P: ISSN No. 2231-0045 RNI No. UPBIL/2012/55438 VOL.-III, ISSUE-IV, May-2015
E: ISSN No. 2349-9435 Periodic Research

Morphometric Analysis of Human Foetal Head and Its Correlation with Gestational Age

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Abstract

Gestational age of foetuses can be made by measuring physical parameters such as crown-heel length, weight of foetus and by noting morphological features, organ development and appearance of ossification centres. Its determination is important in civil and criminal cases but an alternative parameter is desirable in some instances. This study was planned to establish a correlation between foetal head parameters and gestational age. 30 Formalin fixed human foetuses were obtained from Museum of Department of Anatomy, Jawaharlal Nehru Medical College, Aligarh. Foetuses were divided into five groups. (Group I :< 17wks), (Group II: 17-20wks), (Group III: 21-25wks), (Group IV: 26-30wks), (Group V : >30wks). Foetal head parameters i.e. intercanthal length (ICL), nasal length (NSL), ear length (ERL), bi-parietal diameter (BPD), anteroposterior length (APL), oral fissure length (OFL), distance between ear lobule and angle of mandible (EAL) were measured using Vernier calipers. The results showed that said parameters were significantly ($p<0.05$) correlated with gestational age and therefore could be utilized to estimate gestational age. This may serve as an important information in the medicolegal cases in which only head region is available for estimation of gestational age.

Keywords: Foetuses, Foetal Head, Foetal Intercanthal Length, Bi-Parietal Diameter, Foetal Oral Fissure Length

Introduction

Accurate foetal ultrasound measurements are one of the most important factors for high quality obstetrics health care. Common foetal ultrasound measurements include: bi-parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). These measurments are conventionally used to estimate the gestational age (GA) of the foetuses (1) and are an important diagnostic tool. Although ultrasonographic measurements by specialists of BPD, HC, AC, and FL are also quite precise and hold importance as they are done on aborted foetuses, but the quality of the measurements are user-dependent and time consuming. If measurements are done directly on the foetus as this will hold more accuracy and reliability.

Our study we have considered seven parameters in the head of foetuses which are difficult to measure by ultrasound, i.e., intercanthal length (ICL), nasal length (NSL), ear length (ERL), BPD, anteroposterior length (APL), oral fissure length (OFL) and distance between ear lobule and angle of mandible (EAL). Our method can handle previously unsolved issues in the domain of foetal ultrasound imaging due to following reasons. First, our system is able to provide an accurate measurement and relative growth of different foetal head parameters which were difficult to be measured by other techniques. Second, the approach was designed to be absolutely manual, so that user does not need to provide any initial guess or approximation as by ultrasound method. Our data can provide a reference point for other methods of foetal head measurements.

Material and Methods

30 Formalin fixed human foetuses were obtained from Museum of Department of Anatomy, Jawaharlal Nehru Medical College, Aligarh. Institutional ethics committee has no objection on doing research work on these foetuses. Foetuses were divided into five groups (I to V) shown in Table 1.

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Table 1 Grouping of Human Foetuses

Groups	Gestational Age (Weeks of Intrauterine Life)	Number of Foetuses
I	< 17 weeks	06
II	17-20 weeks	06
III	21-25 weeks	06
IV	26-30 weeks	06
V	>30 weeks	06

Following measurements were made with the help of Vernier callipers to nearest of millimeter.

1. Antero-posterior diameter (from glabella to External occipital protubrance).
2. Bi-parietal diameter (between parietal eminences of two sides).
3. Inter-canthal distance (between medial and lateral canthus).
4. Transverse oral fissure (between angles of mouth).
5. Distance between angle of mandible and tip of ear lobule.
6. Nasal length (from glabella to nose tip).
7. Ear height (maximum height of the ear including lobule).

Statistical Analysis

Each reading is taken three times and the mean of the same was considered to avoid human error. All the values are expressed as Mean ± S.D. Statistical significance was calculated by one way ANOVA followed by post hoc Dunnett's multiple comparison tests. $P < 0.05$ was considered to be statistically significant. Graphs were plotted by considering mean values of measurements of different parameters and gestational age on y and x axes respectively, and patterns were analysed.

Observation

The growth of anteroposterior diameter in head of foetus is more or less steady throughout (Fig -1). In figure 2. In figure 2 the transverse diameter or bi-parietal diameter shows steady growth with some fall in last age group. Similarly in figure 3 the inter-canthal distance shows steady growth with gestational age. except between last groups Whereas the transverse oral fissure shows constant growth with decline between groups 3&4 as depicted by (figure 4). In figure 5 maximum growth in b/w angle of mandible and tip of ear lobule is seen between groups 2&3. Length of nose grows with a constant speed during whole gestation as shown by figure 6. figure 7 shows steady growth throughout gestation with an spurt between groups 4&5.

Table-2 Antero Posterior Diameter of the Head of Human Foetuses.

Group	Mean ± SD (mm)	Percent Increase	p value
I	17.16±1.94		
II	21.16±2.85	23.31	NS
III	31.8±3.6	50.28	S
IV	39.5±5.50	24.21	S
V	52.83±6.55	33.74	S

Table-3 Transverse Diameter of Head of Human Foetuses

Group	Mean ± SD (mm)	Percent increase	p value
I	26.33 ± 3.01	----------	
II	34.5 ± 3.02	31.02	S
III	48.00 ± 2.10	39.13	S
IV	66.33 ± 0.52	38.19	S
V	72.50 ± 2.74	9.30	S

Table-4 Width of The Orbit of Human Foetuses

Group	Mean ± SD (mm)	Percent Increase	p value
I	6.67 ± 1.37	---------	
II	9.50 ± 1.97	42.43	S
III	11.33 ± 1.21	19.26	S
IV	13.33 ± 0.52	17.65	S
V	14.00 ± 2.19	5.03	S

Table-5 Width of the Mouth of Human Foetuses

Group	Mean ± SD (mm)	Percent Increase	p value
I	10.33 ± 1.21	----------	
II	14.50 ± 0.55	40.37	S
III	19.17 ± 1.47	32.20	S
IV	19.83 ± 0.98	3.40	S
V	22.00 ± 0.00	10.94	S

Table-6 Distance Between Angle of Mandible and Ear Lobule of The Human Foetuses

Group	Mean ± SD (mm)	Percent Increase	p value
I	6.33 ± 1.03	----------	
II	8.67 ± 1.03	36.97	S
III	12.83 ± 1.17	47.99	S
IV	13.33 ± 0.82	3.90	S
V	13.50 ± 0.55	1.28	S

Table-7 Length of the Nose in Human Foetuses

Group	Mean ± SD (mm)	Percent Increase	p value
I	7.33 ± 1.03	----------	
II	9.33 ± 0.52	27.29	NS
III	10.67 ± 1.03	14.36	S
IV	12.00 ± 1.41	12.46	S
V	14.50 ± 2.74	20.83	S

Table-8 Length of The Ear in Human Foetuses

Group	Mean ± SD (mm)	Percent increase	p value
I	7.50 ± 1.87	-------	
II	12.00 ± 0.63	60.00	S
III	15.83 ± 1.60	31.92	S
IV	18.33 ± 0.82	15.79	S
V	28.00 ± 2.20	52.76	S

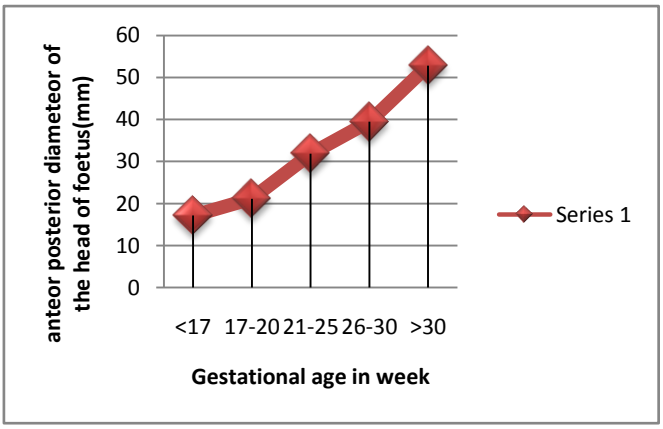

Fig.1- Graph showing growth in antero posterior diameter of the head of human foetuses during intrauterine life.

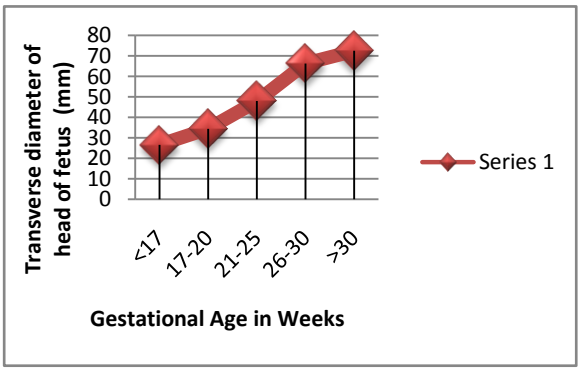

Fig.2- Graph showing growth in transverse diameter of the head of human foetuses during intrauterine life.

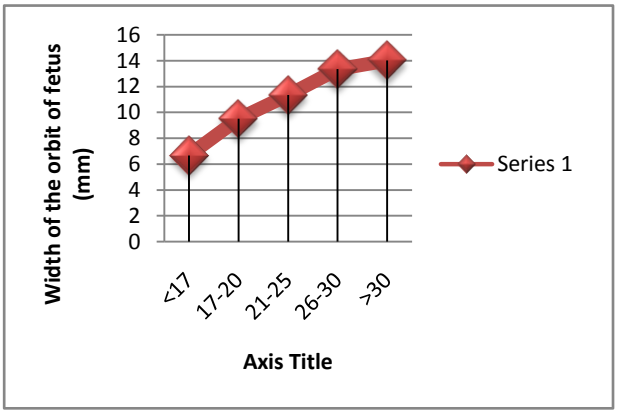

Fig.3- Graph showing growth in width of the orbit of human foetuses during intrauterine life.

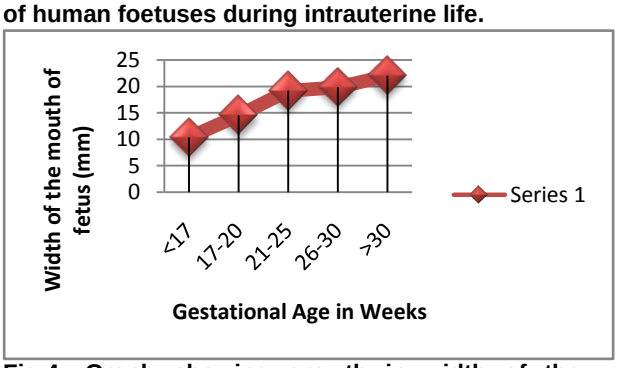

Fig.4- Graph showing growth in width of the mouth of human foetuses during intrauterine life.

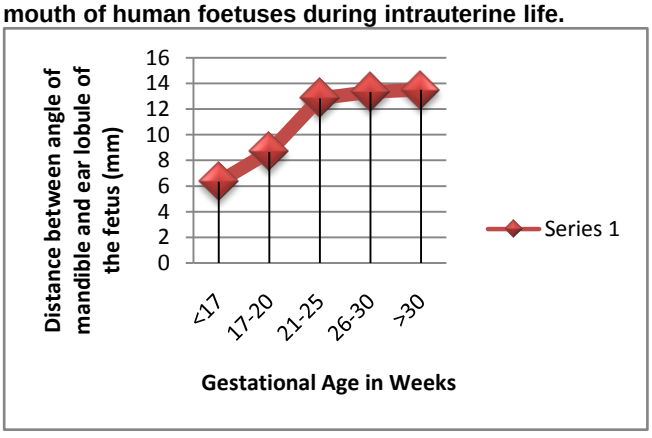

Fig.5- Graph showing effect of gestational age on distance between angle of mandible and ear lobule of the foetuses during intrauterine life.

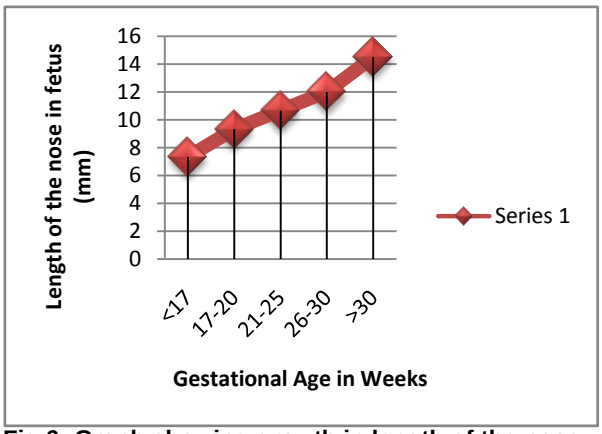

Fig.6- Graph showing growth in length of the nose in human foetuses during intrauterine life.

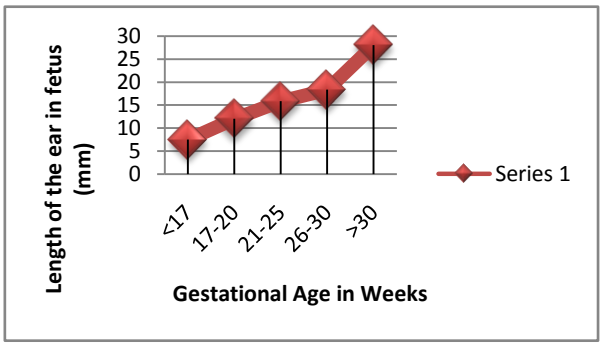

Fig.7- Graph showing effect of gestational age on length of the ear pinna in human foetuses during intrauterine life.

Discussion

For correct assessment of gestational age most of the obstetricians depend on ultrasound. Almost all measurements change with gestational age (2). If measurements are done directly on the foetus as this will hold more accuracy and reliability. Although several parameters are described to evaluate gestational age i.e., MSD, CRL, BPD, HC, AC and FL in normal situations but in cases of macrocephaly/ hydrocephalus/ anencephaly, we obviously cannot use BPD and HC to assess GA. Similarly in short limb dwarfism, FL gives erroneous reading and so does AC in IUGR. Difficulty can arise even in normal term pregnancy when head is engaged and HC/ BPD cannot be correctly measured. Hence we have to look for other alternatives. In this study we present direct foetal measurements that target the accurate and robust detection of several important parameters of foetal head. We have considered seven parameters in the head of foetuses which are difficult to be measured by ultrasound and these readings were correlated with gestational age.

In our observation, BPD and anteroposterior length (APL), showed steady growth throughout the gestation Fig.1, thus significant in determination of feotal age. Berger et al (3) compared biparietal diameter with crown-rump length and these correlated with gestational age. Brenner et al (4) developed a standard of foetal growth using foetal weight and length. Golbus and Berry (5) examined 133 foetuses, and gave great attention to organ weights, without correlating it to gestational age. Several studies have

demonstrated that the BPD is correlated well with gestational age, and there is a highly significant relationship between CRL and BPD (6). Similarly in (Fig.3) the inter-canthal distance shows steady growth with gestational age. Tulika et al,(7) also considerd oropalpebral length, depth and width of orbit and inter orbital distance. Statistical analysis revealed significant positive correlation of all these parameters with gestational age and biparietal diameter. The growth patterns of the orbitofacial and orbital measurements also demonstrated significant correlation between these parameters. Whereas the transverse oral fissure and growth in b/w angle of mandible and tip of ear lobule shows more or less constant growth with gestational age (Fig.4&5). No previous studies are found in these cases. In our study we have demonstrated the feasibility of measuring foetal ear length between 11–14 weeks of gestation. The ears were successfully visualized and measured in all foetuses and in 95% of cases the difference between two consecutive measurements was < 0.45 mm. the aforementioned reading increased linearly with gestational age. This is compatible with the results of previous studies which reported measurements for the second and third trimesters of pregnancy, thus our values are complementary to those of the previous studies (8,9,10,11,).in trisomy 21 foetuses at 11–14 weeks of gestation the ear length was significantly reduced both in postnatal studies and in prenatal sonographic data from the second and third trimesters of pregnancy(12,13,10,8,11,9). The development of the foetal ear is complicated and developmental disorders of the ears are not uncommon (14). In the developmental course changes of ear size, shape, and position may result in deformity (15, 16). The Ear length in normal foetuses has also been measured in many studies (17,10,18,19). These studies are mostly based on Western populations. Our study was based on the Indian population, and our findings suggest that there is a linear relationship between foetal ear length and gestational age. This result is consistent with other studies. The foetal ear length at 24 weeks gestation was 19.80 mm in our study and 20 mm in the study reported by Yeo et al (20). The relationship between ear length and biometric parameters (biparietal diameter, head circumference, and femur length) was also comparable with previous studies (21,22,18). We observed that the ratio between biparietal diameter and foetal ear length were fairly constant between 16 and 23 weeks of gestation. This means that there is a uniform growth pattern. Length of nose grows with a constant speed during whole gestation (Fig.6).on the other hand Guis et al (23) demonstrate an increase in the length of the nasal bones throughout gestation.

Conclusion

Establishing precise duration of pregnancy is of paramount importance for a forensic pathologist. The results showed that said parameters were significantly ($p<0.05$) correlated with gestational age and therefore could be utilized to estimate gestational age. This will be of great help in the medico legal cases in which only head or part of it is available for estimation of gestational age.

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