INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Human Fetal Growth and Age Estimation Based on Osteometry on the Diaphysis of Fetal Tibia

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Abstract:
In dealing with fetal growth, earlier studies carried out on chemically preserved fetuses with very little sample size and measured only the length of fetal long bones. The present study is a pioneer one, taken on naturally macerated fetal tibia bones. There have been six new osteometric measurements introduced on human fetal tibia. Maximum possible osteometric measurements have been taken on a record number of 912 fetal tibia bones from 456 fetuses having age range between 11 weeks to 40 weeks of intrauterine life. Bilateral and bisexual differences have been analyzed. Growth of the fetal tibia has been analyzed, based on its osteometry. The fastest rate of growth is observed in the length of the shaft of fetal tibia in females during 11 weeks to 16 weeks of the intrauterine life of human fetus. For every 1 mm increase in the CRL, the Maximum Length of Tibia (t-ml) is increased by .246 mm in females. Regression values have been calculated to estimate human fetal age from the osteometric measurements on fetal tibia. The age estimation is a crucial factor in dealing with medico-legal cases.

Keywords: *Fetus, tibia, osteometry, fetal growth, fetal age estimation*

1. Introduction

Human growth and developmental aspects have wide range of applications and scope. Very extensive studies have been carried out, in respect of growth on infants and children (Bhalla et al. 1986; Tsuzaki et al.1990), children through adolescence (Kulkarni 1985; Padmanathan et al.1990), and also adults (Macho1986). However very few studies are available on the growth aspects of human fetus in its intrauterine lifebased on its osteometry (Moss et al. 1955; Simon et al. 1984). Although various studies have been carried out by earlier workers on fetal growth and development, the aims of those studies varied from one another. Most of the earlier studies aimed to concentrate on developmental aspects rather than growth aspects based on osteometric analyses (O'Rahilly 1973;Moore 1977; Kulkarni et al. 1981). Few studies were aimed to estimate the age of related human fetus. (Mehta and Singh 1972; Kosa 1997).

Methodology adopted in the earlier studies to prepare fetal material in dealing with prenatal growth and development was not uniform. Ford (1956) and Moore and Persaud (1993) measured human fetuses which were preserved in formalin. In various studies, observations and measurements were taken from photographs (Burdi 1969), radiographs (Scheuer et al.1980) and ultrasonographs (Falkner and Roche 1987; Mankeekar 1993). Moss et al. (1955) studied fetal bones prepared with alizarin staining. In some other studies (Ford 1956; Mehta and Singh 1972) fetal bones were dissected from preserved fetuses and measured. Mehta and Singh (1972) measured the crown-rump length of fetuses, after fixing them in 10% formalin for 4 to 6 months. As one can observe, no uniform method had been adopted in all those earlier studies in preparing the fetal specimens.

The number of fetal specimens considered in the earlier studies also varied from one another. It has been noted that in many cases the number has been found to be quite inadequate. Gray and Gardner (1969), Gardner and Gray (1970) studied a series of only 40 embryos and fetuses. Mehta and Singh (1972) measured the diaphyseal lengths of only 50 fetuses. Feltz (1954) studied only 53 femora. Because of the inadequacy as well as variability in the sample size, no proper comparison could be made between these studies. In the case of osteometry, from the earlier studies, which were aimed to estimate the age from fetal long bones, it has been observed that not all the studies included all the long bones. (Feltz 1954; Moss et al.1955; Gray and Gardner 1969; Gardner and Gray 1970; Mehta and Singh 1972). With different aims,

variations in methodology adopted to make the availability of the human specimens, and also with much variation in the methodology followed to measure the specimens, with lesser number of parameters on too less sample size, the whole scenario depicts an incomplete picture. Thus, it is felt necessary that a systematic studyto be undertaken considering the pitfalls highlighted above by carrying out a detailed osteometric study on human fetal tibia bones with side and sexual differences based on growth pattern on the large number of human fetuses ever carried out.

1.1. Aims and Objectives

The aims and objectives of the present study are:

- To assess bilateral differences, in the growth pattern on the basis of measurements taken on both sides tibia bones of human fetuses.
- To find out the extent of bisexual differences, if any, in the growth pattern of human fetuses on the basis of metric analyses.
- To analyze the rate of fetal growth as exhibited through detailed osteometry.
- To correlate various osteometric measurements on tibia with crown-rump length (CRL) and crown-heel length (CHL) to estimate fetal age.
- To examine the applied significance of those selected measurements in terms of anatomical, clinical and medico-legal aspects.

2. Material and Methods

2.1. Source of Fetuses

The principal author of the present study was an Anatomy staff member in the Department of Anatomy, B.J. Medical College (BJMC) with its Sassoon General Hospitals, Pune, India since 1978 onwards for over the period of 30 years. The Deans of the BJMC and Sassoon General Hospitals, and the Heads of the Department of Anatomy, BJMC were kind enough to cooperate to collect human fetuses from the Sassoon General Hospitals. The Professors and Heads of the Departments of Obstetrics and Gynaecology and Forensic Medicine, BJMC were also cooperative to supply the human fetuses from their respective sections. The fetuses were collected during the above period. The fetuses were from abortions of Medical Termination of Pregnancies (MTPs)/Still Births. The collections of fetuses were done by strictly following official procedures. The study has been conducted in the Department of Anatomy, BJMC and continued in the Department of Anatomy, Dr. V. M. Government Medical College, Solapur, India. Required approval was obtained from the Ethical Committee of BJMC.

2.2. Population Base

Anatomical study on human is both on individual basis and population oriented. In the present study, name of the parents of the fetuses and their place of living indicate that all these parents belong within the geographical area of Maharashtra, India. This broad population base of Maharashtra provides a vital significance, indicating that the fetuses belong to the population based in Maharashtra State of India.

2.3. Categorization of Fetuses

In all there are 912 diaphyses of fetal tibia bones from 456 normal human fetuses included for the present study. Among the 456 fetuses, 244 (53.51%) fetuses are males and 212 (46.49%)fetuses are females. The fetuses which have been selected for the present study are of varying sizes ranging from 51mm to 394mm in crown-rump length (CRL) with 70 mm to 577mm in crown-heel length (CHL). As there is earlier literature available to estimate fetal age from the CRL as well as the CHL, the present study has adopted the already established scales, (Davies 1967; Okajima 1975; Williams and Warwick 1980), to estimate fetal age based on the CRL and CHL. Osteometry has been carried out on all the 912 tibia bones. All the 456 fetuses have been categorized into four age groups, each group having eight weeks duration of age range, except for the first group. The first group has got only six weeks range, as because fetal bones are available for manual measurements only after the period of 11 weeks of the intrauterine development. (Table 1).

Group	Weeks	CRL (mm)	CHL (mm)	Somatometry and Osteometry (456)		
				Male	Female	Total
I	11-16	51-100	Up to 150	18	4	22
II	17-24	101-200	151-300	159	152	311
III	25-32	-	301-400	49	42	91
IV	33-40	-	401-550	18	14	32
Total				244	212	456

Table 1: Distribution of Human Fetuses for the Present Metric Study

2.4. Somatometry

When a fetus was brought to the Department of Anatomy, it was to be prepared for somatometric study. Only those fetuses, which appeared normal, were selected for the purpose of the present study. Firstly, the umbilical cord of the fetus was tied tightly with the help of a thread, near the umbilicus. The purpose of the tying up was to stop oozing out

of the fetal blood from the fetus. The part of the umbilical cord along with the placenta was cut off and removed. The fetus was then cleaned with running water for about few minutes and kept ready for observation and taking somatometric measurements. Sex of the fetus was noted down. There were two somatometric measurements, crown-rump length (CRL) and crown-heel length (CHL), selected for the present study (Table 2).

S.No.	Somatometric Measurement	Abbreviation
1	Crown-Rump Length	CRL
2	Crown-Heel Length	CHL

Table 2: Somatometric Measurements

2.5. Maceration

After the completion of the somatometry, the fetuses were kept in glass jars containing required amount of water so that the fetus got immersed in the water. No chemical was added with the water, as it would affect the natural maceration process. Then the fetuses were kept for maceration in a maceration room for bone preparation. Duration of the maceration process is according to the size of the fetuses. Younger fetuses got macerated in shorter duration. The duration of maceration was between 8 weeks to 16 weeks. Then the bones were cleaned and filtered. The filtration was done by metal sieve having minute holes so that even small bones were not lost. After the maceration, a full set of fetal bones was collected from each fetus. The bones were then allowed to get dried in normal room temperature. Although full sets of fetal bones of human fetuses have been prepared only tibia bones have been selected for the present study. As the epiphyses of tibia bones are not formed/not joined during intrauterine period, only the diaphyses of tibia bones have been measured (Fig. 1). The prepared fetal bones are stored in the Department of Anatomy, B.J. Medical College, Pune, India.

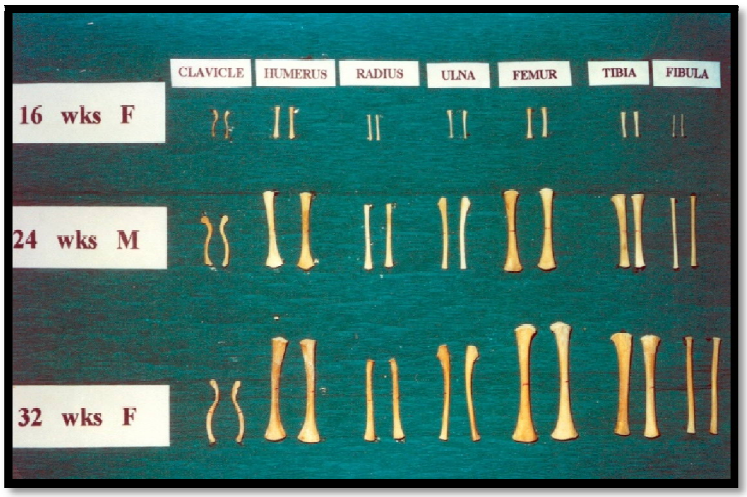

Figure 1: Shafts of Fetal Long Bones (16 to 32 weeks)

2.6. Osteometry

In addition to the two somatometric measurements, there have been seven osteometric measurements taken for the present study (Table 3). All the seven osteometric measurements have been measured on both right and left side bones. Except the maximum length of tibia all the remaining six osteometric measurements taken on fetal tibia are new ones.

S.No.	Osteometric Measurement	Abbreviation
1	Tibia-Maximum Length	t-ml
2	Tibia-Proximal Antero-Posterior Diameter	t-pap
3	Tibia-Proximal Medio-Lateral Diameter	t-pml
4	Tibia-Distal Antero-Posterior Diameter	t-dap
5	Tibia-Distal Medio-Lateral Diameter	t-dml
6	Tibia-Middle Antero-Posterior Diameter	t-map
7	Tibia-Middle Medio-Lateral Diameter	t-mml

Table 3: Osteometric Measurements

The maximum length of tibia is the maximum straight-line distance between the highest point on the proximal end and the lowest point on the distal end of tibia. The remaining measurements have been taken at the proximal/distal/middle part of tibia from the maximum straight-line distance from anterior/posterior/medial/lateral most pointsas per the name of the measurement.

2.7. Number of Measurements

The somatometric and the osteometric studies undertaken for the present work, have involved a very large number of measurements taken on all the 456 fetuses. In all, there have been in order 7296 somatometric and osteometric measurements recorded on 456 fetuses (Table 4).

Measurement			Each Fetus		Total on Somatometry / Osteometry on all fetuses
Name	Sample	Type	Number of Measurements	Total Number of Measurements	
Somatometry	456	Single	2	(2 × 1) 2	(2 × 456) 912
Osteometry	456	Bilateral	7	(7 x 2) 14	(14 × 456) 6384
Grand Total					7296

Table 4: Details of Measurements on Human Fetuses

2.8. Inter-age Groups

As there are four age groups viz. I, II, III, IV, the absolute growth rate is calculated between these four groups. Thus, there are three inter-age groups formed I-II, II-III, and III-IV from the four basic groups. Each inter-age group has the total number of fetuses from both the groups concerned. The absolute growth rate has been calculated only for the Maximum Length of Tibia for the present study.

2.9. Statistical Considerations

Statistical considerations for calculating regression coefficients and tests of significance have been followed from Singh and Bhasin (1989). Calculation of absolute growth has been done by following the formula from Biswas and Bhattacharya (1966).

3. Results and Discussion

3.1. Bilateral Differences

It has been observed that in the earlier studies on fetal growth based on osteometry, side differences were not dealt with. Therefore, comparison of the bilateral differences of the present work with other studies is not attempted in the present study. Bilateral differences have been analyzed on all the tibia bones of the present attempt, on the basis of the osteometric measurements. In the males, from group II, significant right-side dominance has been observed in the t-ml, t-map and t-mml at 1% level and in the t-pml and the t-dap at 5% level. And also, in the males, significant right-side dominance has been observed from group III in the t-dml and the t-map at 1% level and left side dominance has been observed in the t-mml at 5% level. The t-map shows significant right-side dominance at 5% level from group IV.In the females, significant right-side dominance has been observed at 1% level in the t-pml and t-map from group II and in the t-ml from group III. Also, in the females, the t-mml shows significant left side dominance at 5% level from group II.

It is observed that only 11.61% show significant bilateral differences in the osteometric measurements. Therefore, in the present study, all the analyses including the mean and standard deviations, correlation coefficients, regression analyses, analyses on growth and age estimation have been calculated on the basis of the mean values of both the left and right sides merging together.

3.2. Bisexual Differences

Significant bisexual differences have been found in the t-mml at 5% level from group I; In the t-ml, t-pap, t-pml, t-dap, t-dml, t-map at 5% level and in the t-mml at 1% level from group II; In the t-ml at 5% level from group III. In all these measurements females show higher values. On the basis of the analyses, it has been observed that only 16.07% show significant bisexual differences. In spite of the low percentage of bisexual differences in the present study, all the obtained results on correlation coefficients, regression constants for growth rate and also scattergrams along with regression fit lines and bar diagrams have been presented sex wise separately for evolving a broad comparative perspective on both the sexes. Very few studies (Halonen 1929; Birckbech et al. 1975) are available dealing with sexual differences based on osteometric studies on human fetal long bones. Birkbeck et al. (1975) measured 149 fetuses ranging from 8 to 21 weeks for six measurements, which included CRL and CHL stated that the measurements were related to CHL and reported that there was no evidence of sex differences. The sex differences in the present study are analyzed based on four age groups but the same age group categories were not available in the earlier studies.

3.3. Growth Rate

From the regression values (b0, b1) calculated for all the osteometric measurements(Tables 5 and 6), all the measurements show increasing trend of growth rate for every 1 mm increase in CRL and CHL.Theb1 values show increase

in the osteometric measurements for every one mm increase in CRL/CHL. Among all the measurements, the t-ml shows faster rate of growth in both males and females. The fastest rate of growth is observed in female tibia from the group I (11 to 16 weeks). For every 1 mm increase in the CRL, the Maximum Length of Tibia(t-ml) is increased by .246 mm in females. In the group I (11 to 16 weeks) mostly females show slightly higher values in almost all the osteometric measurements than males. The group II (17 to 24 weeks) shows slightly higher rate of growth when compare to group III (25 to 32 weeks) in all the osteometric measurements in both males and females. The growth rate of t-ml is higher in the group I compare to the group IV in both males and females.

TIBIA		**Group –I**		**Group –II**		**Group –III**		**Group –IV**	
Males		**11-16wks (18)**		**17-24wks (159)**		**25-32wks (49)**		**33-40wks (18)**	
Dependent Variable	Independent Variable	b0	b1	b0	b1	b0	b1	b0	b1
t-ml	CRL	-7.134	.202	-9.300	.225	5.939	.152	-6.183	.207
t-pap		-.478	.028	-1.744	.040	2.368	.021	-2.025	.039
t-pml		-.791	.034	-3.193	.057	.517	.040	-3.912	.058
t-dap		-.360	.021	-1.537	.033	.254	.025	-1.492	.032
t-dml		-.485	.024	-2.188	.040	.342	.028	-3.543	.043
t-map		-.143	.014	-.689	.020	.559	.014	-1.810	.023
t-mml		-.250	.014	-.546	.018	.513	.013	-.732	.018
Females		11-16wks (04)		17-24wks (152)		25-32wks (42)		33-40wks (14)	
t-ml	CRL	-11.150	.246	-9.347	.228	-.638	.188	-6.776	.211
t-pap		-9.475	.119	-1.720	.041	.187	.031	-6.549	.053
t-pml		-6.500	.092	-3.201	.058	-1.764	.051	-10.250	.078
t-dap		-6.250	.081	-1.478	.033	.354	.025	-4.533	.041
t-dml		-6.150	.081	-2.099	.040	-1.066	.035	-6.932	.054
t-map		-8.150	.096	-.842	.022	-.043	.017	1.116	.013
t-mml		-8.800	.102	-.686	.020	.644	.012	1.011	.011

Table 5: Regression Values (B0, B1) for Growth Rate in Tibia with CRL in Four Age Groups in Males and Females
B1 Shows Increase in the Osteometric Measurements for Every One Mm Increase in CRL
Number in Parentheses Indicates Sample Size

TIBIA		**Group –I**		**Group –II**		**Group -III**		**Group –IV**	
Males		**11-16wks (18)**		**17-24wks (159)**		**25-32wks (49)**		**33-40wks (18)**	
Dependent Variable	Independent Variable	b0	b1	b0	b1	b0	b1	b0	b1
t-ml	CHL	-5.402	.127	-8.812	.149	-1.872	.125	-9.079	.148
t-pap		-.235	.017	-1.670	.027	1.277	.018	-2.406	.028
t-pml		-.511	.021	-3.057	.038	-1.202	.032	-4.392	.041
t-dap		-.207	.014	-1.466	.022	-.755	.020	-1.672	.022
t-dml		-.279	.015	-2.093	.026	-.905	.022	-3.810	.030
t-map		-.038	.009	-.661	.014	.007	.011	-2.001	.016
t-mml		-.134	.009	-.521	.012	.186	.009	-.859	.012
Females		11-16wks (04)		17-24wks (152)		25-32wks (42)		33-40wks (14)	
t-ml	CHL	-8.748	.151	-8.738	.150	-6.824	.144	-11.567	.152
t-pap		-6.151	.050	-1.594	.027	-.876	.024	-5.760	.034
t-pml		-4.590	.049	-2.974	.038	-3.242	.038	-7.796	.047
t-dap		-4.324	.042	-1.354	.021	-.559	.019	-4.747	.028
t-dml		-5.216	.049	-1.962	.026	-2.007	.026	-6.153	.035
t-map		-7.370	.060	-.763	.014	-.546	.013	-.373	012
t-mml		-8.559	.068	-.617	.013	.255	.010	.075	010

Table 6: Regression Values (B0, B1) for Growth Rate in Tibia with CHL in Four Age Groups in Males & Females
B1 Shows Increase in the Osteometric Measurements for Every One Mm Increase in CHL
Number in Parentheses Indicates Sample Size

Studies on bone growth, based on quantitative analyses, help better understanding the growth pattern. On the basis of the analysis on osteometry, the present study reveals that there is a positive growth trend, which has been observed in all the measurements taken on the fetal tibia from all the four age groups considered. Saettle (1951) plotted growth curves of shafts against fetal height on the basis of the growth curve which was more accurate. Moss et al. (1955)

also stated that the several combinations of osseous shaft lengths revealed a constant ratio between the specific growth rates of all the bones. The present study could not make proper comparison with the above studies, as the methodologies adopted in the earlier studies to prepare the fetal bones differ from the present study. Moss et al. (1955) measured 106 fetuses, which were cleared and stained with alizarin, ranging from 30 mm to 169 mm in CRL. Whereas in the present study in the same age groups (I and II) there are 333 fetuses have been measured. The present osteometric study has been carried out on 912 dried bones from 456 fetuses. Variations observed with the earlier results (Table 7) might be attributed to the very less sample size of the earlier studies and the mode of preparation of the bone material for the osteometric study. Moss et al. (1955) noted a characteristic interphase in the growth of the body shaft in the CRL interval of 80 - 89 mm. Before this interval, the body shafts of all the long bones grow relatively faster than the CRL and after that the growth rate was not as fast as it was before.

Bone	**Group I**		**Group II**	
Tibia	Moss et al. (1955)	Present study	Moss et al. (1955)	Present study
	7.53	11.55	22.80	26.20

Table 7: Mean of Maximum Length of Tibia: Comparison

Vare and Bansal (1977) observed a linear correlation between the diaphyseal lengths of upper and lower limbs and the CRL from 185 fetuses of 116 males and 69 females with CRL ranging from 185 - 415 mm. The bones were dissected from the body and got them measured. Although the muscles and connective tissue were removed from the bones, periosteum was left intact. Vare and Bansal (1977) have reported about all the long bones except clavicle. In these studies, the calculation of growth rate is found not on the basis of age groups. Whereas in the present study the growth rate has been calculated using regression equations, in all the four age groups under male and female categories separately for all the osteometic measurements. Thus,in the present study a broad understanding has been evolved on the growth rate of fetal long bones, age wise and sex wise. Vare and Bansal (1977) reported that for every 1 mm increase in CRL the length of tibia increases by 0.18 mm. Whereas the present study reports that the groups I, II, III and IV show 0.202 mm, 0.225 mm, 0.152 mm and 0.207 mm respectively in males and 0.246 mm, 0.228 mm, 0.188 mm and 0.211 mm respectively in females.

3.4. Absolute Growth Rate

The t-ml of males from the inter-age group I-II (11 weeks to 24 weeks) shows the highest absolute rate of fetal growth as 77.99% per month. The lowest absolute growth rate is found in the t-ml of females from the inter-age group III-IV (25 weeks to 40 weeks) as17.42% per month (Table 8). The absolute growth rate for the Maximum Length of Tibia(Fig. 4)is higher in the inter-age group I-II (11 weeks to 24 weeks) and gradually declining through the proceeding two inter-age groups II-III (17 weeks to 32 weeks) and III-IV (25 weeks to 40 weeks). The bar diagram (Fig. 2) reveals the absolute growth rate for the Maximum Length of Tibia of both males and females between the three inter-age groups. Thus, the prepared bar diagram not only helps to understand the trend of absolute growth rate but also shows with male-female differences.

Sex	**Intergroup I-II**	**Intergroup II-III**	**Intergroup III-IV**
Males	78	29.59	21.60
Females	52.53	28.39	17.42

Table 8: Absolute Growth Rate Per Cent per Month for the Maximum Length of Tibia for Three Inter-Age Groups of Human Fetuses

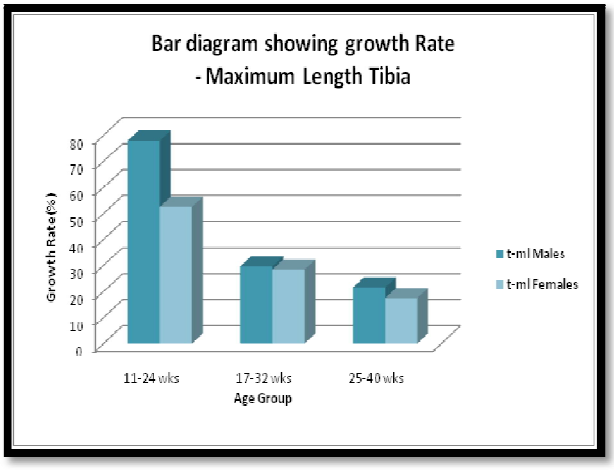

Figure 2: Absolute Growth Rate of Fetuses Based on Maximum Length of Tibia

3.5. Bivariate Distribution

In the case of osteometry, variations between CRL with the t-ml have been computed for males and females separately *(Figs.3 and 4)*. Because of the smaller sample size in the groups I and IV, scatter diagrams have been prepared only for the groups II and III. The scattergrams show that there are very close relationships found between the CRL with t-ml. The obtained scatter diagrams show a good fit between the variables correlated.

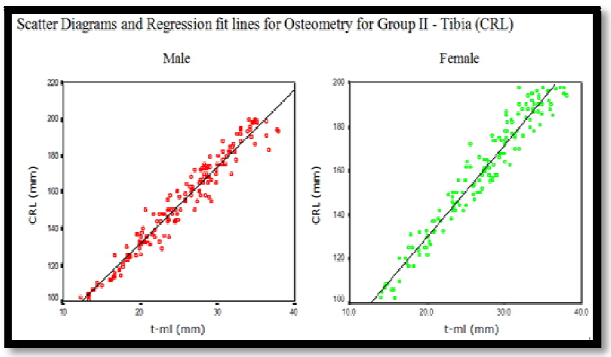

Figure 3: Scatter Diagrams and Regression Fit Lines for Osteometry for Group II-Tibia (CRL)

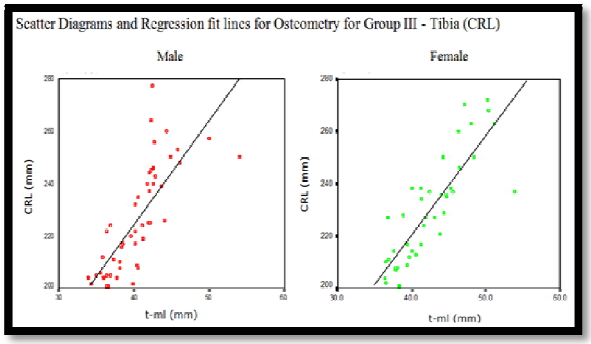

Figure 4: Scatter Diagrams and Regression Fit Lines for Osteometry for Group III-Tibia (CRL)

3.6. Correlations

In the present study, there have been highly significant correlations obtained between the CRL/CHL with all the osteometric measurements. In the males, the highest value of correlation coefficient .993 at 1% level is found between the CRL and t-ml in group I. In the females, the highest value .996 at 1% level is found in between the CHL and t-mml in group I.

3.7. Age Estimation of Human Fetus

As it has been revealed that there are highly significant correlations between the CRL/CHL with all the osteometric measurements, necessary regression equations have been calculated. As there are already established scales available to estimate fetal age from CRL and CHL, it is restricted to calculate only the CRL and CHL from all the osteometric measurements for the purpose of fetal age estimation(Tables 9 and 10). Once the CRL/CHL is calculated, age can be estimated from the already established age estimation scale. Necessary regression values (b0, b1) have been calculated for osteometric measurements for age estimation. With the help of the tables 9 and 10, CRL and CHL can be calculated using the two values b0 and b1 and the given measurements.

The formula to calculate CRL/CHL is as follows:

CRL/CHL = (b1 x measurement) + b0

Regression values (b0, b1) for estimating CRL, from Tibia	**Group –All**	
	b0	**b1**
t-ml	38.190	4.562
t-pap	37.686	25.989
t-pml	51.790	18.061
t-dap	45.140	30.705
t-dml	52.631	25.617
t-map	32.549	50.106
t-mml	24.230	57.659

Table 9: Regression Values (B0, B1) for Estimating CRL, from Tibia from the Total Sample of 456 Fetuses

Regression values (b0, b1) for estimating CHL, from Tibia	Group –All	
	b0	b1
t-ml	56.546	6.812
t-pap	55.896	38.785
t-pml	77.409	26.886
t-dap	67.308	45.756
t-dml	78.636	38.139
t-map	48.083	74.825
t-mml	35.565	86.140

Table 10: Regression Values (B0, B1) for Estimating CHL, from Tibia from the Total Sample of 456 Fetuses

Expert opinion is routinely requested from anatomists, by legal authorities, to know about age and sex of deceased, while dealing with suspected murder cases. While examining the adult cases, as there are already established scales available for age estimation, it becomes easy to estimate the age of the deceased adult individual from the bone remains. On the contrary, when the opinion about the age of a deceased fetus is asked, from the available fetal bones, as there is no established scale or standards available, even anatomists are not in a comfortable position, to provide precise information regarding the age of fetus, from the bone remains. Mehta and Singh 1972; Vare and Bansal 1977; Kosa 1997 attempted to estimate fetal age from chemically preserved fetal long bones. Simon et al. (1992); Simon and Baig (2015)[a]; Simon and Baig (2015)[b] estimated CRL/CHL from fetal clavicle, fetal humerous and fetal femur respectively. The latter studies were carried out on naturally macerated fetal bones without adding any preservatives. In the present study, once the CRL/CHL is calculated from the analyzed regression values, based on the osteometric study on fetal tibia bones, age can be estimated from the already established age estimation scale. The present analysis to estimatefetal age from the measurements on the human fetal tibia would definitely help in solving problems facing estimation of fetal age from human fetal tibia, a crucial requirement in forensics.

4. Summary and Conclusion

The present study is a unique one from the earlier studies. The study is carried out on a record number 912 fetal tibia bones from 456 human fetuses ever studied. Among them 244 (53.51%) fetuses are males and 212 (46.49%) are females. The fetuses are of different ages between11 weeks to 40 weeks of intrauterine life.In addition to CRL and CHL there are seven osteometric measurements attempted on diaphysis of human fetal tibia. Except the Maximum Length of Tibia the remaining six osteometric measurements are new ones introduced for the first time for the purpose of the present study. Total in order there are7296 measurements. Somatometric measurements have been taken directly on fresh fetuses. All the other earlier studies have been undertaken on chemically preserved fetuses / photographs /radiographs /uitrasonographs. In the present study a natural maceration process has been adopted for the first time to prepare the bones. No chemical has been used to prepare the bones. The prepared bones were dried in normal room temperature before taking measurements. It is observed that only 11.61% show significant bilateral differences in the osteometric measurements. It has been observed that only 16.07% show significant bisexual differences. Among all the measurements, the t-ml shows faster rate of growth both in males and females. The fastest rate of grow this observed in the female tibia from the group I (11 to 16 weeks). For every 1 mm in the CRL, the Maximum Length of Tibia (t-ml) is increased by .246 mm.The CRL and CHL are found closely correlated with all the osteometric measurements. Variables of regression equations are calculated for fetal age estimation. The applied significance in the clinical aspects in the present study will enable us to advance a standard which would help us to comprehend the differential growth pattern between normal and abnormal fetuses. One of the crucial applications of this fetal growth study is to stress upon the age estimation of human fetus from fetal tibia. The population orientation of this study on growth pattern in relation to age-sex variations would provide new vistas of researches in human fetal studies.

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