CORRELATION BETWEEN FETAL ORBITAL BIOMETRY AND GESTATIONAL AGE

Chongtham Rajlakshmi
Department of Anatomy, Regional Institute of Medical Sciences (RIMS), Imphal (Manipur)

ABSTRACT

Sonologists uses various parameters for determining gestational age. Although not very popular, orbital dimensions are one such parameter which helps in determining age of fetus. Therefore, the aim of the paper was to construct a nomogram of the size of the fetal orbit as well as the interorbital and binocular distance followed by evaluation of correlation between gestational age and biometrics of fetal orbit. Studied in 128 orbits from 64 fetuses belonging to Manipuri population, different dimensions of orbit were measured using vernier calipers. Measured dimensions include orbital height, orbital width, interorbital distance and binocular distance and subsequent determination of orbital index. The data was elaborated statistically by t-test. Correlation and regression analysis was performed. It was observed that with age, all the dimensions increases, however, difference in growth rate between dimensions were noted. Furthermore, it was observed that there was difference in the orbital values of previous studies as compared to the present study, which could be due to ethnicity of the study group. This easily assessable anatomical part can be used by Sonologists in lieu of biparietal diameter and also, in medicolegal cases of determination of unknown gestational age of fetus.

KEY WORDS: Fetus, orbit, interorbital distance, binocular distance, ethnicity

INTRODUCTION:

Human orbit is present on either side of sagittal plane of the skull between the cranial and facial parts. Basically, orbit develops around the eyeball and helps to protect it from injury. Orbital margin is derived from membranous viscerocranium which gives rise to maxilla and zygomatic bones as well as from membranous neurocranium which gives rise to frontal bone. During fetal life, size of the orbit is big owing to the advanced stage and large size of eyeball.

Orbital dimensions were introduced as new parameters for prenatal diagnosis and dating nearly three decades ago. Ocular biometrics can diagnose congenital anomalies like holoprocencephaly and fetal hydantoin syndrome in which hypertelorism and hypotelorism is an important feature[1]. However, fetal age determination using orbital biometrics is not very popular unlike the biparietal diameter. These dimensions are useful in determining fetal age when the fetal head is abnormal or, in certain position of fetal head like occipitoposterior, in which the face of the fetus faces forward and biparietal diameter could not be measured[2].

Correspondence
Dr. Chongtham Rajlakshmi,
Assistant Professor, Department of Anatomy,
Regional Institute of Medical Sciences (RIMS),
Imphal (Manipur)
E -mail: chongthamrajlakshmi@yahoo.co.in
Mobile number: 09612158875

Racial variations influence cranium[3], hence the orbit too, can vary among various ethnic phenotypes. Ethnicity is a variable that affects craniofacial dimensions, yet to be studied covering all ethnic groups in India. Manipuris, the studied population, are the indigenous people of Manipur which includes two ethnic groups- the Meiteis (inhabiting the plain) and the Tribals (inhabiting the hills). Both groups belong to mongoloid race which is very different from mainland Indian population. Hence, the present study is an attempt to bring forth the reference range for this population and also to compare variation in orbital dimensions between different ethnic groups.

MATERIALS AND METHODS:

The study was carried out in the Department of Anatomy, Regional Institute of Medical sciences (RIMS), Imphal. Younger fetuses used in the study were from the Department of O&G, R.I.M.S following MTP and older fetuses were still born collected from Labour room. Since both right and left orbits were found to be equal therefore only right orbit of 64 fetuses were measured. Fetal age was calculated on the basis of Crown-Rump length[4]. Menstrual history was also considered in determining the age of the fetus. Sex has insignificant influence on fetal craniofacial dimensions[5] and hence not taken into account. Fetuses were fixed in 10% formal saline solution and dissected to expose the craniofacial region. Martins' sliding calipers were used to take the measurements. Following measurements were recorded[6]:

1. Height of orbit was measured as the vertical dimension from middle of superior margin to the middle of inferior margin of orbit.
2. Width of the orbit was measured as the distance between frontomaxillary suture and frontozygomatic suture of the same side.
3. Inter orbital distance was measured between right and left frontomaxillary sutures (Fig1).
4. Binocular distance was measured from frontozygomatic(FZ) suture of one side to the opposite FZ suture (Fig2).
5. Orbital index was calculated as percentage of orbital height to orbital width and interpreted as mesoconch, hypsiconch or chamaeconch[7]

The data was subjected to statistical analysis. Correlation and Regression analysis was done.

OBSERVATION:

Orbital height and width: Both the dimensions significantly increase with advancing fetal age as evident by r= 0.87 and r= 0.86 respectively; p< 0.05

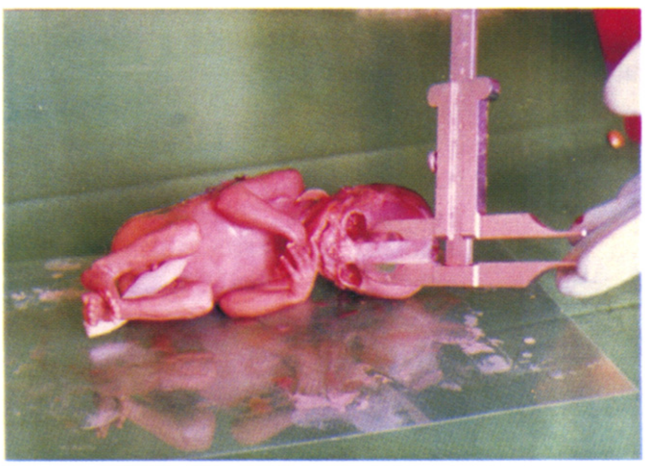

Fig1. Interorbital distance

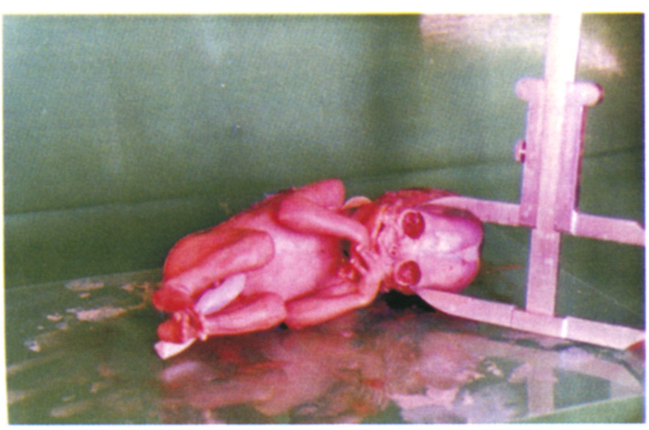

Fig 2. Binocular distance

Gestational age in weeks (n)	Orbital width mean± SD	Orbital height mean± SD
12-16 (7)	8.1± 1.6	7.2± 1.9
16-20 (23)	10.6± 2.0	8.9 ± 1.7
20-24 (8)	12.1± 2.1	11.2 ± 1.3
24-28 (6)	16.3± 2.3	14.8 ± 1.7
28-32 (7)	18.8± 1.8	16.0± 2.8
32-36 (5)	22.4± 2.6	17.6± 2.3
36-40 (8)	23.7± 2.9	18.3 ± 1.6
r	0.86	0.87
p-value	< 0.05	< 0.05

TABLE-I Orbital width & height (in mm) and gestational age

Gestational age In weeks (n)	Mean Binocular distance mean± SD	interorbital distance mean± SD
12-16 (7)	22.4± 4.3	6.4± 0.9
16-20 (23)	29.6± 4.3	8.2± 1.3
20-24 (8)	33.3± 6.0	9.1± 1.4
24-28 (6)	43.0± 4.1	10.6± 1.5
28-32 (7)	48.8 ± 2.7	12.7± 1.4
32-36 (5)	55.2± 3.7	13.3± 2.2
36-40 (8)	61.2± 3.3	15.0± 1.1
r	0.86	0.93
p-value	<.05	<0.01

TABLE-II - Binocular distance and interorbital distance (in mm) to gestational age

Gestational age (weeks)	Height of orbit	Width of orbit	Interorbital distance	Binocular distance
12-16	0.1	0.4	0.3	1.3
16-20	1.4	1.7	1.6	2.9
20-24	1.1	1.1	0.7	1.9
24-28	1.5	1.6	0.8	3.2
28-32	0.2	0.6	0.4	1.4
32-36	1.3	2.1	0.8	3.0
36-40	2.4	4.7	0.3	4.5

TABLE-III - Mean growth rate per week (mm)

Gestational age in weeks (n)	Orbital index (%) ± SD
12-16 (7)	87.8 ±11.2
16-20 (23)	84.1 ±13.2
20-24 (8)	94.2 ±13.2
24-28 (6)	91.0 ±9.3
28-32 (7)	84.5 ±10.3
32-36 (5)	79.2 ±13.5
36-40 (8)	77.7 ±5.2
r	0.55
p-value	> 0.05

TABLE- IV- Orbital index and gestational age

Orbital distance	Mayden et al (1982)	Tuli et al (1995)	Jeanty et al (1982)	Present study
Binocular	0.93	0.98	0.95	0.86
Interorbital	0.76	0.97	0.80	0.93

TABLE-V - Comparative 'r' value of inner and outer orbital distance observed by investigators

(Table I) which shows a strong correlation with gestational age. A faster growth rate of the orbital width was observed as compared to growth rate of the height of the orbit from 32 weeks onward (Table III). Regression equation for orbital height (XH) and width (X_W) is given below, where Y is the gestational age

$Y=2.68+1.74X_H$

$Y=5.94+1.25X_W$

Interorbital and binocular distance: The interorbital and binocular distance in fetus significantly increase with increasing gestational age which was statistically significant, r=0.93; $p<0.01$ and r=0.86; $p<0.05$ respectively (Table II). The growth rate of binocular distance was faster as compared to the interorbital distance in all the age group (Table III). From regression analysis, a significant relationship has been observed between fetal interorbital (XI) and binocular (XB) distance and gestational age (Y),

$Y=2.52+2.66X_I$

$Y=4.02+0.52X_B$

Orbital index: Increased orbital index was observed upto 24 weeks and thereafter gradual decrease in orbital index was noted. No correlation was observed between orbital index and gestational age $p<0.05$ (Table IV).

DISCUSSION:

Position of orbits during fetal development changes. At the beginning of fetal life the face shows a relatively hypertelorism that is related to the lateral position of ocular cups during embryonic period. This relative hypertelorism progressively diminishes during fetal life, leading to decrease in the intercanthal and outercanthal distance ratio. This process continues after birth until adult age8. During fetal life, differential patterns of growth in face and skull exist wherein outer canthal distance to head circumference (HC) ratio decreases but the oropalpebral distance to HC remains constant. Therefore, the growth of the skull predominates over that of the face, and the face grows more rapidly along its vertical axis than along its horizontal axis[5].

Interorbital and binocular distance to determine fetal age was first reported nearly three decades ago [1, 16]. Later, many similar studies by ultrasound were carried out[10,11,12] as well as on the skeletons of fetuses[13,14] wherein orbital dimensions had correlation with fetal age. However, its applicability is not widely popular like the biparietal diameter. Orbital development affects fetal ocular development[15] hence, knowledge of orbital measurements would be useful in diagnosis of clinical cases. Anomalies involving orbital region includes - hypertelorism, hypotelorism, hemifacial microsmia, craniosynostosis, Treacher Collins syndrome. Many of these anomalies require complex orbital surgeries for orbital dystopia.

The present study observed increase in height and width of orbit as the gestational age advances with a significant correlation r=0.87 and r=0.86 respectively (TableI) also observed by Tuli et al[14] in North Indian fetuses. A significant correlation with inner and outer orbital distance and fetal age was observed by present study and by various authors too (Table V). A small, but statistically significant difference was observed for the fetal binocular distance between fetuses of Moroccan origin verses those of Belgian or Turkish[16]. However, the orbital index showed no correlation with fetal age in the present study (r=0.55, Table IV). This observation is in contrast to the study among North Indian fetuses[11] wherein they observed a significant correlation coefficient of 0.71. No other data on fetal orbital index could be found. The main findings concerning the changes of the orbital index with fetal age were: a variation of orbital width starting from 24th week from LMP compared to the height (differential growth of height and length of orbit), a relatively rapid growth of transverse dimensions near term. Therefore, Manipuri fetuses have hypsiconch or long orbit upto 20 weeks and thereafter becomes mesoconch or medium orbit. Such a change in the orbital index is expected in these fetuses in which cephalic index also changes from mesocephalic upto 16 weeks to brachycephalic at term[17]. Present study brings forth a strong ethnic variation in orbital study wherein a growth spurt in the orbital width was observed after 32 weeks with the resultant variation in orbital index but in North Indian fetuses, a gradual increase in width of orbit was reported and so also the orbital index[14]. Orbitofacial parameter depends on development of cheek bone[5].

And, mongoloid race is known to have high cheek bones. Faster growth of orbital width as compared to the height in the present study is assumed to be due to faster growth of zygomatic bone a, hence a higher cheek bone in this racial group. The assumption is supported by the faster growth rate of bizygomatic width as compared to the superior facial height in the same study population18. Therefore, mesoconch type of orbit observed in the term fetuses of the present study is due to a faster growth of orbital width as compared to the height of the orbit. A need for normative data especially for different region because of racial variation is well documented5. A baseline metric measurement of different ethnic groups will not only help in accurate estimation of fetal age of the particular racial phenotype but also to rule out anomalies of orbit An important aspect of forensic anthropology is determination of the racial phenotype of an unknown skeleton. Medico legal experts carry out investigations related to facial traits and classify a victim as Caucasoid, Mongoloid or Negroid from skeletal remains. From the present study, by using the regression equation, age of fetus can be determined in doubtful cases of fetal age as orbital height, orbital width, interorbital and biorbital distance correlated well with gestational age of the fetus. Last but not the least, sonologists can use these dimensions in lieu of biparital diameter when biparital diameter is difficult to interpret the age when the fetal head is in occipitoposterior position or head is abnormal.

REFERENCES

1. Mayden KL, Tortora M, Berkowitz RL, Bracker M, Hobbins JC. Orbital diameter: a new parameter in prenatal diagnosis and dating. Am J Obstet Gynaecol. 1982, 144: 289-297.
2. Campbell S. The prediction of fetal maturity by ultrasonic measurement of the biparietal diameter.J Obstet Gynae Brit C'wlth. 1996, 76: 603-609.
3. Williams P, Dyson M, Dussak JE, Bannister LH, Berry MM, Collins P, Ferguson MWJ. Skeletal System, In: Gray's Anatomy 38th ed, Churchill Livingstone, Edinburgh, London, 1995, pp 607-612.
4. Rajlakshmi Ch, Singh MS, Singh LC. CRL-predictor of foetal age. JMS 2003, 17(2), 60-61.
5. Denis D, Burguire O, Burillon C. A biometric study of eye, orbit and face in 205 normal human fetus. Investigative Ophthalmology and Visual Science. 1998, 39(12): 2232-2238.
6. Guihard- Costa AM. Estimation of fetal age from craniofacial dimensions. Bull Assoc Anat. 1988, 72: 15-19.
7. Singh IP, Bhasin NK. Craniometry. In: Anthropometry. Kem Publishers, New Delhi, 1968, 1st Edn, p165-211
8. Laestradius ND, Aase JM, Smith DW. Normal inner canthal and outer orbital dimensions. J Pediatr. 1969, 74: 465-468.
9. Jeanty P, Dramaix- Wilmet M, Van Gansbeke D, Van Regemorter N, Rodesch F. Fetal ocular biometry by ultrasound. Radiology. 1982, 143: 513-516.
10. Jeanty P, Cantraine F, Cousaert E, Romero R and Hobbins JC. The binocular distance: A new way to estimate fetal age, J Ultrasound Med , 1984, 3 (6): 241-243.
11. Escobar LF, Bixler D, Padilla LM, Weaver DD. Fetal craniofacial morphometrics: in utero evaluation at 16 weeks gestation. Obstet Gynecol, 1988, 72: 674-679.
12. Sukonpan K, Phupong V. Fetal ocular distance in normal pregnancy. J Med Assoc Thai.2008, 91(9): 1318-22.
13. Cussenot O, Zouaoui A, Hidden G. Growth of facial bones of fetus. Reports of the societe Anatomique de Paris. Surg Radiol Anat. 1990, 12: 230-231.
14. Tuli A, Choudhry S, Agrawal S, Anand C, Garg K. Correlation between craniofacial dimensions and fetal age. J Anat Soc India. 1995, 44(1), 1-12.
15. Tomasik E, Czepita D, Zejmo M, Czerwinski F. Development of human eyeball and orbit during fetal life. Ann Acad Med Stetin. 2005, 51 (1): 37-40.
16. Jacquemyn Y, Sys SU, Verdonk P. Fetal binocular distance, no differences between ethnic groups. Gynecol Obstet Invest. 2000, 50: 24-27.
17. Rajlakshmi Ch, Shyamo Singh M, Bidhumukhi Devi Th, Chandramani Singh L. Cephalic index of fetuses of Manipuri population- a baseline study. J Anat Soc India.2001, 50(1): 8-10
18. Rajlakshmi Ch, Bidhumukhi Th. Foetal age from superior facial height and bizygomatic width. J Forensic Med Toxicol. 2001, 18(1), 28-30.