007)³, Todd (1930)⁶, Das Gupta et al (1974)⁹, Bokariya et al (2009)⁴ and S.S. Bhise (2015).¹¹

Our findings are also in accordance with Connor JE (2008)¹⁰ who observed the fusion at 17 -17.9 years of age.

In our study, findings are slightly lower than the Narayan & Bajaj (1957)⁷, Saxena & Vyas (1967)⁸ who observed fusion at 18 to 19 years of age & Stevenson (1924)¹² & Davies Parson (1927)¹³ observed fusion at the age of 19 years.

The finding in our study is slightly higher than the Peterson (1929)¹⁵, Pillai (1936)¹⁶, Galstaun (1937)¹⁷, they observed fusion at 14-17 years of age in female & Flecker (1942)¹⁸ observed fusion in wide range of 14-19 years which is also not inconsistent with our observation.

The finding in our study is in accordance with different authors of standard textbooks as Anil Agarwal²⁸, Ajay Kumar²⁹, Krishnan MKR³⁰ stated that fusion occurs at the age of 16 years of age in female.

The finding in our study is slightly lower than the age as stated by different authors of standard textbooks as K.S.N. Reddy²³, Krishna Vij²⁴, Rao G Nagesh Kumar²⁵ and Sharma R.K²⁶ who mentioned that fusion occurs at the age of 18-19 years.

The finding in our study is slightly higher than the age as stated by different authors of standard textbooks as Apurba Nandy⁵ stated it at 15-16 years of age which is slightly lower than our observation.

FUSION BETWEEN EPIPHYSIS AND DIAPHYSIS IN UPPER END OF TIBIA

In Male: In present study average age of fusion between epiphysis and diaphysis in upper end of tibia was observed at 16-19 years of age in male, which is consistent with the observation of the Todd (1930)⁶, Narayan & Bajaj (1957)⁷, Saxena & Vyas (1967)⁸, Das Gupta et al (1974)⁹, Connor JE (2008)¹⁰, Bokariya et

al (2009)⁴, Kausar Asma (2012)¹, Sangma William (2007)³, Stevenson (1924)¹², Flecker (1932)¹⁴, Peterson (1929)¹⁵, Talwad R.V (2012)²¹ and Flecker (1942).¹⁸

The finding in our study is slightly higher than Pillai (1936)¹⁶ and Galstaun (1937)¹⁷ as they observed fusion at 15-16 years of age in male.

The finding in our study is slightly lower than the Schaefer & Black (2005)¹⁹ who observed fusion at that 17-20 years of age, Bipinchandra Tripude (2015)²⁰ observed fusion at 18-20 years of age in male and Mckern & Stewart (1957)²² who observed fusion at 23 years of age in male.

The finding in our study is in accordance with different authors of standard textbooks as K.S.N. Reddy²³, Krishna Vij²⁴, Rao G Nagesh Kumar²⁵, Sharma R.K²⁶, V. V. Pillai²⁷ mentioned that fusion occurs 18-19 years of age. Anil Agarwal²⁸, Ajay Kumar²⁹, Krishnan MKR³⁰ stated it at 18 years of age and Apurba Nandy⁵ stated it at 16-17 years of age in male.

In Female: In present study average age of fusion between epiphysis and diaphysis in upper end of tibia was observed at 16-19 years of age in Female, which is consistent with the observation of the Kausar Asma (2012)¹, Sangama William (2007)³, Todd (1930)⁶, Das Gupta et al (1974)⁹, Stevenson (1924)¹², Davies & Parson (1927)¹³, Narayan & Bajaj (1957)⁷, Peterson (1929)¹⁵, Saxena & Vyas (1967)⁸ and Connor JE (2008).¹⁰

The finding in our study is slightly higher than the Pillai (1936)¹⁶, Galstaun (1937)¹⁷, they observed fusion at 14-17 years of age in female & Flecker (1942)¹⁸ observed fusion at 14 to 19 years of age in female and Bokariya et al (2009)⁴ observed fusion at 14-15 years of age in female.

The finding of our study is slightly lower than the Bipinchandra Tripude (2015)²⁰ stated it at 16-20 years of age in female.

The finding in our study is in accordance to different authors of standard textbooks as K.S.N. Reddy²³, Anil Agarwal²⁸, Ajay Kumar²⁹, Krishnan MKR³⁰, Krishna Vij²⁴, Sharma R.K²⁶, Rao G Nagesh Kumar²⁵ and V. V. Pillai²⁷ stated it at 18-19 years of age in female. The finding in our study is slightly higher than the age stated by Apurba Nandy⁵ who stated it at 15-16 years of age.

FUSION BETWEEN EPIPHYSIS AND DIAPHYSIS IN UPPER END OF FIBULA

In Male: In present study average age of fusion between epiphysis and diaphysis in upper end of fibula was observed at 17-20 years of age in male, which is consistent with the observation of the Todd (1930)⁶, Narayan & Bajaj (1957)⁷, Saxena & Vyas (1967)⁸, Connor JE (2008)¹⁰, Bokariya et al (2009)⁴, Kausar Asma (2012)¹, Sangma William (2007)³, Stevenson (1924)¹², Flecker (1932)¹⁴, Davies & Parson (1927)¹³, Peterson (1929)¹⁵, Schaefer & Black (2005)¹⁹, Bipinchandra Tripude (2015)²⁰ and Talwad R.V (2012)²¹.

The finding in our study is slightly higher than the Pillai (1936)¹⁶ who observed it at 14-17 years of age, Galstaun (1937)¹⁷ observed it at 11-19 years of age.

Our observation is lower than the findings of Mckern & Stewart (1957)²² who observed it at the age of 22 years.

The finding in our study is in accordance with different authors as K.S.N. Reddy²³, Krishna Vij²⁴, Rao G Nagesh Kumar²⁵, V. V. Pillai²⁷ stated it at 18-19 years of age. Anil Agarwal²⁸, Ajay Kumar²⁹, Krishnan MKR³⁰ stated it at 18 years of age in male.

The finding in our study is slightly higher than different authors as Apurba Nandy⁵ stated it at 14-16 years of age.

In Female: In present study average age of fusion between epiphysis and diaphysis in upper end of fibula was observed at 16-19 years of age in Female, which is consistent with the observation of the Kausar Asma (2012)¹, Sangama William (2007)³, Todd (1930)⁶, Stevenson (1924)¹², Davies & Parson (1927)¹³, Narayan & Bajaj (1957)⁷, Peterson (1929)¹⁵, Saxena & Vyas (1967)⁸, Flecker (1932)¹⁴, Bokariya et al (2009)⁴, Talwad R.V. (2012).²¹ Connor JE (2008)¹⁰ observed the fusion at the age of 17 -17.9 years of age.

The finding in our study is slightly higher than Pillai (1936)¹⁶ who observed it at 14-17 years of age, Galstaun (1937)¹⁷ observed fusion at 14-16 years of age.

The finding in our study is slightly lower than the Bipinchandra Tripude (2015)²⁰ who observed fusion at 16-20 years of age in female.

The finding in our study is in accordance with different authors of standard textbooks as K.S.N. Reddy²³, Anil Agarwal²⁸, Ajay Kumar²⁹, Krishnan MKR³⁰, Krishna Vij²⁴, Sharma R.K²⁶, Rao G Nagesh Kumar²⁵ and V. V. Pillai.²⁷

Apurba Nandy⁵ mentioned that fusion occurs at the age of 14-16 years which is lower than our observation.

This fact is in accordance with all other previous workers.

Pryor (1924)³¹ was first to elucidate that- union of epiphyses takes places considerably earlier in females than in boys. His observations were further confirmed by Parson & Davis (1927)¹³, Peterson (1929)¹⁵ and Flacker (1932).¹⁴

Works in India has also observed that females of particular regions are 1-2 year ahead in epiphyseal appearance or fusion than the males of same area. Findings of Pillai (1936)¹⁶, Saxena & Vyas (1967)⁸ and Das Gupta et al (1974)⁹ also support the view and conclusions drawn by the foreign workers.

Galstaun (1937)¹⁷ attributed this early development of bones in females to early onset of puberty. He emphasized that increased activity of anterior lobe of pituitary and the thyroid gland near puberty, enhance the process of ossification in females.

CONCLUSION

In present study concluded that fusion of various epiphyses has been reported earlier in females (about 1year) in comparison to boys of present series except epiphyseal fusion of upper end of Tibia where no such difference was observed.

REFERENCES

1. Asma Kausar, Varghese. P.S: estimation of age by epiphyseal union of knee joint by radiological examination in bijapur district, IJBAR (2012) 03(02).
2. Parikh C.K. Personal Identity. Parikh's Text book of Medical Jurisprudence and Toxicology 6th ed. CBS Publishers and distributors; 1996. 2.8-2.14
3. Bilkey William Sangma Ch. et. al. Age Determination in Girls of North – Eastern Region of India, JIAFM, 2007 - 29(4).
4. Bokariya Pradeep, Chowdhary D.S et. al: A Review of the Chronology of Epiphyseal Union in the Bones at Knee and Ankle Joint, J Indian Acad Forensic Med.2011,33(3), page: 258-260.
5. Nandy Apurba. Principles of Forensic Medicine Including Toxicology. 3rd ed: New Central Book Agency (Pvt) Ltd. London; 2010. 119-127.

6. Todd TW. The anatomical features of epiphyseal union. Child Dev. 1930; 1:186–194.
7. Narain D, Bajaj ID. Ages of epiphyseal union in long bones of inferior extremity in U.P. subjects. Ind J Med Res.1957;45:645-49.
8. Saxena JS and Vyas SK. Epiphysial union at wrist, knee and iliac crest in resident of Madhya Pradesh. J Ind Med Asso 1969; 53(2):67-68.
9. Dasgupta SM, Prasad V, and Singh S. A Roentgenographic study of epiphysial union around elbow, wrist, knee, and pelvic joints in boys and girls of U.P. Journal of Medical Association 1974; 62(1):10-12.
10. J E O'Connor, C Bogue, L D Spence, and J Last : A method to establish the relationship between chronological age and stage of union from radiographic assessment of epiphyseal fusion at the knee: an Irish population study; J Anat. 2008 Feb;212(2):198–209.
11. S.S. Bhise, B.G. Chikhalkar, S.D. Nanandkar, G.S. Chavan and Anand P Rayamane: Age determination from of ossification center fusion around knee joint in Mumbai region: A radiological study, J Indian Acad forensic Med. Jan-March 2015, vol. 37, No. 1, Page no. 19-23.
12. Stevenson. Age order of epiphyseal union in man. Amer Jr. Phys. Anthrop.1924 Janaury Volume 7, Issue 1; Pages 53–93.
13. Davis A, Parsons F G. The age order of the appearance and union of the normal epiphyses as seen by x-rays. J. Anat. 1927, vol. 62:58-71.
14. Flecker H. Roentgenographic observations of the times of appearance of epiphysis. J Anat 1932; 67: 188-164.
15. Paterson RS. Some factors influencing epiphyseal growth and union. January 18, 1929:691-695.
16. Pillai MJS. The study of epiphysial union for determining the age of south Indians. Indian J Med Res 1936; 23:1015-1017.
17. Galstaun G. (1937); A study of ossification as observed in Indian subject. Indian Journal Medical Research (IJMR), Vol. 25.
18. Flecker H. Time of appearance and fusion of ossification centers as observed by roentgenographic methods: American Journal of Roentology; 1942,47,97-159.
19. Schaefer MC, Black SM. Comparison of ages epiphyseal union in North American and Bosnian skeletal material. J Forensic Sci. 2005; 50: 777-784.
20. Bipinchandra Tirpude, Swapnil Patond, Pankaj Murkey, Ninad Nagrale: A Radiological Study of Age Estimation from Epiphyseal Fusion of Distal End of Femur in the Central India Population; J Indian Acad Forensic Med. Jan-March 2015, Vol. 37, No. 1, page 8-11.
21. Talwad, R. V.; Makandar, U. K: Ossification of Bones of the Knee Joint in 17 to 20 Years of Age in South Indian Population, Ind J. of For. Med & Toxicol; Jul-Dec2012, Vol. 6 Issue 2, p205.
22. McKern TW, Stewart TD. Skeletal age changes in young American males, Analysed from the standpoint of Age Identification. Natick, MA: Headquarters Quartermaster Research and Development Command, Technical Report EP-45. 1957.
23. Reddy KSN. Identification-Growth in Individual bone, In the Essentials of Forensic Medicine and Toxicology.32th ed., 2013 page 70.
24. Vij Krishan. Textbook of Forensic Medicine and Toxicology Principal and Practice. 2nd ed: B L Churchill livingstone Pvt. Ltd. New Delhi; 2002. 74-81.
25. Rao G.Nageshkumar: A Textbook of Forensic Medicine & Toxicology, 19th edition, Jaypee Publication.

26. R.K.Sharma: Concise Textbook of Forensic Medicine & Toxicology, 2005 Edition, Page 15.
27. V.V.Pillay: A Textbook of Forensic Medicine & Toxicology 17th edition Page-80
28. Aggarwal A. Ages of ossification-Personal Identification in Self-Assessment and Review of Forensic Medicine and Toxicology.1st ed. Delhi: Pee-pee Publishers and Distributers (P) Ltd.; 2006.p 51-59.
29. Ajay kumar: A Text Book of Forensic Medicine (Medical Jurisprudence & Toxicology) , 1st edi, Page 62-63
30. Krishanan MKR. Editor Patnaik VP. Handbook of Forensic Medicine Including Toxicology.11th ed: PARAS Publishing, Hyderabad; 1999.
31. Pryor, J.W. difference in the ossification of the male and female skeleton. Journal of Anatomy; 1928; 62 Page-499-506.

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