

## ROENTGENOGRAPHIC STUDY OF BONES AROUND WRIST IN INDIVIDUALS BETWEEN 12 YEARS AND 20 YEARS AND ITS ROLE IN ASSESSMENT OF AGE

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### ABSTRACT

#### BACKGROUND

Age estimation in the living person is one of the most important tasks before a forensic expert especially in the developing countries like India where birth records are often not well maintained. Knowledge of actual age of an individual is necessary as some rights and privileges of a citizen are linked with his age. The help of forensic experts is invariably sought for estimation of actual age of a person, a victim, or accused, as decision on quantum and method of punishment by the law courts also differs with age of an individuals.

Objective of this work is intended to find, establish and recommend a standard data for appearance and fusion of ossification centres in the bones around wrist between the age of 12 years and 20 years in the population of North Bihar.

#### MATERIALS AND METHODS

Present work has been done to study the age of appearance of ossification centres around the wrist joint and age of fusion of its epiphysis with diaphysis. Only those cases, in which the actual age could be ascertained beyond any doubt, were considered for the study.

#### RESULTS

Total 200 individuals of both sexes (53% male and 47% female) falling between the age 12 years and 20 years were studied at DMCH, Darbhanga. It was observed that all carpal bones including pisiform appear by the age of 12 years. Fusion of three epiphyses took place in order metacarpal – ulna – radius.

#### CONCLUSION

All carpal bones appear by the age of 12 years. It was also observed that fusion of bony centres occurs 1–2 years earlier in females. Vegetarian and non-vegetarian diet doesn't have obvious influence in process of ossification.

#### KEYWORDS

Forensic Experts, Ossification Centres, Carpal Bones, Epiphysis, Metacarpal, Ulna, Radius.

**HOW TO CITE THIS ARTICLE:** Kumar A, Kumar S, Kumar B, et al. Roentgenographic study of bones around wrist in individuals between 12 years and 20 years and its role in assessment of age. Journal of Research in Forensic Medicine and Toxicology 2016; Vol. 2, Issue 2, July-December 2016; Page:1-7.

#### BACKGROUND

Age estimation in the living is one of the most important tasks of a forensic practitioner especially in developing countries like India where birth records are often not well maintained. Despite the fact that there are laws requiring registration of births (e.g. Registration of Birth and Death Acts in India); most of the births are not properly recorded. We get a number of cases routinely for estimation of age in living individuals in various situations both criminal and civil.

Knowledge of actual age of an individual is necessary as some rights and privileges of a citizen are linked with his age.

*Financial or Other, Competing Interest: None.*

*Submission 01-12-2016, Peer Review 13-12-2016,*

*Acceptance 19-12-2016, Published 28-12-2016.*

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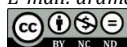
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The law governing people around the world too seeks information about the exact age of a citizen to grant or deprive him of certain privileges or rights. The help of forensic experts is invariably sought for estimation of actual age of a person, a victim, or accused, as decision on quantum and method of punishment by the law courts also differs with age of an individuals.

Estimation of age of a person is based on physical, Dental and Radiological examination of Individuals. External inspection permits only an estimate of age. Skeleton and teeth are the principal sources of information towards the age estimation.<sup>1</sup> With the invention of Roentgen rays it became possible to visualise the ossification centres, to study the progress of ossification and fusion of secondary ossification centre to their respective shafts in the living subjects. Among all data for age determination, radiological data is accepted to be the most reliable.<sup>2</sup> It proved to be of great help in assessing the near actual age of a person.

After exhaustive study by various authors at different times and places, it became an established fact that appearance, ossification and fusion of ossification centres are

influenced by various factors like age, sex, race, environmental, dietary, endocrinal and also some others.<sup>2</sup> Pioneer work in this field was carried out by Pryor (1907), who studied the age and order of appearance of carpal centres with view to formulate a standard data for establishment of age of an individual.

The different work carried showed that there is variation in the time of appearance and fusion of different ossification centres in people belonging to different parts of the country. It differs even up to 2 to 3 years from south to north, east to west.<sup>2</sup> Considering the vastness of our country it is likely that some variation found in appearance and fusion of ossification centres may be due to varying geographical condition, climate, diet habits and also some other factors which might have influenced the bony development of a person.

As such data recommended for one part of the country may not be a true representative for the population of other parts and also some of these factors modifying ossification process keep on changing in particular geographical cultural unit/areas. There is still need of systematic and periodic investigation by sincere authors to devise and recommend a data which may be true a representative for this densely populated area of the country that is Bihar. Nearly all authors recommended more studies at periodic intervals to make the figure relevant and accurate for assessment of age of a person in different parts of the country. Present work is intended to find, establish and recommend a standard data for appearance and fusion of ossification centres of ossification in population of North Bihar. The work may substantiate the previous available data or may indicate any significant variation if found.

The object of this study is to find out a standard data from the ossification changes in the bones around wrist joint that includes lower ends of radius and ulna, carpals and metacarpals of hand and also to see if these findings are at variance with those of others. A well-researched and correct data on the topic will go a long way in helping the course of justice in the medicolegal cases.

## MATERIALS AND METHODS

Present study was conducted in the Department of Forensic Medicine and Toxicology, Darbhanga Medical College. A total number of 200 individuals of both sexes from different families and socio-economic group falling between the age of 12 Years and 20 Years were selected for the present study. Only those cases in whom the actual age could be ascertained beyond any doubt were considered for the study. The person giving an ambiguous or apparently inaccurate account of their age or date of birth was kept out of this study.

A complete clinical examination besides taking the history were carried out in all selected cases to rule out any chronic and debilitating illness and existence of any deficiency disease. Hormonal, hereditary and any congenital abnormalities which may be responsible for any discrepancy between their physical appearance and stated age were completely ruled out before taking the case into consideration. Any history of trauma to bones of hands was also excluded. Age confirmed by taking date of birth from driving licence, passports, ration card, voter's card or other documents available issued by authorised agencies were carried out in all selected cases for study. The stages of eruption of 3<sup>rd</sup> molar were observed. In case of absence of eruption of third molar, the extent of space for 3<sup>rd</sup> molar was looked for.

The anteroposterior view of both wrist joints, including lower end of radius & ulna, metacarpals were taken. Radiographs of both the wrists were taken simultaneously for each individual. The ossification of wrist joint and lower forearm were studied individually for appearance of carpal centres, secondary ossification centres of base of 1<sup>st</sup> metacarpals, lower end of radius and ulna. The maturation and fusion of epiphyses with their respective shafts were also noted. The stages of union of epiphysis with the diaphysis were grouped under following 4 stages:<sup>3</sup>

Stages	Comment
Stage I	No union. Complete gap or space between the epiphysis and shaft of the bone.
Stage II	Partial union. Partial closure of gap or space.
Stage III	Recent union. Closure of the gap of space but a thin line visible at the epiphyseodiaphyseal junction.
Stage IV	Complete union. Epiphyseal space bony in architecture and density; and indistinguishable from either epiphysis or diaphysis.

## RESULTS

In the present study, total 106 male (53%) and 94 female (47%) cases belonging to various age groups from 12-20 Years (Table I) were studied. The male-female ratio is 1.127: 1 in our study.

In this we observed that pisiform appeared in 100% of cases in both male & female in age group of 12-13 Years. (Table II).

In males' fusion at base of 1<sup>st</sup> metacarpal, maximum number of cases (100% of cases) was found by the age groups between 16-17 Years; while in 14 to 15 Years age group only 9.09% cases showed fusion (Table III). In females' fusion at base of 1<sup>st</sup> metacarpals in 100% cases was found between the age group of 15-16 Years while in 14-15 years age group only 69.23% cases showed fusion (Table IV). In both sexes not a single case was detected in 13 to 14 years of age group where epiphysis and diaphysis were fused (Table III & IV).

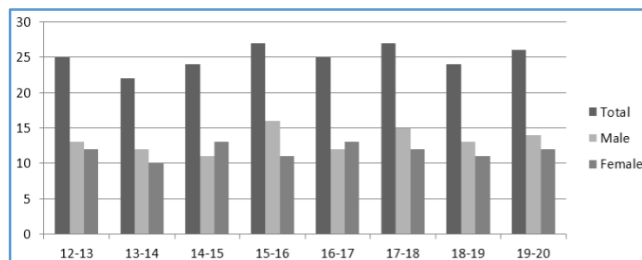
In males, maximum number of cases of epiphyseodiaphyseal union of lower ends of radius were in 19-20 years of age group (100%) and minimum in 16-17 years of age group (33.33%). Not a single case of union was found in 15-16 Years of age group. A significant percentage (66.66%) of cases showed fusion (Table V) between the age group 17-18 yrs. In females, maximum no. of cases of epiphyseodiaphyseal union of lower ends of radius were in 18-19 years of age group (100%) and only 30.76% in 16-17 years age group. Not a single case was detected in 15-16 years age group. A significant percentage (91.66%) of cases in the age group 17-18 years showed fusion (Table VI).

In males, the maximum no. of cases of epiphyseodiaphyseal union of lower end of ulna were in 18-19 years of age group (100%) and minimum in 15-16 years of age group (18.75%). Not a single case was detected in 14-15 years age group. A significant percentage (58.33%) of cases in age group 16-17 years showed fusion (Table VII). In females, the maximum no. of cases of epiphyseodiaphyseal union of lower end of ulna was in 17-18 years age group (18.18%). Not a single case was detected in 14-15 years age group. A significant percentage (84.61%) of cases in the age group 16-17 years showed fusion (Table VIII).

Age Group in Years	No. of Cases	Male	Female
12-13	25	13	12
13-14	22	12	10
14-15	24	11	13
15-16	27	16	11
16-17	25	12	13
17-18	27	15	12
18-19	24	13	11
19-20	26	14	12
<b>Total</b>	<b>200</b>	<b>106</b>	<b>94</b>

**Table 1. Showing Age distribution in both Sexes**

Age Group in Years

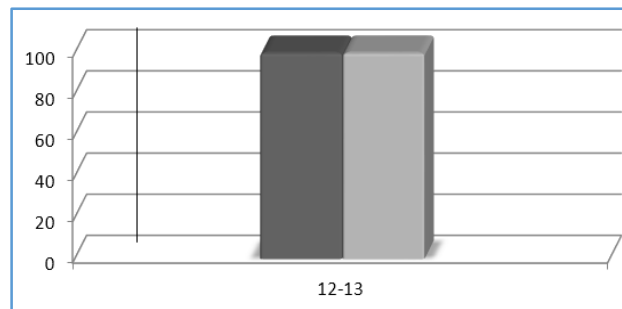


**Figure 1. The Histogram Showing Distribution of cases in different Age Groups**

Sl. No.	Sex	No. of Cases Studied	No. of cases Showing Appearance	Percentage
1.	Male	13	13	100
2.	Female	12	12	100

**Table 2. Showing Appearance of Pisiform in Group I cases (between 12-13 Years) in both Sexes.**

Age Group in years



**Figure 2. The Histogram showing Percentage of Appearance of Pisiform in Group I (12-13 Years) Cases**

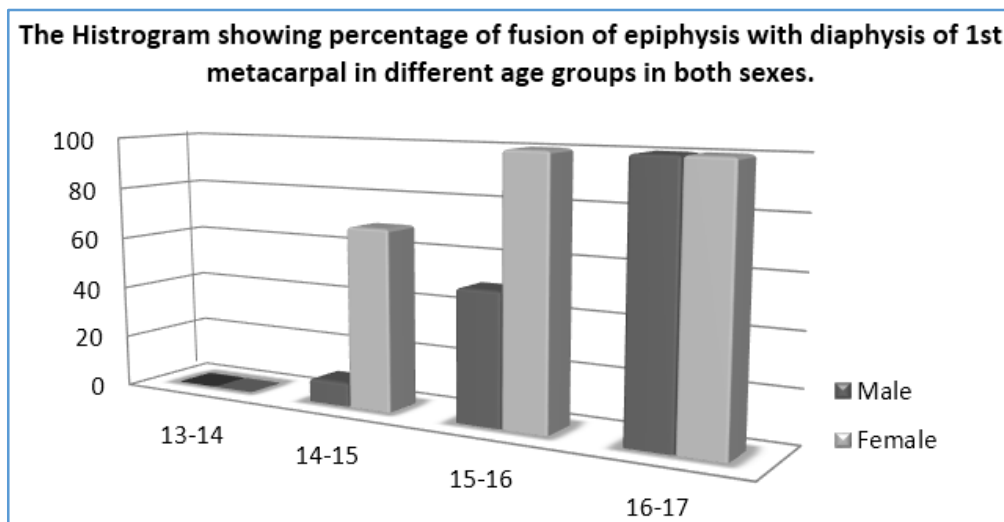
Sl. No.	Group	Age Group in Years	No. of Cases Studied	No. of Cases Showing Fusion	Percentage
1	II	13-14	12	Nil	0
2	III	14-15	11	1	9.09
3	IV	15-16	16	8	50
4	V	16-17	12	12	100

**Table 3. Showing Fusion of Epiphysis with Diaphysis of 1<sup>st</sup> Metacarpal Bone in Males in Groups II, III, IV, and V**

Sl. No.	Group	Age Group in Years	No. of Cases studied	No. of Cases Showing Fusion	Percentage
1	II	13-14	10	Nil	0
2	III	14-15	13	9	69.23
3	IV	15-16	11	11	100
4	V	16-17	13	13	100

**Table 4. Showing Fusion of Epiphysis with Diaphysis of Base of 1<sup>st</sup> Metacarpal Bone in Females in Groups II, III and IV**

Age Group in Years.



**Figure 3**

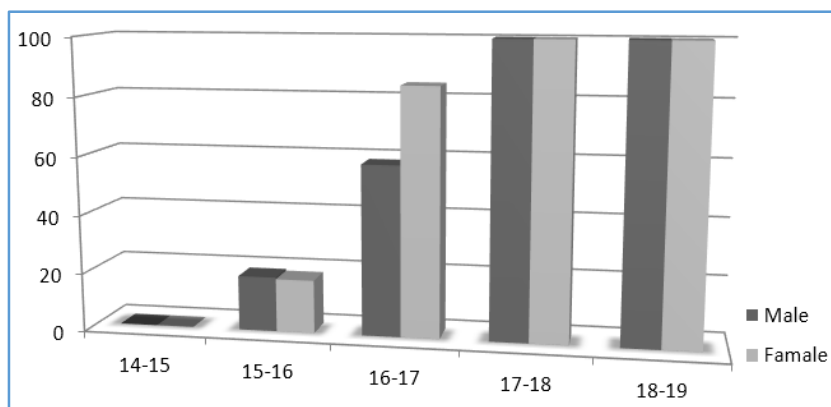
Sl. No.	Age Group in Years	No. of Cases Studied	Stage I (Non-Union)	Sage II (Partial Union)	Stage III (Recent Union)	Stage IV (Complete Union)	Cases without Union I+II	Cases with Union III+ IV	% of Non-Union	% of Union
1.	15-16	16	16	Nil	Nil	Nil	16	0	100	0
2.	16-17	12	Nil	8	4	Nil	8	4	66.66	33.33
3.	17-18	15	Nil	5	6	4	5	10	33.33	66.66
4.	18-19	13	Nil	Nil	5	8	Nil	13	0	100
5.	19-20	14	Nil	Nil	Nil	14	Nil	14	0	100

**Table 5. Showing Stage of Union of Epiphysis with Diaphysis at Distal End of Radius and their Percentage in Males**

Sl. No.	Age Group in years	No. of Cases studied	Stage I (Non-Union)	Sage II (Partial Union)	Stage III (Recent Union)	Stage IV (Complete Union)	Cases without Union I+II	Cases with Union III+ IV	% of Non-Union	% of Union
1.	15-16	11	11	Nil	Nil	Nil	11	0	100	0
2.	16-17	13	Nil	9	3	1	9	4	69.23	30.76
3.	17-18	12	Nil	1	3	8	1	11	8.33	91.66
4.	18-19	11	Nil	Nil	Nil	11	Nil	11	0	100
5.	19-20	12	Nil	Nil	Nil	12	Nil	12	0	100

**Table 6. Showing Stage of Union of Epiphysis with Diaphysis at Distal End of Radius and their Percentage in Females**

Age Group in Years



**Figure 4. Histogram Showing Percentage of Fusion at lower end of Radius in Both Sexes at different Age Groups**

Sl. No.	Age Group in Years	No. of Cases Studied	Stage I (Non-Union)	Sage II (Partial Union)	Stage III (Recent Union)	Stage IV (Complete Union)	Cases without Union I+II	Cases with Union III+ IV	% of Non-Union	% of Union
1.	14-15	11	11	Nil	Nil	Nil	11	0	100	0
2.	15-16	16	5	8	3	Nil	13	3	81.25	18.75
3.	16-17	12	Nil	5	3	4	5	7	41.66	58.33
4.	17-18	15	Nil	Nil	3	12	Nil	15	0	100
5.	18-19	13	Nil	Nil	Nil	13	Nil	13	0	100

**Table 7. Showing Stage of Union of Epiphysis with Diaphysis at Distal End of Ulna and their Percentage in Males**

Sl. No.	Age Group in Years	No. of Cases Studied	Stage I (Non-Union)	Sage II (Partial Union)	Stage III (Recent Union)	Stage IV (Complete Union)	Cases without Union I+II	Cases with Union III+ IV	% of Non-Union	% of Union
1.	14-15	13	13	Nil	Nil	Nil	13	Nil	100	0
2.	15-16	11	1	8	2	Nil	9	2	81.81	18.18
3.	16-17	13	Nil	2	7	4	2	11	15.38	84.61
4.	17-18	12	Nil	Nil	Nil	12	Nil	12	0	100
5.	18-19	11	Nil	Nil	Nil	11	Nil	11	0	100

**Table 8. Showing Stage of Union of Epiphysis with Diaphysis at Distal End of Ulna and their Percentage in Females**

Age Group in Years

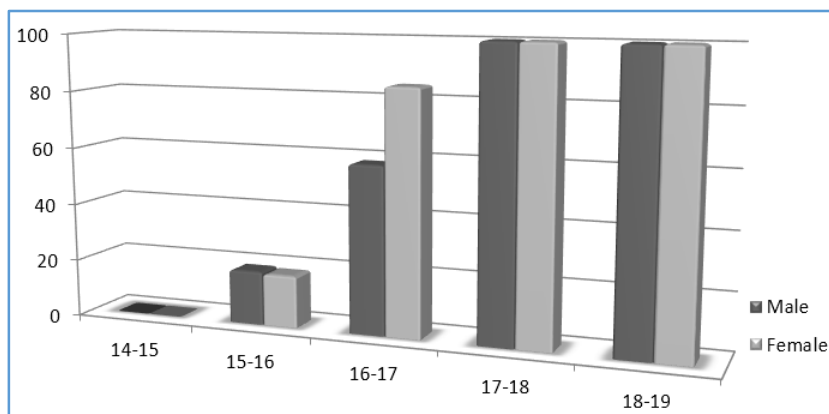


Figure 5. Histogram Showing Percentage of Fusion at Lower End of Ulna in Both Sexes at different Age Groups

Sex	Pryor (1928)	Flecker (1932)	Galstaun (1937)	Cunningham (1958)	Hasan & Narayan(1963)	Mishra (1966)	Bajaj et al (1967)	Mitra et al	Present work
Male	12-13 yrs.	11 Yrs.	12-17 yrs.	13 yrs.	13-14 yrs.	14-15 yrs.	13.08±1.4 yrs.	10-13 yrs. 9 months.	Before 12 yrs.
Female	9-10 yrs.	9 Yrs.	9-12 Yrs.	11 yrs.	9-10 yrs.	12-13 yrs.	10.2±1.5 yrs.	6 yrs. 10 months - 9 yrs. 11 months.	Before 12 yrs.

Table 9. Showing Appearance of Pisiform as Observed by Different Authors

Sex	Flecker (1932)	Galstaun (1937)	Cunningham (1958)	Gupta (1961)	Mishra (1966)	Present work
	Australia	Bengal	England	U.P	Orissa	N.Bihar
Male	18 Years	16-18 Years	19 Years	16-17 Years	17 Years	16-17 Years
Female	16 Years	14-15 Years	17 Years	15-16 Years	16 Years	15-16 Years

Table 10. Showing Fusion of Base of 1<sup>st</sup> Metacarpal by Different Authors

Sex	Lal & Nat (1934)	Pillai (1936)	Galstaun (1937)	Su & Basu (1938)	Lall & Townsend (1939)	Mittal (1952)	Loomba (1958)	Sharma (1962)	Franklin (1962)	Prasad (1965)	Mishra (1966)	Saxena et al (1969)	Dasgupta et al (1974)	Present work
	U.P	Madras	Bengal	Bengal	U.P	U.P	U.P	U.P	Maharashtra	S. Bihar	Orissa	M.P	U.P	N. Bihar
Male (age in years)	19	-	18	-	-	-	20-21	18-19	-	-	17-18	19-20	20-21	17-18
Female (age in years)	-	14-18	17	16-17	18-19	17-18	18-19	17-18	17-18	18-19	16-17	17-18	20-21	16-17

Table 11. Showing Fusion at the Distal End of Ulna as obtained in the present series and recommended by other Authors

Sex	Lal & Nat (1934)	Pillai (1936)	Galstaun (1937)	Hep worth (1929)	Basu & Basu (1938)	Lall & Townsend (1939)	Mittal (1952)	Loomba (1958)	Sharma (1962)	Franklin (1962)	Prasad (1965)	Mishra (1966)	Saxena et al (1969)	Das-gupta et al (1974)	Present work
	U.P	Madras	Bengal	Punjab	Bengal	U.P	U.P	U.P	U.P	Maharashtra	S. Bihar	Orissa	M.P	U.P	N. Bihar
Male (age in years)	19	-	18	16-17	-	-	-	20-21	18-19	-	-	Beyond 18	19-20	20-21	18-19
Female (age in years)	-	14-18	16.5-18	16-17	16-17	18-19	17-18	18-19	17-18	17-18	18-19	16-17	17-18	20-21	17-18

Table 12. Showing Fusion at Distal End of Radius as obtained in present series and recommended by various other Authors

## DISCUSSION

In the present work, it was observed that all the carpal bones including pisiform had appeared in all the cases in the age group 12-13 years (Table II).<sup>4,5</sup> As regards carpal bones these findings are very similar to observations made by different authors except pisiform. The age of appearance of pisiform as observed during present work has been compared with the observation of previous authors and shown in table IX. Present observation is in agreement with the finding of all the previous authors as regard to age of appearance of pisiform bone in female is concerned. The figures in male cases are in agreement with Flecker (1932) & Mitra et al (1973).<sup>6</sup> Little difference in age of appearance stated by Hasan and Narayan<sup>7</sup> (1963), Mishra (1966) and Bajaj et al (1967) was possibly due to variation of environmental, dietary and other factors besides the facts that present study covered only age range between 12 Years and 20 Years and not many cases falling between 12-14 Years of age were included in this study.

### Age of Fusion of Epiphysis with Diaphysis of 1<sup>st</sup> Metacarpal, Lower End of Ulna & Lower End of Radius

In present study, it was observed that the fusion of epiphysis with their shaft at the base of 1<sup>st</sup> metacarpal occurred earlier than the distal end of radius & ulna. It is consistent with the observation made by several other authors viz Galstaun (1937), Flecker (1932), Mishra (1966), Cunningham (1958), Gupta (1961) and Mishra (1966) (Table X).

In the present series, 17-18 years was found to be the age of union at distal end of ulna in case of males, where 100% of cases showed the union (Table XI). This is in agreement with the observation of Galstaun (1937) and Mishra (1966). It is also almost close to the observation made by Sharma (1962). 16-17 Years was observed to be the age of Union of distal end of ulna in cases of females (Table XI) in the present work. It is also consistent with the observations made by Galstaun (1937),<sup>8</sup> Basu and Basu (1938), Mishra (1966).<sup>9</sup> It is also nearer to the findings obtained by Mittal (1952), Sharma (1962) & Saxena (1969). However, it differs from the observation made by Lall & Townsend (1939), Loomba (1958) and Dasgupta (1974). These variations may be due to regional, hereditary and other factors.

For union at distal end of radius, it was found to occur by the age of 18-19 Years in males (Table-XII). These are consistent with the findings made by Galstaun (1937), Lall and Nat (1934), Sharma (1962), Mishra (1966). This, however, differed from observation made by Hepworth (1929), Loomba (1958), Saxena (1968), and Dasgupta (1974). These variations may be due to environmental, dietary, hereditary, regional and other factors. In case of females in this study, it was found that lower end of radius united by the age of 17-18 Years (Table XII). It coincides with the observation made by Mittal (1952). Sharma (1962), Franklin (1962), Mishra (1966). This, however, differed from that of Pillai (1936), Basu and Basu (1938), Lall & Townsend (1939), Loomba (1958), Prasad (1965) and Dasgupta (1974) which may be due to regional hereditary and other factors.<sup>10</sup>

### Sexual Variation

In the present work, it was observed that epiphyseodiaphyseal union had occurred 1-2 Years earlier in females than the males.<sup>11</sup> This is due to the fact that females mature earlier than the males and consequently their epiphyses unite earlier.

No difference of opinion exists about this variation. All of them had nearly similar views on this matter.<sup>12</sup>

### Effect of Climate & Geographical Distribution on Ossification

Several authors in India and abroad had made remarkable observation on the influence of climate and geographical distribution on skeletal maturation.

Hepworth (1929) who worked on Punjabi population stated that ossification was advanced by 1-2 Years in Indians than English and American People. The findings recommended by Cunningham; who worked on English Population were also higher than the data obtained for Indian Population.

The result also differed in different states of India and even in the same state. The result of present study also differed from the observation made by Pillai and Galstaun, although are not too wide as in case of Cunningham. This difference in time of fusion of epiphysis centre may be attributed to the fact that climate and geographical conditions of North Bihar differed from the climatic and geographical conditions of Madras and Bengal though being in the same country. However, variation occurred proportionately in both sexes.

### Effects of Diet

In the present study out of total cases, 177 were non-vegetarian & 23 cases were vegetarian. No difference in the stage of union was observed in two groups suggesting that the vegetarian & non-vegetarian diets do not play any significant role in the process of ossification. This is consistent with findings of Dasgupta et al (1974) who worked on population of Uttar Pradesh. It differed from the findings of Loomba (1958) who opined that non-vegetarian diet enhances the process of ossification.

## SUMMARY AND CONCLUSION

1. All carpal bones including pisiform appear by the age of 12 years.
2. Fusion of three epiphyses took place in the order "metacarpal-ulna-radius".
3. Base of 1<sup>st</sup> metacarpal fuses by the age of 16-17 years in case of males and by 15-16 years in case of females.
4. The distal end of ulna shows fusion by the age of 17-18 years in cases of males and by 16-17 years in cases of females.
5. Fusion at the distal end of radius occurs by the age of 18-19 years in males and by 17-18 years in females.
6. Ossification and fusion of bony centres around the wrist joint occur 1-2 years earlier in females than their male counterparts.
7. Variations do exist, when compared with figures recommended by other authors for different regions, though not wide; in the ossification and fusion of bony centres around wrist joint in the native of North Bihar. This may be attributed to the variation in racial and geographical factors as prevailing in different parts of the world as also within the country.
8. Ossification of bones around wrist in the population of North Bihar occurs 1-2 years earlier than Europeans.
9. Vegetarian or non-vegetarian diets do not have obvious influence on process of ossification.

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