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Digital Roentgenography of Elbow Joint for Age Estimation in Living Individuals of Gujarat.

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ABSTRACT

Age estimation by the use of X-rays is an age-old method of identification. However, there can be variations depending upon various factors such as age, an individual's genetic makeup, diet, geographical habitat, and so on. Creating a regional database is need of the X-rays of the elbow joints of individuals of Gujarat were studied by using Microsoft Office Picture Manager 2010 version for the appearance of ossification centers and epiphyseal fusion in the Department of Forensic Medicine and Department of Radio-diagnosis at a Medical College in Ahmedabad, Gujarat after the approval from Institutional Ethics Committee. All the findings showed a statistically significant association between age groups and the appearance of ossification centers and epiphyseal fusion. The study's findings are discussed and compared to previous studies by authors from the Indian sub-continent &foreign. The persistence of epiphyseal scar on some bones may be influenced by factors other than chronological age.

Introduction:

In civil or criminal cases, estimating a person's age based on their appearance and fusion of the ossification centers of a bone is a frequent practice. In partial or incomplete identification, only specific facts like age, sex, race, stature, etc., are determined.[1] So, based on the presence of ossification centers and epiphyseal fusion of the elbow joint, a radiological approach can be used to estimate age, and it is a reasonably accurate guide for determining a person's age. The persistence of epiphyseal scar on some bones may be influenced by factors other than chronological age.[2] In the present study, patients between the ages of 0 to 25 years, who were referred to the radio-diagnosis department of a medical college in Ahmedabad for clinical purposes, were examined roentgenographically for epiphyseal appearance and union at the elbow joint.

Aims and Objectives:

1. To observe the average age of appearance of ossification centers of the elbow joint.
2. To observe the average age of fusion of the epiphyses of the elbow joint.
3. To compare our observations with those of authors

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from the Indian sub–continent and foreign.
4. To find out scientific reasons for variations in the age of appearance and fusion of ossification centers, if any.
5. To create a database for future references and evaluate the medico-legal application of observation in the exercise of age estimation.

Materials and Methods:

A total of 116 X-rays of the elbow joint, showing the medial epicondyle, the lateral epicondyle, the capitulum, the trochlea of the humerus, the upper end of the radius, and 110 X-rays of the elbow joint in AP and lateral views, showing the upper end of the ulna, were studied for the appearance and fusion of the epiphysis. The study group consisted of patients referred to the Radio-diagnosis department of GCS Medical College, Ahmedabad, Gujarat (Previous workplace of authors) for X-ray examination of the elbow for clinical purposes. Both males and females of known age between 0 to 25 years with normal physical development were included in this study but, patients with known case of nutritional deficiency, trauma, endocrinal disorders, history of chronic drug intake (e.g. anti-epileptic drugs, steroids), bony deformity or pathology, congenital malformation, and chronic illness thus affecting the skeletal growth development of the individual, more than 25 years of age and cases of unknown age were excluded. X-ray machine - GE DX 300 with Fuji IP cassette was used for taking X-ray, and the image was processed with FCR Capsula XL II. All the X-rays were studied in digital form in "JPG format" in Microsoft Office Picture Manager 2010 version for the appearance of ossification centers and epiphyseal fusion. The appearance of the ossification center and the process of fusion of epiphysis and diaphysis were classified as follows:
Not Appeared (NA): The ossification center has not appeared.
Appeared (A): The ossification center has appeared.
Non-fusion (NF): The ossification center has appeared, but there is no evidence of commencement of union between the epiphysis and diaphysis.
Partial fusion (PF): Obliteration commences in the space between the epiphysis and the diaphysis.
Recent fusion (RF): The space gets closed but, the line of fusion is visible at the junction of epiphysis and diaphysis.
Complete fusion (CF): Epiphyseal space obliterated by bony fusion showing the same density as that of the shaft.
All the data were analyzed by SPSS software version 26.

Observations and results:

Table 1 showed that at the age of 6 - 10 years, 62.9 % of X-rays showed the appearance of the medial epicondyle of the humerus and appeared in all X-rays at above 11 years. At 16 - 20 years old, 92.3 % of X-rays showed complete fusion with the shaft of the humerus. Table 2 shows that at the age of 11-15 years, 69.6% of X-rays showed the lateral epicondyle of the humerus, and it appeared in all X-rays at above 16 years. Table 3 showed that at the age of 11-15 years, 69.6% of X-rays showed the appearance of trochlea, and appeared in all X-rays at above 16 years. Table 4 showed that at the age of 0 - 5 years, 88.2% of X-rays showed the appearance of capitulum, and it appeared in all X-rays at above 6 years. Table 5 showed that from the age of 16 years, almost all X-rays showed complete fusion of conjoint epiphysis of distal end of humerus.
Table 6 showed that from the age of 16 years, all X-rays except one showed complete fusion of the conjoint epiphysis with the shaft. Table 7 showed that from the age of 6 years, 91.5% of X-rays showed the appearance of the head of radius, and from the age of 16 years, all X-rays except one showed complete fusion. Table 8 showed that at the age of 11-15 years, 79.84 % of X-rays showed the appearance of the olecranon process, at 16 years and above, all X-rays showed complete fusion.

Table 1. Appearance and fusion of secondary ossification centre of medial end of epicondyle.

Age group in years	Total No. of X-rays	NA	NF	PF	RF	CF	
0-5	34	33 (97.1%)	1 (2.94%)	0	0	0	Chi Square = 186.548 p value = 0
6-10	35	13 (37.14%)	16 (45.71%)	5 (14.3%)	1 (2.9%)	0	Degree of freedom = 16 Yates Chi-Square = 165.984
11-15	23	0	21 (91.3%)	2 (8.7%)	0	0	p value = 0
16-20	13	0	0	1 (7.7%)	0	12 (92.3%)	
21-25	11	0	0	0	0	11 (100%)	
Total	116	46	38	8	1	23	

Table 2. Appearance and fusion of lateral epicondyle of humerus

Age group in years	Total No. of X-rays	NA	A	
0-5	34	34 (100%)	0	Chi Square = 77.442
6-10	35	30 (85.71%)	5 (14.3%)	p value = 0
11-15	23	7 (30.43%)	16 (69.6%)	Degree of freedom = 4
16-20	13	0	13 (100%)	Yates Chi-Square = 68.608
21-24	11	0	11 (100%)	P value = 0
Total	116	71	45	

Table 3. Appearance of Trochlea of humerus.

Age group in years	Total No. of X-rays	NA	A	
0-5	34	34 (100%)	0	Chi Square = 72.559
6-10	35	28 (80%)	7 (20%)	*p* value = 0
11-15	23	7 (30.43%)	16 (69.6%)	Degree of freedom = 4
16-20	13	0	13 (100%)	Yates Chi-Square = 64.165
21-24	11	0	11 (100%)	*p* value = 0
Total	116	69	45	

Table 4. Appearance of Capitulum

Age group in years	Total No. of X-rays	NA	A	
0-5	34	4 (11.8%)	30 (88.2%)	Chi Square = 9.992
6-10	35	0	35 (100%)	*p* value = 0.040563
11-15	23	0	23 (100%)	Degree of freedom = 4
16-20	13	0	13 (100%)	Yates Chi-Square = 5.373
21-24	11	0	11 (100%)	*p* value = 0.25112
Total	116	4	112	

Table 5. Fusion of Conjoint epiphysis of distal end of Humerus

Age group in years	Total No. of X-rays	NF	PF	RF	CF	
0-5	34	34 (100%)	0	0	0	
6-10	35	35 (100%)	0	0	0	Chi Square = 102.83
11-15	23	20 (87%)	0	0	3 (13.04%)	p value = 0
16-20	13	0	0	2 (15.4%)	11 (84.62%)	Degree of freedom = 12
21-24	11	0	0	1 (9.1%)	10 (90.9%)	Yates Chi-Square = 83.789
Total	116	89	0	3	23	p-value = 0

Table 6. Fusion of conjoint epiphysis with shaft of humerus

Age group in years	Total No. of X-rays	NF	PF	RF	CF	
0-5	34	34 (100%)	0	0	0	Chi Square = 113.81
6-10	35	35 (100%)	0	0	0	*p* value = 0
11-15	23	20 (87%)	1 (4.35%)	0	2 (8.7%)	Degree of freedom = 12
16-20	13	0	0	1 (7.7%)	12(92.3%)	Yates Chi-Square = 97.603
21-24	11	0	0	0	11 (100%)	*p* value = 0
Total	116	89	1	1	25	

Table 7. Appearance of secondary ossification center and epiphyseal fusion of head of radius.

Age group in years	Total No. of X-rays	NA	NF	PF	RF	CF	
0-5	34	31 (91.2%)	3 (8.8%)	0	0	0	Chi Square = 193.238
6-10	35	3 (8.6%)	31 (88.6%)	1 (2.9%)	0	0	*p* value = 0 Degree of freedom = 16 Yates Chi-Square = 170.482
11-15	23	0	20 (87%)	2 (4.35%)	0	1(4.35%)	*p* value = 0
16-20	13	0	0	1 (7.7%)	0	12 (92.3%)	
21-24	11	0	0	0	0	11 (100%)	
Total	116	34	54	4	0	24	

Table 8. Appearance of secondary ossification center and epiphyseal fusion of Olecranon process of Ulna.

Age group in years	Total No. of X-rays	NA	NF	PF	RF	CF	
0-5	34	34 (100%)	0	0	0	0	Chi Square = 147.841 p value = 0 Degree of freedom = 16 Yates Chi-Square = 128.002
6-10	35	21 (63.5%)	11 (33.33%)	1 (3.03%)	0	0	p value = 0
11-15	23	4 (21.05%)	13 (68.42%)	2 (4.35%)	0	1(5.3%)	
16-20	13	0	0	1 (7.7%)	0	13 (100%)	
21-24	11	0	0	0	0	11 (100%)	
Total	116	59	24	4	0	25	

Discussion:

In the present study, the medial epicondyle of the humerus appeared in all the X-rays at 10 years, this was later than the observations of Reddy KS and Murty OP,[1] Davies and Parson,[3] Paterson RS,[4] Flecker H,[5] Galstaun,[6] and Govindiah D.[7] All the X-rays showed complete fusion of the medial epicondyle with shaft of the humerus at 18 years in present study. This was similar with observations of Patel DS et al,[8] and Choudhary U et al,[9]but earlier compared to observations of Davies and Parson,[3] Paterson RS,[4] and, Alwahbahny SA et al,[10] and later than the observations of Reddy KS and Murty OP,[1]Flecker H,[5] Galstaun,[6] Govindiah D,[7] Memchoubi Ph,[11] Sangma WB et al,[12,13] Saini PC et al,[14] and Mazumder A and Nagrale N.[16] In the present study, lateral epicondyle of the humerus appeared in all the X-rays at 14 years and this was similar with Paterson RS,[4] but later than the observations of Reddy KS and Murty OP,[1]Davies and Parsons,[3]Flecker H,[5] Galstaun,[6]and Govindiah D.[7] Trochlea appeared in all the X-rays at 14 years in present study and this was later than the observations of Reddy KS and Murty OP,[1]Davies and Parsons,[3] Paterson RS,[4]Flecker H,[5] Galstaun,[6]and Govindiah D.[7] In the present study, capitulum appeared in all the X-rays at 2 years and this was similar with Davies and Parsons[3] and Flecker H,[5]but later than the observations of Reddy KS and Murty OP,[1] Paterson RS,[4]and Govindiah D.[7] Present study shows that majority of X-rays showed complete fusion of conjoint epiphysis of distal end of humerus at 16 - 24 years. Reddy KS and Murty OP,[1] Paterson RS,[4]Flecker H,[5] Galstaun,[6] Choudhary U et al,[9] and Singh A et al,[17]also showed complete fusion at this age group but, this was later than the observations of Davies and Parsons.[3] In the present study, all the X-rays showed complete fusion of conjoint epiphysis of the distal end of humerus with the shaft of the humerus at 18

years, this was similar with Singh A et al,[17] but, earlier than the observations of Paterson RS,[4] and Alwahbahny SA et al,[10] and later than the observations of Reddy KS and Murty OP,[1] Davies and Parsons,[3] Flecker H,[5] Patel DS et al,[8] Choudhary U et al,[9] Memchoubhi Ph,[11] Sangma WB et al,[12,13] Saini PC et al,[14] and Mazumder A and Nagrale N.[16]The secondary ossification centre of the head of the radius appeared in all X-rays at 10 years in present study. This was later than the observations of Reddy KS and Murty OP,[1] Davies and Parsons,[3] Paterson RS,[4] Flecker H,[5] Galstaun,[6] and Govindiah D.[7] Complete fusion was seen in all the X-rays at 18 years, this was earlier than the observations of Paterson RS,[4] and Alwahbahny SA et al,[10] but later compared to observations of Reddy KS and Murty OP,[1]Davies and Parsons,[3] Flecker H,[5] Galstaun,[6] Govindiah,[7] Patel DS et al,[8] Memchoubi Ph,[11] Sangma WB et al[12,13]and Mazumder A and Nagrale N.[16] In the present study, the secondary ossification centre of the olecranon process of ulna appeared in all the X-rays at 14 years and this was later than the observations of Reddy KS and Murty OP,[1] Davies and Parsons,[3] Paterson RS,[4] Flecker H,[5] Galstaun,[6] and GovindiahD.[7] Complete fusion was seen in all the X-rays at 16 years and this was similar with observations of Flecker H,[5] and Sangma WB et al[12,13] but, earlier compared to observations of Reddy KS and Murty OP,[1]Davies and Parsons,[3] Paterson RS,[4] Galstaun,[6] Patel DS et al,[8] Alwahbahny SA et al,[10]Memchoubi Ph,[11] and Mazumder A and Nagrale N.[16]The disparity in age of appearance and complete fusion of ossification centers between this study and others could be due to variations in the number of subjects in specific age groups and difference in criteria for selecting generalization and the methods used for staging of epiphyseal union, ethnic variations, climate, dietary habits and geographic location etc.

Conclusion:

1.The average age of appearance of the secondary ossification centre of the medial epicondyle of the humerus is 10 years, and the average age of its complete fusion with the shaft of the humerus is 18 years.
2.The average age of appearance of the lateral epicondyle of the humerus is 14 years.
3.The average age of appearance of the trochlea of the humerus is 14 years.
4. The average age of appearance of the capitulum of the humerus is 2 years.
5. The average age of complete fusion of the conjoint epiphysis of the distal end of the humerus is 16 - 24 years.
6. The average age of complete fusion of the conjoint epiphysis of the distal end of the humerus with the shaft of the humerus is 18 years.
7. The average age of appearance of the secondary ossification centre of the head of the radius is 10 years and the average age of complete fusion of epiphysis of the head of the radius is 18 years.
8. The average age of appearance of the secondary ossification centre of the olecranon process is 14 years and the average age of complete fusion of the epiphysis of the olecranon process is 16 years.
9. In the present study, there is a statistically significant association between age and appearance and fusion of ossification centers of the elbow joint. So, it is safe to conclude that the age at which the ossification centers of the elbow joint appear and fuse is fairly consistent, but with minimal variances between persons living in various areas of the world and even within the same country. As a result, similar studies should be carried out in different parts of the country using uniform criteria for the appearance of ossification and epiphyseal fusion of the elbow joint, which will be very helpful in estimating age for medico-legal purposes in that particular region.

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Conflict of Interest:

None declared.

Ethical Clearance:

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