DOI: 10.7860/IJNMR/2020/44485.2270

Original Article

Anatomy Section

Sonographic Assessment of Fetal Cephalic Index among the Population of Western UP: A Prospective Observational Study

NANDKISHOR GUPTA[1], NEESHU BALA[2], NITYA NAND SRIVASTAVA[3], KAILASH MITTAL[4]

ABSTRACT

Introduction: Cephalic Index (CI) also called as cranial index is the ratio of the maximum breadth to maximum length of head.

Aim: To assess the shape of skull according to the CI and to identify factors affecting the CI estimation like gestational age, weight of fetus, maximum breadth of fetal heads and maximum length of fetal heads in the Etawah Region (UP) in India.

Materials and Methods: The present prospective observational study was performed on the pregnant ladies. These ladies were enrolled for the study when they visited the Radio-diagnosis Department of Uttar Pradesh Medical University Hospital, Saifai, Etawah for Ultrasound (USG). A total number of 550 ultrasound images were collected for study. The measurement of Maximum Breadth of Fetal Heads (BPD i.e., Biparietal Diameter) and Maximum Length of Fetal Heads (APD i.e., Antero-Posterior Diameter) were taken on USG machine, recorded for analysis. When associating the measures of precision for different subgroups, one-way ANOVA analysis of variance was used for the modest and efficient errors. Multivariate logistic regression analysis was used to identify factors affecting the CI estimation like gestational age, weight of fetus, maximum breadth of fetal heads and maximum length of fetal heads.

Results: Out of 550 studied fetus, majority 222 (40.4%) of the fetus were belonging to the gestational age group 30-35 weeks. Weight of fetus, maximum breadth of fetal heads, and maximum length of fetal heads in different gestational age were statistically significant; but CI was statistically insignificant. Pearson correlation between the gestational age, weight of fetus, maximum breadth of fetal heads, maximum length of fetal heads and CI was determined and correlation was statistically significant with each other's; but statistically insignificant correlation was observed between maximum length of fetal heads and CI.

Conclusion: Mesocephaly is the dominant head shape among the western part of UP (India) particularly in Etawah and Mainpuri region which was of CI range from 75 to 79.9.

Keywords: Antero-posterior diameter, Gestational age, Maximum breadth of fetal heads, Maximum length of fetal heads, Weight of fetus

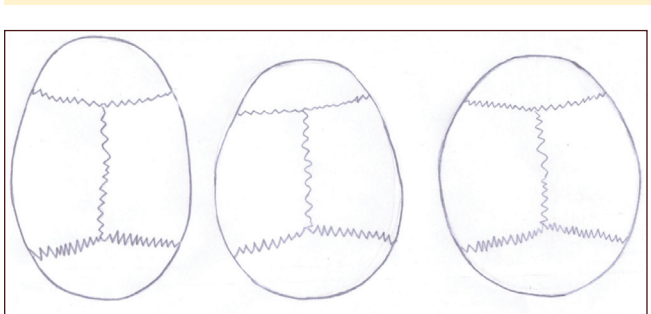
INTRODUCTION

A CI is defined as the ratio of BPD to the APD of the skull. CI is very helpful to access the normal shape and size of skull and it can also detect irregularity in the skull during development [1]. The skull breadth is the maximum distance between the two parietal eminences (BPD) whereas the skull length is the distance between glabella anteriorly and external occipital protuberance posteriorly (APD). It is used to adjust the head size and shape of the developing fetus [2]. It is also significantly responsible for the race of the individuals.

The term CI is influenced from a Greek word "Kephalic" which means "Head" and "Index" is the Latin word meaning "which points out". In the 20th century, the anthropologists extensively used CI to categorise human population [3]. A crucial role is played by cephalic indices in comparison of cephalic morphometry between the parents, offspring's and siblings and provides evidence on birthright pattern [3].

"According to Modi's Medical jurisprudence and Toxicology, the skulls having CI between 70 and 74.9 are called Dolicho-Cephalic or long headed [Table/Fig-1] [4]. This type is common among Aborigines and pure Aryans. Skulls having CI from 75 to 79.9 are grouped under Mesati-Cephalic and are common features of Europeans and Chinese. The more CI from 80 to 84.9 are called as Brachy-Cephalic or short headed. The Mongolian race is the example of brachycephalic head [5].

Ultrasonography is an extremely useful and precise method for determining the fetuses gestational ages [6]. The most commonly used parameter for fetal age assessment and its measurement is BPD. BPD is a consistent indicator of the



[Table/Fig-1]: Different shapes of the skull [4].

gestational age up to 26 weeks; if the head is a normal ovoid transaxial shape [7]. If the developing head is too round i.e., brachiocephaly or too stretched i.e., dolichocephaly, the measurement of BPD would increase or decrease falsely, and will provide wrong fetal dating. The head measurements are preferred in second trimester of gestational age; especially through BPD which is the commonly used fetal biometry measurement while the disparities in the fetal skull shape have a significant effect on BPD measurements [6].

An ultrasound scan is primarily advantageous and quite handy for Gynaecologists around most part of the globe where pregnant women are unable to provide accurate date of their last menstrual period often [8]. Several fetal ages estimation graphs are available for the ultrasound parameters [9]. Some of them have been assembled based on similar fetal population and are preferentially being used where available [10]. The use of modified fetal growth charts, taking into consideration factors normally manipulating the fetal growth, diminishes the number of the false positive [11]. It has been assumed that each population must use their specific normograms because of the ethnic and racial differences [5]. This present study to the best of our knowledge is the first to capture data on fetal CI among the Etawah Region (UP) in India to assess the CI among the fetuses of different gestational age.

Aims

To find out the shape of skull of normal developing fetus and to categorise them accordingly:

To compare the shape of skull according to the CI with other categorisation (of different researchers).

To find out the relationship between development of skull and weight of normal healthy growing fetuses in different gestational age.

MATERIALS AND METHODS

The present prospective observational study was performed in pregnant women coming to obstetric clinic in the second and third trimesters between July 2019 to December 2019 in the department of Radio-diagnosis, Uttar Pradesh University of Medical Science, Saifai, Etawah, UP India. The Consent from the patient and University's Ethical Committee was taken to carry out the procedure (666/upums/dean/2019-20/E.C.NO.2019/21 DATE 08.07.2019). A total of 550 USG images were identified for the study.

Formula for Computing Sample Size

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Z is the statistic corresponding to level of confidence,

P is expected prevalence

d is precision (corresponding to effect size).

Sample size calculation [12]

Assumptions:

Precision = 5.0% (0.05)

Prevalence = 10.0% (0.10)

Population size = Infinite (0)

Z=1.96

Estimated sample size:

n = 138

95% Binomial Exact Confidence Interval

The final sample size for this study was found to be 553 with prevalence of 10%. This is the reason our precision (d) decreases to ±2.5%, this implies that the end result may vary by ±2.5% precision, hence,sample size of 550 was taken.

Inclusion and Exclusion Criteria

The pregnant women having gestational age of 12 weeks or more with good indication of fetal viability and singleton gestation were included in the study. The pregnant women with twins and any kind of anomaly diagnosed during ultrasound scanning related to development of skull or brain and the fetuses with less amniotic fluid diagnosed during ultrasound scanning and the maternal medical history of diabetes mellitus, hypertension etc., or having gestational age of less than 12 weeks were excluded from the study. The subjects were examined using an ultrasound machine equipped with 3.4 MHz 128 elements, 39.7 mmR (SONOACE R7, Korea). Predesigned proforma for data collection (Semi structured Clinical Data Sheet) was used.

For the analysis purpose the measurement of APD and BPD taken on USG machine was recorded. The measurement of BPD

and APD of skull is taken from their outer table. The fetal BPD was calculated in an axial plane of the head, at the level of the thalami [13]. The BPD measurement was taken from the outer edge of the closest parietal bone to the outer edge of the other side parietal bone [13]. The superimposing soft tissue margin was omitted [13]. The measurement of APD was done between the foremost edge of the frontal bone and the outer boundary of the occiput in the midline of the same plane so as to sidestep hazy lateral margins of the calvarium [14]. The calipers for both measurements were perpendicular to each other.

Sonographic picture were presenting the weight of fetus, maximum breadth of fetal heads, maximum length of fetal heads, and CI in various gestational ages shown in [Table/Fig-2]. The formula used to calculate the CI is:

CI = (max. Breadth of skull/max length of skull) × 100

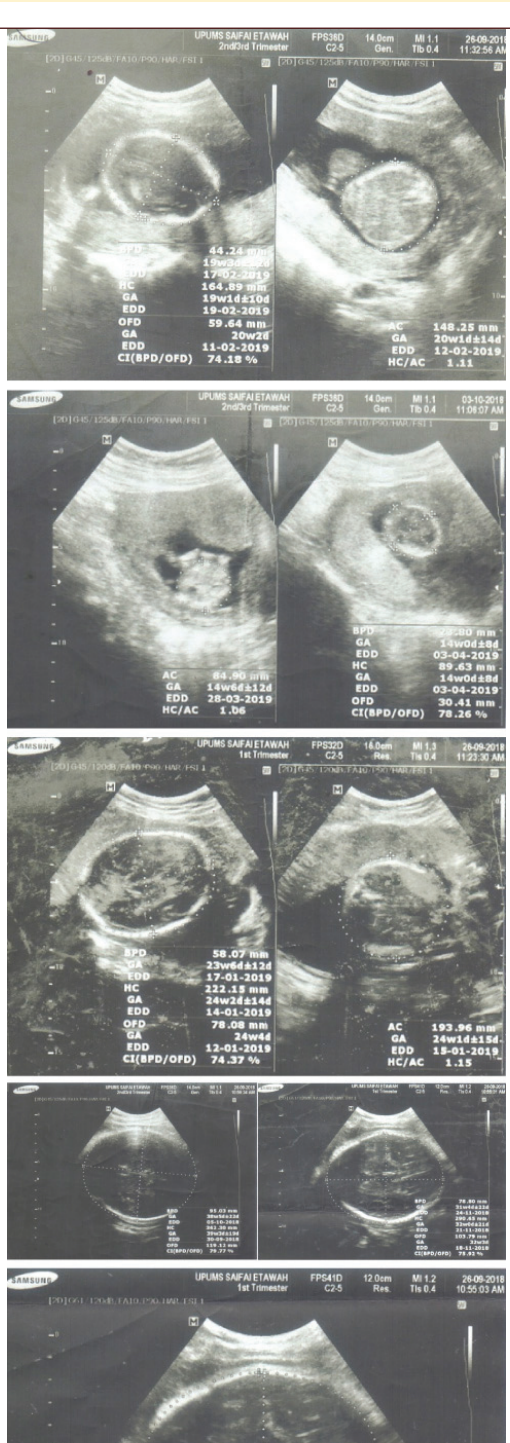
For record, observation and analysis purpose, all the fetuses were classified in five groups at 5 weeks interval from 12th week onwards [Table/Fig-3].

STATISTICAL ANALYSIS

Statistical analysis was done by using the Statistical Package for Social Sciences (SPSS 23) program. Data was expressed in the form of frequency in percentage and value in mean and Standard Deviation. When associating the measures of precision for different subgroups, one-way ANOVA analysis of variance was used for the modest and efficient errors. Multivariate logistic regression analysis was used to identify factors affecting the CI estimation like gestational age, weight of fetus, maximum breadth of fetal heads and maximum length of fetal heads. A p-value of <0.05 was used as the criterion of statistical significance.

RESULTS

Out of the total 550 studied fetus, the majority 222 (40.4%) of the fetus were of gestational age group 30-35 weeks and the mean gestational age of the total studied patients was 29.17±6.65 weeks (range 12-40 weeks) [Table/Fig-4]. The mean weight of fetus was 1.74±1.02 kg , mean Maximum Breadth of Fetal Heads (BPD) was 72.64±18.23 mm, mean Maximum Length of Fetal Heads (APD) was 91.75±23.24 mm and mean Cephalic Index (CI) was 79.08±4.34 (CI range 44.99-97.69) [Table/Fig-5]. The distribution of weight of fetus, Maximum Breadth of Fetal Heads (BPD), and Maximum Length of Fetal Heads (APD) in different gestational age was statistically significant; while CI was statistically insignificant [Table/Fig-6]. The gestational age, Weight of Fetus, Maximum Breadth of Fetal Heads (BPD), Maximum Length of Fetal Heads (APD) and CI and correlation was statistically significant with each other; but statistically insignificant correlation was observed only between maximum length of fetal heads and CI [Table/Fig-7]. Dolichocephalic type of skull was found more in <30 weeks



[Table/Fig-2]: Sonographic picture presenting the weight of fetus, Biparietal Diameter (BPD), Anterio-Posterior Diameter (APD), and Cephalic Index (CI) in various gestational ages.
CI= (Maximum. breadth of skull/Maximum length of skull) *100 [4].

S. no.	Group no.	Gestational age of fetuses
1	I	12-17 weeks
2	II	18-23 weeks
3	III	24-29 weeks
4	IV	30-35 weeks
5	V	36 weeks to full term

[Table/Fig-3]: Gestational age features.

Gestational age (weeks)	Frequency	Percent
12-17 weeks	40	7.3%
18-23 weeks	82	14.9%
24-29 weeks	110	20.0%
30-35 weeks	222	40.4%
36-40 weeks	96	17.5%
Total	550	100.0%

[Table/Fig-4]: Distribution of fetus on the basis of gestational age.

Parameters	Mean±SD	Median	Range
Gestational age (weeks)	29.17±6.65	31.00	12-40
Weight of fetus (kg)	1.74±1.02	1.76	0.09-4.07
Maximum Breadth of Fetal Heads (BPD) (mm)	72.64±18.23	78.62	19.42-99.34
Maximum Length of Fetal Heads (APD) (mm)	91.75±23.24	99.30	11.67-190.21
Cephalic Index (CI)	79.08±4.34	79.11	44.99-97.69

[Table/Fig-5]: Mean value of the studied fetus.

gestational age, Brachycephalic type of skull was more in 30-35 weeks gestational age [Table/Fig-8].

DISCUSSION

The CI indirectly points out cranial capacity, used indirectly to reveal the volume of the brain and also predict mental ability [15]. Many studies have been reported on cephalic indices of different populations, both national and international [5,16-19]. The result of this study showed a mean CI of 79.08±4.34 and range from 44.99 to 97.69, which indicates that the studied population is mesocephalic in nature according to the international CI categorisation [20]. Similarly, Mohammed YM et al., reported the fetal mean CI as 79.06±3.52 and the mean±2SD ranged from 72.02 to 86.10 [7].

The finding was similar to the studies by Bhargav T and Kher GA study in Madhya Pradesh, India [15], Oladipo GS and Olotu EJ study in Nigeria [16], and Fawehinmi HB et al., in Nigeria [17]. Dominant type of head from the present study was not similar to a study in India by Kasai K et al., as 58.5% of the population was dolichocephalic [18].

In the present study the Pearson's correlation between the gestational age, weight of fetus, Maximum Breadth of Fetal Heads (BPD), Maximum Length of Fetal Heads (APD) and CI was statistically significant with each other; but statistically insignificant correlation was observed between maximum length of fetal heads (APD) and CI. Hadlock FP et al., and Jeauty P et al., stated in their respective studies that not so strong correlations were seen between CI and BPD, between CI and APD, between CI and FL, and between CI and gestational age [19,21]. The measurements of fetal CI demonstrated no statistically significant changes with increase in gestational age. Another study reported that fetal CI may vary with increasing gestational age [22].

Highly positive correlations were seen between maximum breadth of fetal heads and occipito-frontal diameter, maximum breadth of fetal heads and FL and maximum breadth of fetal heads and gestational age. This specifies that as the gestational age increases subsequent maximum breadth of fetal heads, occipito-frontal diameter and FL also systematically increases. This designates that using such parameters together would ease in the analysis of achondroplasia in the fetus, predominantly when the maximum breadth of fetal heads and occipito-frontal diameter measurements are found to be in coordination with gestational age, and FL is not symmetrically associated with gestational age, therefore achondroplasia is suspected [7].

Gestational age (weeks)	n=550	Weight of fetus (kg)	Maximum Breadth of Fetal Heads (BPD) (mm)	Maximum Length of Fetal Heads (APD) (mm)	Cephalic Index (CI)
12-17 weeks	40 (7.3%)	0.28±0.288	30.78±5.20	39.23±6.77	78.65±5.04
18-23 weeks	82 (14.9%)	0.50±0.421	50.26±8.01	64.20±10.11	78.42±4.35
24-29 weeks	110 (20%)	1.07±0.25	68.29±5.06	86.83±7.00	78.80±4.18
30-35 weeks	222 (40.4%)	2.17±0.41	82.56±4.44	104.61±7.90	79.14±4.56
36-40 weeks	96 (17.5%)	3.18±0.34	91.22±3.02	113.07±11.16	79.99±3.55
One-way ANOVA test	**F value**	941.116	1606.261	848.753	1.771
	p-value	**<0.001**	**<0.001**	**<0.001**	**0.133**

[Table/Fig-6]: Distribution of Weight of Fetus, Maximum Breadth of Fetal Heads (BPD), Maximum Length of Fetal Heads (APD) and Cephalic Index (CI) in different gestational age.

Parameters		GA	WEIGHT	BPD	APD	CI
Gestational Age	Pearson correlation	1	0.935**	0.980**	0.945**	0.095*
	p-value	--	**<0.001**	**<0.001**	**<0.001**	**0.026**
WEIGHT	Pearson correlation	0.935**	1	0.892**	0.852**	0.01**
	p-value	**0.001**	--	**<0.001**	**<0.001**	**0.009**
BPD	Pearson correlation	0.980**	0.892**	1	0.949**	0.0168**
	p-value	**0.001**	**0.001**	--	**0.001**	**0.001**
APD	Pearson correlation	0.945**	0.852**	0.949**	1	-0.068
	p-value	**0.001**	**0.001**	**0.001**	--	0.113
CI	Pearson correlation	0.095*	0.111**	0.168**	-0.068	1
	p-value	**0.026**	**0.009**	**0.001**	0.113	--

[Table/Fig-7]: Pearson correlation.
****: Correlation is significant at the 0.01 level (2-tailed); *: Correlation is significant at the 0.05 level (2-tailed)**

Gestational age group (weeks)	Type of skull				Total (n=550)
	Dolichocephalic (CI= 70-75) (n=82)	Mesocephalic (CI= 75.01-80) (n=254)	Brachycephalic (CI= 80.01-85) (n=174)	Hyper-brachycephalic (CI= 85.01-90) (n=40)	
12-17 weeks	8 (9.8%)	21 (8.3%)	7 (4.0%)	4 (10.0%)	40 (7.3%)
18-23 weeks	19 (23.2%)	39 (15.4%)	18 (10.3%)	6 (15.0%)	82(14.9%)
24-29 weeks	18 (22.0%)	47 (18.5%)	39 (22.4%)	6 (15.0%)	110 (20.0%)
30-35 weeks	32 (39.0%)	97 (38.2%)	78 (44.8%)	15 (37.5%)	222 (40.4%)
36-40 weeks	5 (6.1%)	50 (19.7%)	32 (18.4%)	9 (22.5%)	96 (17.5%)

[Table/Fig-8]: Distribution of study fetus on the basis of CI and Type of skull.

A steady CI of 78.3±4.4 from 14-40 weeks was seen by Hadlock FP et al., with no significant variation as the fetal age increases [19]. Tuli A et al., also reported a constant value of 76.4±5.1 from 12-40 weeks [23]. Jeauty P et al., found that CI was age independent [21]. On the contrary, Gray D et al., observed a change in CI with increasing age of fetus, and reported a wide normal range for CI [Table/Fig-9] [7,13,19,22-24].

Studies	Years	Place	Cephalic Index (mean)
Hadlock FP et al., [19]	1981	Washington, United State	78.3±4.4
Gray D et al., [22]	1989	Houston, United State	78.4±7.5
Tuli A et al., [23]	1995	New Delhi, India	76.4±5.1
Chaudhary R et al., [24]	2001	Manipur, India	82.9
Mador ES et al., [13]	2010	Jos-Nigeria	78.3±4.4
Mohammed YM et al., [7]	2018	Borno State Nigeria	79.06±3.52
Present Study	2019	India	79.08±4.34

[Table/Fig-9]: Comparative studies for the Cephalic Index (CI) [7,13,19,22-24].

Limitation(s)

Limited data on the fetal craniofacial dimensions of study population is a huge barrier in the precise estimation of the gestational age. Also, this study is performed on the basis of ultrasound scans so there may be few variations in knowledge as no direct patient is involved.

CONCLUSION(S)

Mesocephaly is the dominant head shape among the western part of UP (India) particularly in Etawah and Mainpuri region, with CI. The present study head shape was found to be Mesocephaly which was of CI range from 75 to 79.9. A correction factor for adjusting a typical fetal head shape in the north India population has also been derived in this study and would be helpful in predicting fetal gestational age.

Recommendations of the study: Further studies on gene variation basis are recommended to determine the specific genetic factors accountable for differences in cephalic indices among tribes, sexes, and races.

REFERENCES

[1] Abuhamad AZ, ed: Perinatal Ultrasonography. IN: Niswander KR Evans AT. Manual of Obstetrics Fifth Edition. Little Brown and Company. 1996; 371-82.
[2] van Lindert EJ, Siepel FJ, Delye H, Ettema AM, Berge SJ, Maal TJJ, et al. Validation of cephalic index measurements in scaphocephaly. Child's Nervous System. 2013;29(6):1007-14.
[3] Praveen K, Janaki C, Vijayaraghavan V, Delhi R. A study on measurement and correlation of cephalic and facial indices in male of south Indian population. International Journal of Medical Reseach and Health Sciences. 2013; 2(3):439-46.

[4] Aggrawal A. Textbook of forensic medicine and toxicology. Avichal Publication Compony, 1st edition 2014.

[5] Modi's Medical jurisprudence and Toxicology, 23rd edition page no 269-70.

[6] Beigi A, Zarrinkoub F. Ultrasound assessment of fetal biparietal diameter and femur length during normal pregnancy in Iranian women. International Journal of Gynaecology & Obstetric. 2000;69(3):237-42.

[7] Mohammed YM, Anthony UC, Ali Alhaji M, Mohammed A. Sonographic assessment of fetal cephalic index among the fulanis in Maiduguri, Borno State. IOSR Journal of Nursing and Health Science (IOSR-JNHS). 2018;7(1) Ver. II:55-59.

[8] Waldenstrom V, Axlesson O, Nilsson S. A comparison of the ability of a sonographic biparietal diameter and the last menstrual period to predict the spontaneous onset of labour. American Journal of Radiology. 1990;76(3):336-38.

[9] Giampaolo M. Guideline for fetal intrauterine growth restriction and chronic fetal hypoxemia. Timisoara Medical Journal. 2009;59(2):9-12.

[10] Bernstein I, Mohs G, Rucquoi M. Case for hybrid fetal growth curves: a population-based estimated of normal fetal size across gestational age. Journal of Matern Fetal Medicine. 1996;5(3):124-27.

[11] Gardosi J, Chang A, Kalyan B. Customized antenatal growth chart. The Lancet. 1992;339:283-87.

[12] Pourhoseingholi MA, Vahedi M, Rahimzadeh M. Sample size calculation in medical studies. Gastroenterol Hepatol Bed Bench. 2013;6(1):14-17.

[13] Mador E, Goncim H, Pam I, Mutihir J, Adoga G, Ogunranti J. Cephalic index: a fetal gestational age-dependent biometric parameter. Asian journal of Medical Sciences. 2010;1:45-48.

[14] Eroje M, Fawehinmi H, Jaja B, Yaakor L. Cephalic index of ogbia tribe of Bayelsa State. International Journal of Morphology. 2010;28(2):389-92.

[15] Bhargav T, Kher GA. An anthropometry study of Central India, Bhol of Dhan District ofMadhya Pradesh. Journal of the Anatomical Society of India. 1960;9:14-19.

[16] Oladipo GS, Olotu EJ. Anthropometric comparism of cephalic indices between the Ijaw and Igbo tribes. Global Journal of Pure and Applied Sciences. 2006;12(1)137-38.

[17] Fawehinmi HB, Osunmoke AE, Ligha AE, Okoh PD. A comparative study on the cephalic indices of normal growing children and children with sickle cell anaemia in Port Harcourt. Journal of Experimental and Clinical Anatomy. 2008;7(1):27-29.

[18] Kasai K, Richards LC, Brown T. Comparative study of craniofacial morphology in Japanese and Australian aboriginal populations. Human Biology. 1993;65(5):821-34.

[19] Hadlock FP, Deter R, Carpenter R, Park S. Estimating fetal age: effect of head shape on biparietal diameter. American Journal of Radiology. 1981;137:83-85.

[20] Eroje M, Fawehinmi H, Jaja B, Yaakor L. Cephalic index of ogbia tribe of Bayelsa State. International Journal of Morphology. 2010;28(2):389-92.

[21] Jeauty P, Cousaert E, Hobbins J, Tack B, Bracken M, Contraine F. A Longitudinal study of fetal head biometry. American Journal of Perinatology. 1984;2(1):118-28.

[22] Gray D, Songster G, Parvin C, Crane J. Cephalic index: a gestational age-dependent biometric parameter. Obstetrics and Gynaecology.] 1989;4(4):600-03.

[23] Tuli A, Choudhry R, Agarwal S, Anand C, Garg H. Correlation between craniofacial dimensions and fetal age. Journal of the Anatomical Society of India. 1995;44(1):1-12.

[24] Chaudhary R, Singh MS, Devi B, Singh C. Cephalic index of foetuses of manipuri population-a baseline study. J Anat Soc India. 2001;50(1):8-10.

PARTICULARS OF CONTRIBUTORS:

1. Lecturer, Department of Anatomy, Uttar Pradesh University of Medical Science, Saifai, Uttar Pradesh, India.
2. Medical Officer, Department of Radiology, Uttar Pradesh University Of Medical Science, Saifai, Etawah, Uttar Pradesh, India.
3. Professor, Department of Anatomy, Uttar Pradesh University of Medical Science, Saifai, Etawah, Uttar Pradesh, India..
4. Associate Professor, Department of Radio-Diagnosis, Uttar Pradesh University of Medical Science, Saifai, Etawah, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Nandkishor Gupta,
c 304 Type 4 New Campus UPUMS, Saifai, Uttar Pradesh, India.
E-mail: nandkishorgupta5577@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jun 26, 2020
- Manual Googling: Mar 31, 2020
- iThenticate Software: Aug 08, 2020 (00%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Mar 30, 2020**
Date of Peer Review: **May 03, 2020**
Date of Acceptance: **Jul 06, 2020**
Date of Publishing: **Sep 30, 2020**