Research Article

Ultrasonographic evaluation of foetal sacral length measurement as a new parameter for assessment of gestational age

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Abstract

Aim: This study evaluates the prenatal ultrasonographic measurement of sacral length to assess the gestational age. **Materials and Methods:** In this prospective cross sectional study 100 cases of gestational age between 15-40 weeks of women aged between 19-36 years were selected after ruling out any abnormality in mother and fetus. At a single sitting biparietal diameter, head circumference, femur length and sacral length were measured. Each parameter recorded, was compared with its standard nomogram. Mean and Correlation tests were applied for analysis and interpretation of the results. **Observations:** Scatter graphs were plotted for BPD, HC, AC, FL and sacral length with gestational age and their correlation was calculated. Pearson's coefficient (r^2) was equal to 0.988 ($P < 0.01$), 0.987, 0.996, 0.995, 0.997 respectively. A statistically significant linear correlation was found between the sacral length and gestational age (R^2=0.997) indicating it to be a reliable indicator of gestational age. The maximum error in predicting gestational age by sacral length (in cams) was found to be 1.5 weeks and mean error of 0.27 week. Maximum mean error was found with abdominal circumference of 0.42 weeks and second least with sacral length after femur length indicating it to be a reliable indicator. **Conclusion:** sacral length is independent of fetal head; it can be a useful alternative parameter in conditions where the fetal head is not accessible as in third trimester deeply engaged head or in multiple pregnancies. It is also useful in conditions of femur length deformities along with skull deformity like achondroplasia etc. Therefore, it was concluded that this study has provided normative sacral length measurements throughout pregnancy especially towards the third trimester. Sacral length can be used as a reliable routine parameter and also as an alternative in conditions where other routine parameters are difficult to assess or give incorrect predictions.

Keywords: sacral length, Mean gestational age, correlation.

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INTRODUCTION

Last two decades have seen a tremendous progress in application of ultrasound as a diagnostic modality, revolutionizing the management towards better care. This is particularly due to its non-invasive and non-ionizing nature besides its cost effectiveness leading to wider acceptability. It provides more accurate estimation of gestational age which prevents unnecessary labour inductions. Accurate dating is essential for the proper timing of Chorionic Villi sampling and Nuchal Translucency assessment, amniocentesis and timing for elective caesarean section. The present study was undertaken to correlate ultrasonographic sacral length measurement, with gestational age and to compare it with gestational age determined by other parameters that are routinely used for the ante partum foetal age determination (BPD, HC, AC, FL).

MATERIAL AND METHODS

The present study "Ultrasonographic evaluation of fetal sacral length measurement as new parameter for assessment of gestational age" was conducted in the Department of Obstetrics and Gynecology, and Department of Radio diagnosis G.R. Medical College, Gwalior (Madhya Pradesh) from May 2009 to Oct 2010. The study was performed on a gray scale real time

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scanner, ALOKA PROSOUND SSD – 400D (Aloka Trivitron Medical Technologies Pvt. Ltd.; Tokyo Japan) using 2.5-6 MHz curved array transducer. Various routine fetal biometric parameters (BPD, AC, HC, FL) and also the sacral length was recorded during the study. For this study 100 cases of gestational age between 15-40 weeks of women aged between 19-36 years were selected after ruling out any abnormality in mother and fetus. The criteria for the selection of cases were as follows: The patient had regular menstrual cycles i.e. 26-30 days and was definite of her last menstrual period date. Fundal height on examination corresponded with the LMP. The patient had single live pregnancy with no known abnormality. The patient had no complication of pregnancy and was otherwise healthy i.e. was low risk pregnancy. The patients were excluded when found to be of irregular menstrual cycles and when gestational age as predicted by LMP could not be confirmed by early ultrasound. Details of history regarding regularity and the duration of menstrual period were taken Systemic examination for any cardiovascular or respiratory disease, obstetric examination to estimate the fundal height, fetal lie, multiple pregnancy, obvious IUGR or poly-oligohydramnios was carried out. To rule out maternal disease, likely to affect the outcome of pregnancy; routine blood examination was carried out. This included hemoglobin, blood group, urine for albumin and sugar, blood urea and blood sugar.

For Ultrasonographic examination

(A) Preparation of the patient: A full bladder serves as an acoustic window for better visualization of the uterus, its contents and the adnexa. Therefore, the patients were instructed not to empty the bladder 3 hrs prior to the examination especially in early pregnancy. If needed they were advised to take plenty of oral fluids in order to fill their urinary bladder. **(B)Technique of scanning:** At a single sitting bipari *et al* diameter, head circumference, femur length and sacral length were measured. The measurements were taken employing freeze frame technique using electronic callipers calibrated in mm. **S**acral length was determined by using the technique described by Sherer D M *et al*[1]. By this technique, the foetal sacrum was measured in the saggital plane by means of the distal tip of the spine, S5 and the anterior superior aspect of S1. At times during the third trimester a thin echogenic plate, clearly different from vertebral body, can be visualized distal to the central ossification centre of S5. This thin structure represented the unossified cartilaginous coccyx, and was not included in the sacral length measurement. The fetal sacrum is most easily visualized with the occiput-anterior in the vertex-presenting fetuses or sacrum-anterior position in breech presenting fetuses. The sacral length in this study was measured in the saggital section from the sacral promontory to last visualized ossified sacral vertebrae depending on the period of gestation. Each parameter so recorded, was compared with its standard nomogram. Suitable bar diagram, scatter diagram and pie charts were made to represent the data. Mean and Correlation tests were applied for analysis and interpretation of the results.

OBSERVATIONS

Table: 1 shows Clinical characteristics of present pregnancy.

Age group(years):	No. of Cases	Percentage
19-21	31	31
21-27	51	51
> 27	18	18
Gravidity:		
Primigravidae	27	27
Multigravidae	73	73
Parity:		
0	31	31
1	35	35
2	28	28
3	6	6
>3	0	0
Known menstrual age (in weeks):		
15-20	6	6
20-25	16	16
25-30	26	26
30-35	40	40
35-41	12	12

Table 2: Comparison of mean BPD in present study with standard BPD nomogram

Gestational age (in weeks)	Standard Nomogram (Sabbagha and Hughey) (mm)	Mean BPD in Present study (in mm)
16	36	36
17	39	45
18	42	45
19	45	47
20	48	50.25
21	51	52
22	54	58
23	58	58.25
24	61	63
25	64	65.25
26	67	67.66
27	70	70.66
28	72	74.5
29	75	75.6
30	78	79
31	80	82
32	82	82
33	85	85.9
34	87	86.25
35	88	88.5
36	90	90.4
37	92	91
38	93	92
39	94	92
40	95	94

Table 3: Comparison of mean head circumference in the present study with standard head circumference nomogram by (Hadlock et al. 1982)

Gestational age (in weeks)	Standard Nomogram (Hadlock et al 1982) (mm)	Mean Head circumference in present study (mm)
16	122	120
17	134	138
18	148	149.5
19	160	159
20	177	171
21	182	183.3
22	193	191.5
23	208	209.5
24	221	221.66
25	239	235.28
26	241	239
27	256	254.83
28	271	266.75
29	273	271.4
30	276	278.87
31	281	281.5
32	292	288.7
33	302	301
34	308	308.87
35	317	315
36	322	322
37	328	321
38	334	335
39	340	338
40	345	341

Table 4: Comparison of mean femur length in the present study with the standard nomogram by Hadlock et al 1982

Gestational age (in weeks)	Standard Nomogram (Hadlock et al 1982) (mm)	Mean Femur length in present study (mm)
16	23	23
17	26	27
18	28	30
19	30	33
20	33	36
21	35	37
22	38	40.5
23	40	42.25
24	42	45.33
25	45	47
26	47	48.66
27	49	51.8
28	52	54.25
29	54	55.8
30	57	58.125
31	59	60.5
32	61	62.14
33	64	64.8
34	66	67.125
35	69	68.25
36	71	71.6
37	73	73
38	76	76
39	78	80
40	80	79

Table 5: Comparison of mean abdominal circumference in the present study with standard abdominal circumference nomogram

Gestational age (in weeks)	Standard Nomogram (Hadlock et al 1982) (mm)	Mean abdominal circumference in present study (mm)
16	105	104
17	117	114
18	129	126.5
19	141	136
20	152	150.75
21	164	161
22	175	175
23	186	184.75
24	197	197
25	208	208.28
26	219	219
27	229	231.5
28	240	241.5
29	250	252
30	260	261.12
31	270	271.66
32	280	276.85
33	290	287
34	300	300
35	309	304
36	318	316
37	327	321
38	336	330
39	345	340
40	354	345

Table 6: Comparison of the mean sacral length in present study with the standard nomogram

Gestational age (in weeks)	Standard nomogram Sherer et al, 1993(in cm)			Sacral length measured in present study (in cm)
	- 2 SD	Mean	- 2 SD	
15	1.1	1.4	1.8	-
16	1.2	1.5	1.9	1.4
17	1.3	1.6	2.0	1.5
18	1.4	1.7	2.1	1.6
19	1.5	1.8	2.2	1.8
20	1.6	1.9	2.3	1.8
21	1.7	2.0	2.4	1.9
22	1.8	2.1	2.5	2.0
23	1.9	2.2	2.6	2.1
24	2.0	2.3	2.7	2.2
25	2.1	2.4	2.8	2.3
26	2.2	2.5	2.9	2.4
27	2.3	2.6	3.0	2.6
28	2.4	2.7	3.1	2.76
29	2.5	2.9	3.2	2.82
30	2.6	3.0	3.3	2.96
31	2.7	3.1	3.4	3.1
32	2.8	3.2	3.5	3.157
33	2.9	3.3	3.6	3.28
34	3.0	3.4	3.7	3.4
35	3.1	3.5	3.8	3.5
36	3.2	3.6	3.9	3.6
37	3.3	3.7	4.0	3.7
38	3.4	3.8	4.1	3.8
39	3.6	4.0	4.3	3.9
40	3.7	4.1	4.4	3.9

Table 7: Distribution of sacral length measurement (in cms)

Sacral Length (in cms)	Gestational age (in wks)	No. of cases	% of cases
1.2-2.0	16-22	15	15
2.1-2.9	23-29	33	33
3.0-3.7	30-37	52	52

Table 8: The error in predicting gestational age with various parameters

Parameter	Maximum error	Mean Error
BPD	1 Week	0.31 Week
HC	2.2 Week	0.28 Week
AC	2.2 Week	0.42 Week
FL	1.5 Week	0.25 Week
Sacral length	1.5 Week	0.27 Week

Table 9: Coefficient of correlation between various parameters and gestational age

Independent variable	Dependent variable	Coefficient of correlation
Gestational age	BPD	0.988
Gestational age	HC	0.987
Gestational age	AC	0.995
Gestational age	FL	0.996
Gestational age	SL	0.997

Table 10: Various previous studies on sacral length

	Sherer et al(1993)	Pajak et al[8] (1998)	Karabulut et al[9] (2001)	Vignolo et al (2004)	M Ozat et al (2010)	Present study
Cases with normal growth studied	506	453	186	80	2184	100
Cases with Abnormal growth studied	80	None	None	None	None	None

Gestational age of cases	15-41wks	16-41wks	14-40 wks	2nd trimester	16-40wks	16-40wks
Addition feature ,if any	Sacral length in 80 cases with abnormal growth was compared with nomogram	-	sacral bones of 101 spontaneously aborted foetuses aged from 13 to 39 weeks were dissected and measured	Gender differences in ossification studied	-	-
Correlation between sacral length and MGA	Strong R^2=0.959	Strong	Strong R^2=0.96	Strong	Strong R^2=0.96	Strong R^2=0.997
p value	<0.001 Significant	Significant	<0.001 Significant	Significant	<0.001 Significant	<0.01 Significant
Additional conclusions if any	SL can be used as a parameter in cases of abnormal growth also.	Variability in SL measurement increases with MGA, reaching 7 wks at term.	Measurements of USG and dissection matched	Ossification timing was earlier in females than males.	-	-

Fetal maturity was assessed by four of the conventional parameters namely: BPD, Head circumference, Femur length and abdominal circumference. The credibility of the above parameters has been proved by various previous standard nomograms given by previous researchers. **Table-1:** shows clinical characteristics of present pregnancy. The maximum numbers of patients were from the 21-27 yrs of age group. The maximum of the patients included in the present study were Multigravidae. The mean maternal age of the study group was 25 yrs and the median parity 1. Patients with bad obstetric history (i.e. fetal loss more than thrice in the past) were not included in the study. The maximum numbers of cases were between 30-35 weeks of gestation. BPD in the present study was compared with standard nomogram by Sabbagha and Hughey[2] [**Table 2**]. Except in conditions of abnormal head position head shape such as breech presentations or dolichocephaly, BPD was found to be a good indicator of gestational age between 16-30 weeks. In the later period of gestation (30-40 weeks) the accuracy of predicting gestational age by BPD decreased with a difference of 2-3 mm. The maximum error in predicting gestational age was 1 week with a mean error of 0.31 weeks. Scatter graph was plotted between BPD and gestational age and their correlation was calculated. Overall Pearson's coefficient (r^2) between the two was found to be equal to 0.988 ($P < 0.01$). Head circumference too is used as a reliable indicator of gestational age as established by Hadlock *et al*[3]. Although not as reliable as BPD; it is used routinely for gestational age estimation [**Table 3**]. It is especially reliable in conditions where BPD cannot be relied upon as in dolichocephaly. With gestational age between 16-30 weeks, it is found to be a good predictor of gestational age. Beyond 30 weeks, on an average 4-5 mm and maximum 7 mm difference was found between standard and present study data. Scattered graph was plotted between head circumference and gestational age and then correlation was calculated. Coefficient of correlation (r^2) was found to be equal to 0.987, indicating it to be a good parameter for assessing gestational age. The maximum error in predicting gestational age was 2.2 weeks with mean error of 0.28 week. Femur length is used as a reliable parameter for gestational age determination. It is especially of value in conditions where head cannot be used accurately like dolichocephaly, brachycephaly, deeply engaged head and also in IUGR where it is last to be effected. The femur-length in the present study correlated well with the standard nomogram by Hadlock *et al*[3] [**Table 4**]. Beyond 32 weeks, the femur length was more close to the standard value. The maximum error in predicting menstrual age was found to be 1.5 week and mean error 0.25 week. A highly significant coefficient of correlation (R^2=0.996) between femur length and gestational age was observed indicating it to be a reliable predictor. Scattered graph was plotted between gestational age and femur length and coefficient was calculated. Abdominal circumference in the present study was compared with standard Hadlock chart [**Table 5**] and was found to be a good predictor of gestational age in early second trimester. However, in late second trimester and third trimester; it was found to be an unreliable indicator with maximum error in predicting gestational age up to 2.2 weeks and mean error 0.42 week. Nonetheless, it can be used as a predictor of gestational age in cases in which bipari *et al* diameter is technically impossible or in cases in which moulding of head can significantly alter the accuracy of BPD. Scattered graph was plotted between abdominal circumference and gestational age. Coefficient of correlation was found to be

equal to 0.995. The results in the present study were well correlated with the standard nomogram by Hadlock *et al*.

GESTATIONAL AGE ASSESSMENT BY A NEW PARAMETER - SACRAL LENGTH MEASUREMENT:

In the present study the sacral length measured in the foetuses in various periods of gestation were compared with the standard nomogram by Sherer *et al*[1] [**Table 6**]. The maximum error in predicting gestational age by sacral length (in cms) was found to be 1.5 weeks and mean error of 0.27 week. The observations showed that the present study data correlates very well with the standard nomogram throughout gestation. A scattered graph was plotted between sacral length measurement and gestational age and their correlation was calculated. A statistically significant linear correlation was found between the sacral length and gestational age (R^2=0.997) indicating it to be a reliable indicator of gestational age. The sonographic evaluation of sacral length shows a linear relationship throughout gestation. The sacral length in present study (in centimetres) is within 2 standard deviation of the study by Sherer *et al*[1]. The sacral length in centimetres corresponds exactly with the gestational age in weeks more in the third trimester of gestation when the ossification of the vertebral bodies is complete. In majority of the cases (52%) the sacral length values are between 3.0-3.7 cms; corresponding to period of gestation ranging from 30 to 37 weeks. **Table-7** shows distribution of sacral length measurements. **Table-8** shows the error in predicting gestational age with various parameters. Maximum mean error was found with abdominal circumference of 0.42 weeks and second least with sacral length after femur length indicating it to be a reliable indicator. **Table-9** shows co efficient of correlation between various parameters and gestational age. The Pearson Coefficient (R^2) obtained from regression analysis of sacral length with BPD, head circumference and femur length demonstrates the relative strength of sacral length measurement as compared with these standard parameters of gestational age and fetal growth.

DISCUSSION

Ultrasonography is a useful means of detecting gestational age and to monitor foetal growth and development accurately. Gestational age must be reliably established so that needless interference and perinatal morbidity and mortality rates can be decreased. The foetal sacral length as a new and unique parameter, which is independent and can also be used when other parameters cannot be relied upon due to some reasons. In the present study the correlation coefficient between gestational age and BPD is equal to 0.988, indicating a high level of correlation between the two. In spite of the high level of correlation, the varying of growth patterns in different individuals makes prediction by BPD inaccurate in the third trimester. Breech presentation, dolichocephaly, uterine anomalies and multiple gestations further reduce the reliability of this parameter. BPD is difficult to record after the head gets engaged in third trimester. Head circumference is a reliable indicator of gestational age, in situations where head shape is altered significantly, such as in breech presentation or transverse lie, HC measurement offers better correlation than BPD. **Hadlock *et al*** also evaluated the relationship between foetal head circumference and menstrual age in 400 foetuses (15-41 weeks). Mathematical modeling of the data indicated that the head circumference growth curve is not always linear, similar to the BPD growth curve. Predicted head circumference values for the linear cubic function were found to be comparable to established normal values on the basis of postnatal measurements at 25-40 weeks. HC correlated well with Hadlock nomogram up to 30 weeks; after 30 weeks on an average 4-5 mm difference was found between western nomogram and present study data. **Ott J. William** derived an ultrasonic foetal head circumference curve from a group of 1278 ultrasound examinations in 710 normal obstetrical patients. These data compared the accuracy of head circumference to the last menstrual period and biparietal diameter for the prediction of an accurate expected date of confinement (EDC) and thereby calculate gestational age. Femur length has a linear relationship with gestational age, similar to BPD, but the growth appears to be slow in third trimester. Foetal femur length has been used widely for the prediction of menstrual age.Femur length is also very reliable and consistent predictor of gestational age when BPD cannot be relied upon as in late third trimester, after the head is engaged, and in cases of hydrocephalus, anencephaly and dolichocephaly. ZÜYLAN T, MURSHID. K. A[5] study showed significant correlation of GA with FL (r = 0.905). The abdominal circumference is also used routinely as one of the parameters for gestational age determination. But since AC is not as efficient as BPD or FL where reproducibility is concerned, its value as a sole estimator of gestational age is limited. The evolution of variability in predicting menstrual age from abdominal circumference indicates that it is a poor predictor of menstrual age than BPD, except during 36-40 weeks of pregnancy (Hadlock *et al*[2]). The abdomen shape is not constant and is affected by various factors including foetal breathing In addition to this, certain technical factors may contribute to the fluctuations in the evolution of gestational age by AC. It is an established fact that the Indian foetal growth due to the influence of various socioeconomic and environmental factors is less than western standards. But the outcome of foetuses was found to be normal with

lower birth weights in comparison with western Hadlock's charts. Hence, they cannot be labeled as cases of IUGR, in the Indian setup. The fetal sacrum is consistently identifiable structure and a landmark that provides a reproducible plane for measurement. Vignolo M *et al*[6] also worked on Fetal spine ossification and the gender and individual differences illustrated by ultrasonography. **Biasio De P *et al*[7]** worked on Ossification timing of sacral vertebrae by ultrasound in the mid-second trimester of pregnancy. It was found that S1 ossification nuclei were visualized in all foetuses at 15 weeks and S2 nucleus was found in all foetuses within 17 weeks. S3 nucleus was detected in 45% of foetuses by the beginning of the 16th week. S4 was visualized in 55% of the cases at 18 weeks and progressively in a higher percentage of cases during the following weeks of gestation. The fetal sacrum is most easily visualized with occiput-anterior in vertex presenting foetuses and sacrum-anterior in breech presenting foetuses. The coccyx is cartilaginous at birth and becomes ossified only after delivery. Its ultrasonographic appearance differs from that of ossified vertebrae. The distal vertebral body ossification centre of the spinal column visualized in gestation truly represents S5. The sacral vertebrae undergo ossification in a staged manner as do other vertebrae. Each vertebra usually has three primary ossification centers, one for body and one for each side of the posterior neural arch. Besides being used for the estimation of gestational age, the visualization of sacrum also allows the physician to investigate the anatomic integrity of lower spine and to specify any related congenital abnormalities such as spina bifida, sacral agenesis and sacrococcygeal teratoma. In the present study the anterior aspect of the ossification centre in the vertebral body was taken as the reference point for the measurement of sacral length. In the present study, the presence of five sacral ossification centers is seen by 15 weeks. Table: 10 show various previous studies on sacral length. Fetal sacral length appears as an easily achieved and valuable parameter, which directly and strongly correlates with gestational age and other biometrical measurements. Therefore, foetal sacral length can be utilized as a complementary tool in both the evaluation of foetal growth and prediction of gestational age. Further research is required to determine the significance of foetal sacral length in prenatal follow-up.

CONCLUSION

In this cross sectional study, we evaluated ultrasonographically the sacral length for the assessment of gestational age and fetal growth and to compare this parameter with other routinely used parameters such as the BPD, HC, FL, AC.As sacral length is independent of fetal head, it can be a useful alternative parameter in conditions where the fetal head is not accessible as in third trimester deeply engaged head or when head is deformed due to overcrowding such as in multiple pregnancy. It is also useful in conditions of femur length deformities along with skull deformity like achondroplasia etc. Therefore, it was concluded that this study has provided normative sacral length measurements throughout pregnancy especially towards the third trimester. Sacral length can be used as a reliable routine parameter and also as an alternative in conditions where other routine parameters are difficult to assess or give incorrect predictions.

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