Original Article

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Foetal Brain Biometry using Magnetic Resonance Imaging in an Indian Population- A Retrospective Cohort Study

Radiology Section

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ABSTRACT

Introduction: The utility of Magnetic Resonance Imaging (MRI) has increased significantly in the assessment of foetal brain development. Foetal biometry is a part of every imaging examination and is needed to confirm that the growth is proceeding normally.

Aim: To provide normal MRI reference biometric data of the foetal brain in Indian population.

Materials and Methods: This was a retrospective cohort study conducted in the Department of Radiodiagnosis at Sri Ramachandra Hospital, Chennai, Tamil Nadu, India. The data was collected from the MR imaging studies done between January 2013 to December 2020. The present study was carried out on 101 foetuses with gestational age ranging from 20 to 38 gestational weeks with normal brain appearance. Following biometric parameters had been obtained: skull occipitofrontal diameter and Biparietal Diameter (BPD), Brain-Biparietal Diameter (BPD) and fronto-occipital length, Head Circumference (HC), atrial diameter, vermian height, width and area. Descriptive statistics was used to calculate the median value with Interquartile Range (IQR). A p-value of less than 0.05 was considered as significant using Spearman's rank correlation.

Results: The skull occipitofrontal diameter (r-value=0.88, p-value <0.001), skull biparietal diameter (r-value=0.92, p-value <0.001), brain biparietal diameter (r-value=0.95, p-value <0.001), brain fronto-occipital length (r=0.94, p-value <0.001), head circumference (r-value=0.92, p-value <0.001), atrial diameter (r-value=0.86, p-value <0.001), Vermian height (r-value=0.86, p-value <0.001), Vermian width (r-value=0.84, p-value <0.001) and Vermian area (r-value=0.88, p-value <0.001) showed positive correlation with gestational age. Mean Head Circumference (HC) and BPD values were almost similar to the standard Indian reference mean values of ultrasound. All biometric parameters were compared with the European references. The values from present study were found to be in the lower range of the European biometric values.

Conclusion: Normal biometric MRI data of the foetal brain in an Indian population from 20 to 38 weeks gestational age was presented. A significant correlation was found between gestational age and parameters. MRI BPD and HC values showed a positive correlation with ultrasound BPD and HC values.

Keywords: Biparietal diameter, Gestational age, Head circumference, Occipital length

INTRODUCTION

Biometric measurements are good markers of foetal brain maturation and growth and serve as basis for the diagnosis of developmental and brain abnormalities. Abnormal measurement is often the first warning of foetal growth problems that requires further investigation [1]. The initial step in prenatal diagnosis on ultrasound (US) and Magnetic Resonance Imaging (MRI) is to compare foetal brain development by using reference charts. This can detect common pathologies like microcephaly, cerebellar hypoplasia, foetal growth retardation, and ventriculomegaly [2]. The utility of MRI has increased significantly in the assessment of foetal brain development. Sonography is the primary modality used in the antenatal examination. Sonographic biometric charts are routinely being used as part of the foetal examination. The MRI is mainly used to diagnose structural abnormalities, as it has been shown to be complementary to US in this regard. The advantage of MRI is that, it provides more accurate measurements of the foetal brain, together with better parenchymal signal and gyration analysis [3-7]. Some studies have demonstrated a good agreement between both techniques for biometry [8-10]. There is scanty data regarding MRI based biometry in normal foetuses. The present study aimed to provide normal MRI reference biometric data of the foetal brain in Indian population.

MATERIALS AND METHODS

This was a retrospective cohort study conducted in the Department of Radiodiagnosis at Sri Ramachandra Hospital, Chennai, Tamil Nadu, India. The data was collected from the MRI studies done between January 2013 to December 2020 and data was analysed between October to December 2021. This hospital being a tertiary care centre situated in a city, caters to a population of several states. The present study was approved by the Institutional Ethics Committee (IEC) (NI/20/FEB/74/25). A total of 101 foetuses from singleton pregnancies with a normal appearance on foetal brain MRI were included in the present study with the power of 90%.

Inclusion criteria: Mothers referred for foetuses MRI, in the evaluation of anomalies and found to be normal and foetuses of mothers, who were subjected to MRI for placental evaluation were included in the study.

Exclusion criteria: Foetuses with Intrauterine Growth Retardation (IUGR), congenital malformations, poor image quality/artifacts, infections and metabolic pathologies and foetuses of mothers with infections and metabolic disorders were also excluded from the study.

The follow-up of these foetuses were obtained from the delivery notes and neonatologist examination notes from the hospital database. Further confirmation to establish the normalcy of the foetuses were made by a telephonic conversation with the parents. The MRI values of the present study were compared with the ultrasound values in the Indian population previously reported by Aggarwal N and Sharma GL [11].

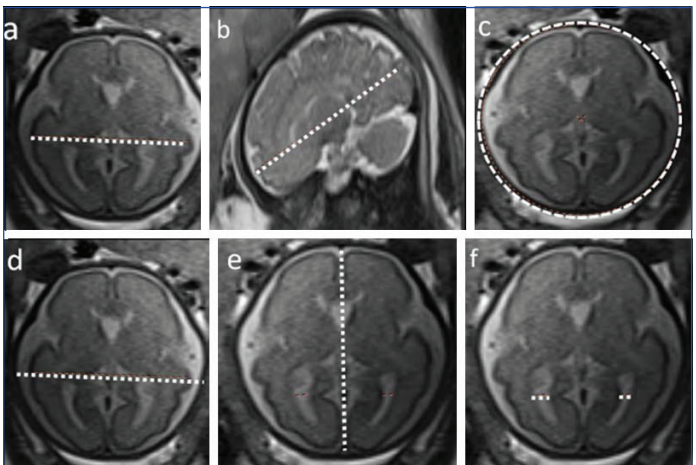
Magnetic Resonance Imaging

Foetal MRI was performed using 1.5 T MRI (Avanto Siemens, Erlangen, Germany) with an 8-element torso array coil. The patient was positioned feet first in supine position and body coil was placed over the abdomen. The localiser was centered over anterior superior iliac spine. The foetal brain examination was performed using Half-

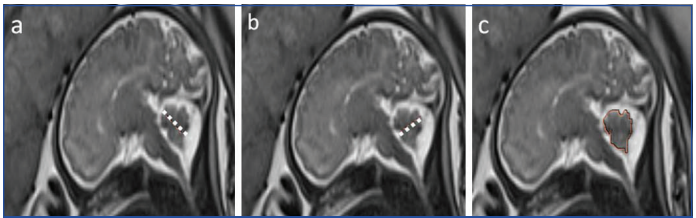
fourier Acquisition Single shot Turbo spin Echo sequence (HASTE) in three planes. The following scan parameters were used: TR: 900 ms, TE: 90 ms, FOV: 24-28 cm, matrix: 256×256, number of excitations: 1, slice thickness: 4mm, intersection gap: 0.2 mm.

Image analysis: Measurements were taken on the 3D reconstruction images on a dedicated workstation. These included the skull biparietal diameter, skull occipitofrontal diameter, Brain Biparietal Diameter (BPD), brain fronto-occipital length, diameter, Head Circumference (HC), atrial diameter, vermian height, width and area similar to the study by Kyriakopoulou V et al., [12].

- The biparietal diameter of the brain was measured in the axial plane, the maximum brain width was measured [Table/Fig-1a].
- The fronto-occipital length was measured in the mid-sagittal plane corresponding to the maximum distance of the frontal and occipital lobes [Table/Fig-1b].
- The foetal head (skull) circumference was measured in the axial plane using the eclipse tool [Table/Fig-1c].
- The skull biparietal diameter was measured in the axial plane corresponding to the outer edge of the parietal bone to the inner edge of the opposite parietal bone [Table/Fig-1d].
- The occipito-frontal diameter of the skull was measured in the axial plane with the cursors being placed in the middle of the diploic space [Table/Fig-1e].
- The lateral ventricular atrial diameter was measured at the level of the atrium, where the 3rd ventricle and thalami were visible [Table/Fig-1f].
- The vermian height, width and area were obtained from the mid-sagittal section. The vermian height was obtained by measuring the maximum superior-inferior distance [Table/Fig-2a].
- The vermian width was obtained by measuring the length in between the fastigium and posterior most point of the vermis [Table/Fig-2b].
- A freehand drawing tool was used to calculate the vermian area [Table/Fig-2c].



[Table/Fig-1]: T2 weighted HASTE images; a-f) Showing the methodology of obtaining the measurements; a) Axial image showing brain BPD measurement; b) Sagittal image showing Brain fronto-occipital length measurement. (c-f) Axial images showing head circumference; c) Skull BPD; d) Skull fronto-occipital length; e), and atrial diameter; f) Measurements.



[Table/Fig-2]: T2 weighted HASTE sagittal images (a,b,c) Showing the methodology of measuring the vermian dimensions; a) Vermian height; b) Vermian width; c) vermian area.

STATISTICAL ANALYSIS

Statistical analysis was done using the Statistical Package for the Social Sciences (SPSS) software. The data were analysed using the Kruskal-Wallis test and it showed a non normal distribution. Descriptive statistical methods were employed to calculate the median with Interquartile Range (IQR). A p-value of less than 0.05 was considered as significant using Spearman's rank correlation.

RESULTS

The MR images of 101 foetal brains ranging from 20 to 38 gestational weeks were analysed. The median of all the foetal biometric parameters with IQR against the gestational weeks along with correlation (r) and p-value are presented in [Table/Fig-3].

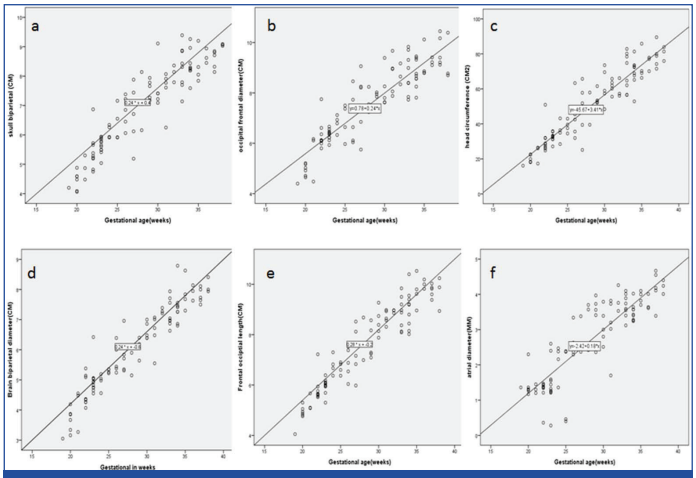
Parameters	Gestational age (weeks)	Median (IQR)	r-value	p-value
Skull biparietal diameter (cm)	19-24	5.4 (1.0)	0.92	<0.001
	25-31	7.2 (1.2)		
	32-38	8.4 (0.7)		
Occipitofrontal diameter (cm)	19-24	6.2 (0.6)	0.88	<0.001
	25-31	7.8 (1.0)		
	32-38	9 (0.8)		
Brain biparietal diameter (cm)	19-24	4.6 (0.8)	0.95	<0.001
	25-31	6.0 (1.1)		
	32-38	7.6 (0.7)		
Fronto-occipital length (cm)	19-24	5.7 (0.8)	0.94	<0.001
	25-31	7.6 (1.7)		
	32-38	9.4 (1.0)		
Head circumference (cm^2)	19-24	28.7 (8.1)	0.92	<0.001
	25-31	52.8 (19.8)		
	32-38	72.6 (12.7)		
Atrial diameter (mm)	19-24	1.4 (0.2)	0.86	<0.001
	25-31	2.7 (1.1)		
	32-38	3.7 (0.6)		
Vermis height (cm)	19-24	0.9 (0.3)	0.86	<0.001
	25-31	1.4 (0.3)		
	32-38	1.8 (0.3)		
Vermis width (cm)	19-24	0.8 (0.3)	0.84	<0.001
	25-31	1.2 (0.5)		
	32-38	1.5 (0.3)		

[Table/Fig-3]: Median of all the foetal biometric parameters with IQR against the gestational weeks along with correlation (r) and p-value.
Kruskal-Wallis test were employed to calculate the median with interquartile range (IQR).

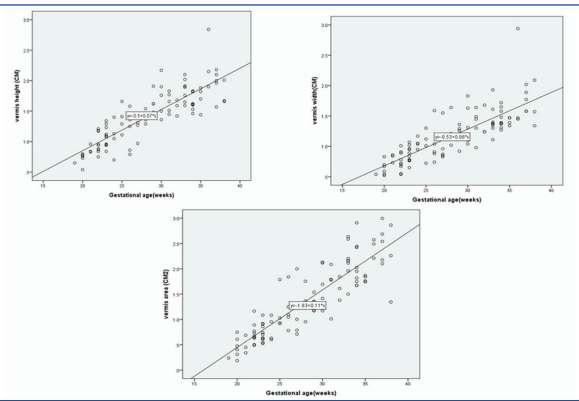
The following measurements, viz skull occipitofrontal diameter (r-value=0.88, p-value <0.001), skull biparietal diameter (r-value=0.92, p-value <0.001), brain biparietal diameter (r-value=0.95, p-value <0.001), brain fronto-occipital length (r-value=0.94, p-value <0.001), head circumference (r-value=0.92, p-value <0.001), lateral ventricular atrial diameter (r-value=0.86, p-value <0.001), vermian height (r-value=0.86, p-value <0.001), vermian width (r-value=0.84, p-value <0.001) and vermian area (r-value=0.88, p-value <0.001) showed positive correlation with gestational age. There was also positive correlation between the parameters and the gestational age [Table/Fig-4,5]. Correlation values were calculated between MRI values of BPD and HC of present study and ultrasound values of BPD and HC of Aggarwal N and Sharma GL, study. There was a strong positive correlation (r-value=0.99, p-value <0.001) [Table/Fig-6,7] [11].

DISCUSSION

The present study provided the biometric data from 101 foetal brains between 20 and 38 weeks of gestation. Sonography is the primary modality used in the antenatal examination. Sonographic biometric charts are routinely being used as part of the foetal examination. The MRI is mainly used to diagnose structural abnormalities, as it



[Table/Fig-4]: Scatter diagram showing the distribution of data at various gestational age; a) Skull BPD; b) Occipitofrontal diameter; c) Head circumference; d) Brain BPD; e) Fronto-occipital length; f) Atrial diameter.



[Table/Fig-5]: Scatter diagram showing the distribution of vermian data at various gestational age; a) Vermian height; b) Vermian width; c) vermian area.

Gestational age (Weeks)	Mean Head circumference (mm)		% Difference of mean	r-value
	Present study	Aggarwal N and Sharma GL, [11]		
20	172.0	175.70	-2.12	
21	186.3	189.10	-1.49	
22	195.0	191.70	1.70	
23	212.4	211.70	0.23	
24	219.1	218.70	-0.21	
25	221.6	226.10	-2.01	
26	232.6	230.50	0.86	
27	255.0	247.40	3.02	
28	264.1	255.70	3.23	
29	268.0	273.20	-1.92	0.99
30	270.2	276.0	-2.12	
31	280.0	281.60	-1.65	
32	287.0	281.60	0.24	
33	291.0	288.60	0.82	
34	301.0	297.90	1.03	
35	308.0	304.80	1.04	
36	310.0	313.20	-1.02	
37	320.0	315.70	1.35	
38	323.0	331.60	-2.44	

[Table/Fig-6]: Comparison of mean of HC of present MRI study with sonographic mean HC reference values [11].

has been shown to be complementary to United States of America in this regard. The advantage of MRI is that it produces excellent contrast resolution [3-7]. Though routine biometry of the foetal brain MRI is not usually performed, it is required to identify conditions like vermian hypoplasia, microcephaly. In present study, in addition

Gestational age (weeks)	Biparietal diameter (mm)		% Difference of mean	r-value
	Present study	Aggarwal N and Sharma GL, [11]		
20	47.1	47.70	-0.21	
21	49.8	50.91	-2.38	
22	51.9	52.70	-1.52	
23	56.2	57.70	-2.63	
24	57.9	58.90	-1.20	
25	62.4	61.30	1.77	
26	64.6	62.40	3.46	
27	66.8	66.90	3.65	
28	72.5	70.10	3.36	
29	77.0	75.10	2.49	0.99
30	78.1	77	1.41	
31	79.5	78.50	1.26	
32	79.7	79	0.88	
33	80.3	79.40	1.12	
34	81.4	82.70	-1.58	
35	83.8	84.80	-1.18	
36	85.1	86.80	-1.97	
37	88.2	88.70	-2.40	
38	89.0	89.60	-0.67	

[Table/Fig-7]: Comparison of mean BPD of present MRI study with sonographic mean BPD reference values along with percentage difference of the two means [11].

to the skull Biparietal Diameter (BPD), skull occipitofrontal diameter and Head Circumference (HC) (similar to sonography), brain BPD and occipitofrontal diameter of the brain had also been taken (excluding the skull and extra parenchymal CSF). These values can predict the growth of the brain better.

Aggarwal N and Sharma GL, have published foetal ultrasound parameters reference values in the Indian population and they found that the biometry values (BPD, HC) of Indian foetuses were in the lower range of the western babies [11]. In present study, MRI values with the ultrasound values had been correlated in the Indian population. The percentage difference of the means of HC ranged from -2.12 to 3.23 and for BPD, it ranged from -2.38 to 3.65.

Biparietal diameter on sonography has been extensively studied, well reproduced and recommended as a strong marker in China [13]. Gafner M et al., (Israel) found good agreement between modalities in HC and BPD [10]. Galjaard S et al., (Belgium) have shown that the HC and BPD are considerably greater in males than in females from 20 weeks of gestation onwards [14]. Kyriakopoulou V et al., (London) have published normative biometry of the foetal brain using volumetric MRI with a large cohort of 127 foetuses and a wide gestational age [12]. However, they did not examine if the MRI findings correlated with the biometric parameters obtained using sonography. In present study, foetal biometric parameters (skull BPD, skull HC) were compared with European sonography and it has revealed that, they were in the lower range with the western foetuses [15].

In the present study, all measurements showed a strong correlation with increasing gestational age. Previous studies, also reported good agreement between the foetal ultrasound and MRI in the measurement of atrial diameter [16,17]. For precise prenatal diagnosis, biometric analysis of the vermis plays a major role in the evaluation of an abnormal posterior fossa. In the present study, new reference MRI data for vermian height, width and area for the Indian population had been added and compared with the study by Katorza E et al., [18]. It has revealed that mean vermian values were in the lower range with the western foetuses. [Table/Fig-8] shows the comparison of mean of Vermian height of present MRI study with the mean reference values from 27 to 35 weeks.

Gestational age (weeks)	Vermis height (mm) (mean±SD)	
	Present study	Katorza E et al., [18]
20	7.3±0.8	-
21	8.6±0.7	-
22	9.7±1.58	-
23	10.5±1.4	-
24	10.7±1.8	-
25	11.6±1.9	-
26	11.8±3.0	-
27	12.7±1.5	14.10±0.65
28	13.9±1.05	14.70±0.63
29	15.2±0.84	15.90±1.32
30	16.5±1.97	17.70±1.21
31	16.8±1.45	17.90±0.98
32	17.4±0.58	18.60±1.27
33	18.0±1.71	19.60±0.88
34	18.3±0.82	19.40±0.92
35	18.8±0.43	20.20±1.56
36	20.2±1.25	-
37	20.6±0.86	-
38	21.1±0.46	-

[Table/Fig-8]: Comparison of mean of vermian height of present MRI study with the mean reference values from 27 to 35 weeks [18].

The MRI biometric cerebral measurements help in the further assessment of foetuses, during 20-40 weeks gestational age as they produce an objective data of the foetal cerebrum and they disregard the surrounding CSF space-bone [13]. The MRI biometric charts are also used to improve MRI assessment of foetal growth. Sometimes, congenital anomalies are associated with foetal growth retardation and MRI reference values will be handy to decide, if there is associated growth retardation. However, there may be variations in the foetal biometry due to parental ethnicity, nutritional factors, genetic background and socio-economic status. These factors can explain the difference in biometry of Indian foetuses, with those of the western population [11].

Limitation(s)

The present study is retrospective in nature and included small sample size of the population.

CONCLUSION(S)

The present study provided normal biometric MRI data of the foetal brain in Indian population from 20 to 38 weeks gestational age. A significant correlation between gestational age and various parameters were found. The MRI estimation of BPD and HC values showed a positive correlation with ultrasound BPD and HC values. Further studies on Indian population are recommended with larger sample size to improve the accuracy of the foetal biometry reference values.

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- Manual Googling: Aug 08, 2022
- iThenticate Software: Sep 20, 2022 (13%)

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