Research Article

Fetal Occiput Spine Angle During Active Phase of Labour and Its Correlation with Labour Outcome: A Prospective Cohort Study

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Abstract

Background: Labour dystocia remains a leading indication for cesarean delivery. The occiput spine angle (OSA), measured by transabdominal ultrasound, quantifies fetal head deflexion during labour and has emerged as a promising intrapartum sonographic predictor of labour outcome. Aims: To measure OSA during the active phase of labour and correlate it with labour duration, mode of delivery, and maternal and neonatal outcomes. Settings and Design: Prospective cohort study conducted at SRM Medical College Hospital and Research Centre, Tamil Nadu, from May 2024 to September 2025. Materials and Methods: One hundred and thirteen term pregnant women in active labour with cervical dilatation of 4–6 cm underwent transabdominal ultrasound for OSA measurement. Women were categorised as OSA <126° or OSA ≥126° based on receiver operating characteristic (ROC) curve analysis. Statistical Analysis: Independent samples t-tests, chi-square tests, Pearson correlation analysis, and multivariable logistic regression were used. Statistical significance was set at P <0.05. Results: The mean OSA was 102.8 ± 12.7°. Women with OSA <126° (n=96, 85%) had significantly longer first stage duration (5.82 ± 2.32 vs. 3.56 ± 1.24 hours; P<0.001), second stage duration (38.6 ± 19.9 vs. 22.9 ± 13.2 minutes; P<0.001), and higher cesarean delivery rate (17.7% vs. 0%; P=0.042) compared to those with OSA ≥126° (n=17, 15%). OSA demonstrated a strong negative correlation with total labour duration (r = −0.68; P<0.001). OSA predicted cesarean delivery with an area under the ROC curve of 0.88 (95% CI 0.81–0.94), sensitivity of 100%, and negative predictive value of 100%. In multivariable analysis, OSA remained an independent predictor of cesarean delivery (adjusted OR 0.38 per 10° increment; 95% CI 0.23–0.63; P<0.001). Conclusions: OSA <126° measured during active labour significantly predicts prolonged labour duration and cesarean delivery. Routine OSA assessment can enhance intrapartum risk stratification in tertiary care settings with high cesarean delivery rates.

Keywords: Occiput spine angle, fetal head deflexion, labour duration, cesarean delivery, intrapartum ultrasound, labour dystocia, predictive tool.

1. Introduction

Labour dystocia, defined as abnormally slow or arrested progress of labour, constitutes one of the most common obstetric complications and accounts for 30–40% of all cesarean deliveries in nulliparous women.[1] Rising cesarean delivery rates pose significant short-term and long-term maternal and neonatal morbidity concerns. In Tamil Nadu, cesarean rates exceed 40% according to the National Family Health Survey (NFHS-5, 2019–2021), underscoring the urgent need for objective intrapartum risk stratification tools.[2]

Fetal head attitude, specifically the degree of flexion or extension of the fetal head relative to the cervical spine, is a critical but often underappreciated determinant of labour progress. A well-flexed fetal head presents the suboccipitobregmatic diameter (~9.5 cm) to the pelvis, facilitating smooth descent. Even minor degrees of fetal head deflexion — clinically undetectable by digital vaginal examination in 20–70% of cases — increase the presenting diameter to the occipitofrontal diameter (11.5 cm), augmenting cross-sectional presenting area by approximately 40% and substantially amplifying resistance to descent.[3]

The occiput spine angle (OSA) is a transabdominal two-dimensional sonographic parameter that quantifies fetal head deflexion by measuring the angle between a tangential line to the fetal occipital bone and a tangential line to the body of the first cervical vertebra (C1) in a sagittal plane.[4] First described by Ghi et al. in 2016, OSA has been validated across multiple international cohorts as a reliable predictor of labour duration and mode of delivery.[4] However, published data from South India and Tamil Nadu are entirely absent from the literature. This study was therefore conducted to evaluate the correlation between OSA measured during the active phase of labour and labour outcomes in a South Indian tertiary care population.

2. MATERIALS AND METHODS

Study Design and Setting
This prospective cohort study was conducted in the Department of Obstetrics and Gynaecology at SRM Medical College Hospital and Research Centre, Kattankulathur, Tamil Nadu, from May 2024 to September 2025. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Study Population
Consecutive eligible women in active labour were enrolled. Active labour was defined as regular uterine contractions with cervical dilatation of 4–6 cm. Women were followed from enrolment to delivery outcome.

Inclusion Criteria
Term singleton pregnancy (37–42 weeks of gestation); vertex presentation; cervical dilatation of 4–6 cm at enrolment; occiput anterior or occiput transverse position; adequate ultrasound image quality for OSA measurement; and written informed consent.

Exclusion Criteria
Multiple pregnancy; preterm labour (<37 weeks); known fetal anomaly; occiput posterior position; body mass index (BMI) >35 kg/m²; prelabour rupture of membranes >24 hours; previous uterine surgery; placenta praevia; suspected cephalopelvic disproportion; and prior cervical surgery.

Sample Size
Based on a prior study reporting mean OSA difference of 6° between groups with a standard deviation of 10°, a sample size of 110 was required at 80% power and 5% significance level. A total of 113 women were enrolled to account for potential dropouts.

OSA Measurement Technique
The mother was positioned semi-recumbent at 30–45° with a lateral tilt wedge. A curved transabdominal transducer (3.5–5.0 MHz) was positioned longitudinally just superior to the pubic symphysis to obtain a sagittal view of the fetal head and upper cervical spine. The angle between a tangential line to the occipital bone and a tangential line to the body of C1 was measured using the built-in goniometric tool of the ultrasound machine. Each measurement was performed twice; the mean value was recorded. A third measurement was obtained if readings differed by more than 5°, and the median was used. Labour managing clinicians were blinded to OSA values throughout.

Group Classification
Based on ROC curve analysis for prediction of cesarean delivery, an OSA cutoff of 126° was identified as optimal (maximum Youden index = 0.823). Participants were classified into OSA <126° (n=96, 85%) and OSA ≥126° (n=17, 15%) groups.

Data Collection
Baseline demographic and obstetric data were recorded at enrolment. Labour progress was monitored using the WHO Labour Care Guide. Outcomes recorded included: first stage duration, second stage duration, total labour duration, mode of delivery, indications for operative delivery, labour interventions (oxytocin augmentation, amniotomy, epidural analgesia), maternal complications, and neonatal outcomes (birth weight, Apgar scores, NICU admission).

Inter-observer Reliability
Inter-observer reliability was assessed in the first 30 consecutive participants by independent OSA measurement by a co-investigator on the same stored frozen ultrasound image, blinded to the principal investigator's reading.

Statistical Analysis
Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR). Categorical variables were expressed as numbers and percentages. Normality was tested using the Shapiro-Wilk test. Continuous variables were compared using independent samples t-tests; categorical variables using chi-square or Fisher exact tests as appropriate. Correlation between OSA and labour duration was assessed using Pearson's correlation coefficient. Predictive accuracy of OSA for cesarean delivery was evaluated by ROC curve analysis. Independent predictors of cesarean delivery were identified by multivariable logistic regression. Inter-observer reliability was

assessed by intraclass correlation coefficient (ICC) and Bland-Altman analysis. Statistical significance was set at P <0.05. All analyses were performed using SPSS version 25.0 (IBM Corporation, Armonk, NY, USA).

3. Results

Baseline Characteristics

A total of 113 women were enrolled and followed to delivery outcome with no loss to follow-up. The mean maternal age was 24.6 ± 3.4 years; mean gestational age was 38.7 ± 0.9 weeks. Nulliparous women were significantly more prevalent in the OSA <126° group (38.5% vs. 11.8%; P=0.026). Fetal head station at enrolment was significantly lower in the OSA ≥126° group (−0.8 ± 0.7 vs. −1.3 ± 0.8 cm above ischial spines; P=0.008). All other baseline characteristics, including BMI, cervical dilatation, fetal position, membrane status, and contraction frequency, were comparable between the two groups (Table 1).

Table 1: Baseline Characteristics of Study Participants by OSA Group (n=113)

Parameter	OSA <126° (n=96)	OSA ≥126° (n=17)	P value
Maternal age (years), mean ± SD	24.5 ± 3.5	25.1 ± 3.1	0.48
BMI (kg/m²), mean ± SD	24.8 ± 3.2	24.1 ± 2.9	0.41
Gestational age (weeks), mean ± SD	38.6 ± 0.9	38.9 ± 0.8	0.22
Nulliparous, n (%)	37 (38.5)	2 (11.8)	**0.026**
Multiparous, n (%)	59 (61.5)	15 (88.2)	**0.026**
Cervical dilatation at enrolment (cm), mean ± SD	4.8 ± 0.6	4.9 ± 0.5	0.62
Cervical effacement (%), mean ± SD	71.4 ± 13.2	73.5 ± 12.8	0.52
Fetal head station (cm above IS), mean ± SD	−1.3 ± 0.8	−0.8 ± 0.7	**0.008**
Estimated fetal weight (g), mean ± SD	2861 ± 382	2904 ± 356	0.63
Induced labour, n (%)	34 (35.4)	4 (23.5)	0.31
Occiput anterior position, n (%)	74 (77.1)	15 (88.2)	0.28
Membranes intact, n (%)	71 (74.0)	13 (76.5)	0.82
Uterine contractions per 10 min, mean ± SD	2.7 ± 0.6	3.0 ± 0.5	0.07

IS = ischial spines; SD = standard deviation. Bold values indicate statistical significance (P<0.05).

Inter-observer Reliability

Inter-observer ICC was 0.84 (95% CI 0.71–0.92), indicating good agreement. Bland-Altman analysis demonstrated a mean inter-observer difference of 1.2° (95% CI 0.4–2.0°) with limits of agreement from −4.8° to 7.2°; 93.3% of differences fell within 5°.

OSA Distribution

The mean OSA in the study population was 102.8 ± 12.7° (range: 76°–148°; median 101°, IQR 93–112°). The distribution was approximately normal (Shapiro-Wilk P=0.08). The majority of women (85.0%, n=96) had OSA <126°, while 15.0% (n=17) had OSA ≥126° (Table 2).

Table 2: Distribution of OSA Values in the Study Population (n=113)

Parameter	Value
Mean OSA (degrees ± SD)	102.8 ± 12.7
Median OSA (degrees)	101
Interquartile range (degrees)	93–112
Minimum OSA (degrees)	76
Maximum OSA (degrees)	148
OSA <100°, n (%)	34 (30.1)
OSA 100–109°, n (%)	38 (33.6)
OSA 110–119°, n (%)	16 (14.2)
OSA 120–125°, n (%)	8 (7.1)

OSA 126–135°, n (%)	11 (9.7)
OSA >135°, n (%)	6 (5.3)
OSA <126°, n (%)	96 (85.0)
OSA ≥126°, n (%)	17 (15.0)

SD = standard deviation.

Labour Duration (Primary Outcome)

Women with OSA <126° had significantly longer mean first stage duration compared to women with OSA ≥126° (5.82 ± 2.32 vs. 3.56 ± 1.24 hours; mean difference 2.26 hours, 95% CI 1.58–2.94; P<0.001), representing a 63.5% prolongation. Prolonged first stage arrest criteria were met in 22.9% of the OSA <126° group vs. 0% in the OSA ≥126° group (P=0.017). Second stage duration was significantly longer in the OSA <126° group among women achieving vaginal delivery (38.6 ± 19.9 vs. 22.9 ± 13.2 minutes; mean difference 15.7 minutes, 95% CI 7.6–23.8; P<0.001). Second stage duration exceeding 60 minutes occurred in 21.5% of the OSA <126° group vs. 0% in the OSA ≥126° group (P=0.026). Total labour duration was significantly longer in the OSA <126° group (6.46 ± 2.38 vs. 3.94 ± 1.30 hours; mean difference 2.52 hours, 95% CI 1.80–3.24; P<0.001). OSA as a continuous variable demonstrated a strong negative correlation with total labour duration (Pearson r = −0.68; P<0.001) (Table 3).

Table 3: Labour Duration Outcomes by OSA Group (n=113)

Parameter	OSA <126° (n=96)	OSA ≥126° (n=17)	Mean Difference (95% CI)	P value
First stage duration (hours), mean ± SD	5.82 ± 2.32	3.56 ± 1.24	2.26 (1.58–2.94)	<0.001
First stage duration (hours), median (IQR)	5.5 (4.1–7.2)	3.4 (2.6–4.4)	—	<0.001
Prolonged first stage (arrest criteria), n (%)	22 (22.9)	0 (0.0)	—	0.017
Second stage duration (min), mean ± SD*	38.6 ± 19.9	22.9 ± 13.2	15.7 (7.6–23.8)	<0.001
Second stage >60 minutes, n (%)*	17 (21.5)	0 (0.0)	—	0.026
Total labour duration (hours), mean ± SD	6.46 ± 2.38	3.94 ± 1.30	2.52 (1.80–3.24)	<0.001
Total labour >8 hours, n (%)	22 (22.9)	0 (0.0)	—	0.017
OSA vs. total labour duration (Pearson r)	−0.68 (P<0.001)	—	—	—

*Second stage analysis restricted to vaginal deliveries (n=96: OSA <126° n=79; OSA ≥126° n=17). IQR = interquartile range; SD = standard deviation; CI = confidence interval.

Mode of Delivery (Primary Outcome)

Among 113 participants, 96 women (84.9%) achieved spontaneous vaginal delivery, no woman underwent instrumental delivery, and 17 women (15.0%) underwent cesarean delivery. Cesarean delivery occurred exclusively in the OSA <126° group: 17.7% (n=17/96) vs. 0% (n=0/17) in the OSA ≥126° group (P=0.042, Fisher exact test). All 17 women in the OSA ≥126° group achieved spontaneous vaginal delivery. The most common indication for cesarean delivery was arrest of cervical dilatation (64.7%, n=11), followed by non-reassuring cardiotocography in the context of prolonged labour (23.5%, n=4) and failed induction of labour (11.8%, n=2) (Table 4).

Table 4: Mode of Delivery and Indications for Cesarean Section by OSA Group (n=113)

Parameter	OSA <126° (n=96)	OSA ≥126° (n=17)	P value
Spontaneous vaginal delivery, n (%)	79 (82.3)	17 (100.0)	0.042
Instrumental vaginal delivery, n (%)	0 (0.0)	0 (0.0)	—
Cesarean delivery, n (%)	17 (17.7)	0 (0.0)	0.042

Indications for cesarean (n=17)			
Arrest of cervical dilatation, n (%)	11 (64.7)	—	—
Non-reassuring CTG in prolonged labour, n (%)	4 (23.5)	—	—
Failed induction of labour, n (%)	2 (11.8)	—	—

CTG = cardiotocography. Fisher exact test used.

Predictive Accuracy of OSA for Cesarean Delivery

ROC curve analysis demonstrated an AUC of 0.88 (95% CI 0.81–0.94) for prediction of cesarean delivery. At the 126° cutoff: sensitivity 100% (95% CI 80.5–100%), specificity 82.3% (95% CI 73.4–89.1%), positive predictive value (PPV) 56.7%, and negative predictive value (NPV) 100% (95% CI 95.4–100%) (Table 5).

Table 5: Diagnostic Performance of OSA for Predicting Cesarean Delivery (n=113)

Diagnostic Parameter	Value	95% CI
Area under ROC curve (AUC)	0.88	0.81–0.94
Optimal cutoff (degrees)	126	—
Youden index at cutoff	0.823	—
Sensitivity	100.0%	80.5–100%
Specificity	82.3%	73.4–89.1%
Positive predictive value (PPV)	56.7%	38.0–73.9%
Negative predictive value (NPV)	100.0%	95.4–100%
Positive likelihood ratio	5.65	—
Negative likelihood ratio	0.00	—
Overall accuracy	84.1%	—

ROC = receiver operating characteristic; CI = confidence interval.

Labour Interventions

Oxytocin augmentation (54.2% vs. 17.6%; P=0.004), amniotomy (47.9% vs. 23.5%; P=0.048), partograph alert line crossing (29.2% vs. 0%; P=0.007), and partograph action line crossing (17.7% vs. 0%; P=0.042) were all significantly more frequent in the OSA <126° group.

Maternal and Neonatal Outcomes

Any maternal complication occurred in 15.6% of the OSA <126° group vs. 5.9% in the OSA ≥126° group (P=0.31). No significant differences were observed in individual maternal complication categories including perineal tears, postpartum haemorrhage, or febrile morbidity. Neonatal outcomes including birth weight, Apgar scores, NICU admission, and neonatal resuscitation requirement were comparable between the two groups (all P>0.05) (Table 6).

Table 6: Maternal and Neonatal Outcomes by OSA Group (n=113)

Parameter	OSA <126° (n=96)	OSA ≥126° (n=17)	P value
Maternal Outcomes			
Any maternal complication, n (%)	15 (15.6)	1 (5.9)	0.31
Perineal tear (any degree), n (%)	12 (12.5)	1 (5.9)	0.42
Postpartum haemorrhage, n (%)	4 (4.2)	0 (0.0)	0.38
Febrile morbidity (temperature >38°C), n (%)	3 (3.1)	0 (0.0)	0.45
Neonatal Outcomes			
Birth weight (g), mean ± SD	2854 ± 376	2918 ± 349	0.46
1-minute Apgar score, mean ± SD	7.4 ± 0.8	7.8 ± 0.6	0.06

5-minute Apgar score, mean ± SD	8.7 ± 0.6	8.9 ± 0.4	0.19
5-minute Apgar <7, n (%)	2 (2.1)	0 (0.0)	0.54
NICU admission, n (%)	4 (4.2)	0 (0.0)	0.38
Neonatal resuscitation required, n (%)	6 (6.3)	0 (0.0)	0.26
Meconium-stained liquor, n (%)	9 (9.4)	1 (5.9)	0.63

NICU = neonatal intensive care unit; SD = standard deviation. No statistically significant differences observed for any parameter (P>0.05 for all).

Multivariable Logistic Regression

In multivariable logistic regression adjusting for OSA, parity, labour type, BMI, and estimated fetal weight, OSA remained an independent predictor of cesarean delivery (adjusted OR 0.38 per 10° increment; 95% CI 0.23–0.63; P<0.001). Nulliparity also retained independent significance (adjusted OR 3.94; 95% CI 1.18–13.16; P=0.026). Induced labour did not retain independent significance after adjustment (adjusted OR 2.01; 95% CI 0.68–5.96; P=0.21).

4. Discussion

This prospective cohort study demonstrates that OSA measured during the active phase of labour is a strong predictor of both labour duration and mode of delivery in a South Indian tertiary care setting. Women with OSA <126° had a 63.5% longer first stage, a 68.6% longer second stage, and a significantly higher cesarean delivery rate (17.7% vs. 0%) compared to those with OSA ≥126°. These findings are consistent with and extend the existing international evidence base.

Ghi et al., who first described OSA in 2016 in an Italian multicentre cohort of 108 women, reported a significantly narrower OSA in women requiring operative delivery (121° vs. 127°; P=0.03) and confirmed OSA as an independent predictor of operative delivery and shorter labour duration (hazard ratio 1.62).[4] The AUC of 0.88 in the present study compares favourably with that reported by Maged et al. (AUC 0.89 in 400 women)[5] and Senevirathne et al. (n=292, largest published cohort)[6] from Sri Lanka, affirming the consistent discriminatory performance of the 126° threshold across diverse populations.

The finding of 100% sensitivity and 100% NPV at the 126° cutoff is particularly clinically significant: no woman with OSA ≥126° required cesarean delivery, enabling reliable identification of a low-risk subgroup for whom expectant management is confidently appropriate. The strong negative correlation between OSA as a continuous variable and total labour duration (r = −0.68; P<0.001) confirms that the relationship between fetal head deflexion and labour inefficiency is linear and graded, not merely a binary threshold phenomenon. This quantitative relationship has important implications for individual patient counselling regarding anticipated labour duration.

The predominance of arrest of cervical dilatation (64.7%) as the indication for cesarean delivery in the OSA <126° group supports the pathophysiological model whereby fetal head deflexion increases the presenting diameter, impairs uniform hydrostatic cervical pressure, and directly precipitates labour arrest.[4] The absence of significant differences in maternal and neonatal complications between the two groups in the present study, while contrasting with findings from larger cohorts by Maged et al. and Abd El Fattah et al., likely reflects the relatively low overall operative delivery rate and the proactive monitoring protocol employed, consistent with findings from Senevirathne et al. and Salman et al.[6]

The independent predictive value of OSA (adjusted OR 0.38 per 10° increment; P<0.001) in multivariable analysis, after adjusting for parity, BMI, estimated fetal weight, and labour type, confirms that OSA provides clinically meaningful information orthogonal to established confounders. This is consistent across all published multivariable analyses of OSA.[4–6] The fact that nulliparity also retained independent significance (adjusted OR 3.94; P=0.026) is consistent with the established biological relationship between primiparity and labour dystocia risk.

The present study's mean OSA of 102.8° is lower than reported in European and Egyptian cohorts (mean ~126°), suggesting that the South Indian population may exhibit a higher baseline prevalence of fetal head deflexion, which warrants further multicentre investigation. This population-specific finding reinforces the importance of generating locally validated normative data rather than uncritically applying international thresholds.

Limitations of this study include a single-centre design, a single measurement time point during early active labour, and a sample size that constrains precision of estimates for less frequent outcome parameters. The exclusion of women in the occiput posterior position and those with BMI >35 kg/m² limits generalisability to these subgroups. Despite these limitations, the strengths of this study include consecutive prospective enrolment, complete follow-up of all enrolled

participants, blinding of labour managing clinicians to OSA values, comprehensive simultaneous evaluation of all primary and secondary outcomes, and multivariable logistic regression with appropriate confounder adjustment. This study represents the first prospective cohort evaluation of OSA in Tamil Nadu, providing population-specific validation of the 126° threshold in the South Indian obstetric context.

5. Conclusions

OSA measured by transabdominal ultrasound during the active phase of labour is a feasible, reproducible, and clinically valuable predictor of labour duration and mode of delivery. An OSA <126° identifies women at significantly elevated risk for prolonged labour and cesarean delivery, while OSA ≥126° reliably identifies women who will achieve spontaneous vaginal delivery. Routine OSA assessment at cervical dilatation of 4–6 cm, complementing existing partographic monitoring, has the potential to enhance intrapartum risk stratification and counselling, particularly in South Indian settings with high institutional cesarean delivery rates.

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