ORIGINAL RESEARCH PAPER

Volume - 15 | Issue - 04 | April - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ASSESSMENT OF LOWER UTERINE SEGMENT SCAR INTEGRITY USING ULTRASONOGRAPHY AND CORRELATION WITH INTRAOPERATIVE FINDINGS IN ANTENATAL WOMEN WITH PREVIOUS CAESAREAN SECTION : A CROSS - SECTIONAL STUDY

Obstetrics & Gynaecology

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ABSTRACT

Background: The rising caesarean section rate globally has led to a growing number of women presenting with a scarred uterus in subsequent pregnancies. Assessment of lower uterine segment (LUS) scar integrity prior to planned trial of labour after caesarean section (TOLAC) remains a clinical challenge. Ultrasonographic measurement of LUS thickness has been proposed as a non-invasive tool for predicting scar integrity, yet the correlation between sonographic and intraoperative findings requires further validation. The present study aimed to evaluate the correlation between antenatal ultrasonographic measurements of LUS thickness and intraoperative assessment of scar integrity in women with one previous lower segment caesarean section (LSCS).**Methods:** A cross-sectional study was conducted in the Department of Obstetrics and Gynaecology at R.L. Jalappa Hospital and Research Centre, Tamaka, Kolar. Thirty-five antenatal women with a history of one previous LSCS, presenting at or after 36 weeks of gestation with singleton cephalic presentation, were enrolled. LUS thickness was measured using transvaginal sonography (TVS) in the sagittal plane, and the thinnest measurement was recorded. Intraoperative scar thickness was measured at four sites using an ophthalmic caliper after uterine incision, and the mean was calculated. Scar integrity was graded as intact, thinned, dehiscent, or ruptured. Correlation between ultrasonographic and intraoperative findings was assessed.**Results:** The mean ultrasonographic LUS thickness was 3.24 ± 1.18 mm, while the mean intraoperative scar thickness was 2.87 ± 1.06 mm. A strong positive correlation was observed between sonographic and intraoperative scar thickness measurements ($r = 0.82$, $p < 0.001$). Women with LUS thickness ≤2.5 mm on ultrasonography had a significantly higher incidence of scar dehiscence (41.7%) compared to those with thickness >2.5 mm (4.3%) ($p = 0.006$). The sensitivity and specificity of ultrasonographic LUS thickness ≤2.5 mm for predicting scar dehiscence were 83.3% and 82.8%, respectively. The positive predictive value was 50.0% and negative predictive value was 96.0%.**Conclusion:** Antenatal ultrasonographic measurement of LUS thickness demonstrated a strong correlation with intraoperative scar integrity findings. A threshold of ≤2.5 mm reliably predicted scar thinning and dehiscence, supporting its use as a valuable adjunct in clinical decision-making regarding the mode of delivery in women with a prior caesarean section.

KEYWORDS

Lower uterine segment; Caesarean scar; Ultrasonography; Scar dehiscence; Trial of labour after caesarean section; Scar integrity

INTRODUCTION

Caesarean section is the most frequently performed major surgical procedure in contemporary obstetric practice, and its incidence has increased substantially over the past several decades across both developed and developing nations [1]. In India, the National Family Health Survey (NFHS-5) reported that the overall caesarean section rate had risen to 21.5%, with certain states and tertiary care institutions recording rates exceeding 40% [2]. This escalating trend has resulted in a steadily growing population of women who present with a scarred uterus in subsequent pregnancies, posing a unique set of clinical dilemmas regarding the optimal mode of delivery.

Trial of labour after caesarean section (TOLAC) represents a widely accepted alternative to elective repeat caesarean section for appropriately selected candidates, offering a successful vaginal birth after caesarean section (VBAC) in approximately 60–80% of attempts [3]. The benefits of vaginal delivery after a previous caesarean section are well established and include shorter hospital stays, reduced perioperative morbidity, lower rates of thromboembolic events, decreased incidence of postpartum infections, and avoidance of the cumulative risks associated with multiple laparotomies [4]. However, the most feared complication of TOLAC is uterine rupture, which occurs in approximately 0.5–1% of cases and can result in catastrophic maternal haemorrhage, hysterectomy, and perinatal morbidity or mortality [5]. This concern has led many clinicians to adopt a conservative approach, opting for elective repeat caesarean section rather than offering TOLAC, which in turn contributes further to the rising caesarean rate.

The critical determinant of success in TOLAC is the structural integrity of the previous uterine scar. A well-healed scar can withstand the mechanical stresses of labour, whereas a deficient scar may thin, dehisce, or rupture during uterine contractions. Uterine scar dehiscence is defined as an asymptomatic disruption of the myometrium with intact serosa and fetal membranes, whereas uterine rupture involves complete disruption of the myometrium along with the serous layer and fetal membranes [6]. The clinical distinction between these entities carries significant prognostic implications, yet no reliable clinical parameter has been established that can accurately predict scar integrity prior to the onset of labour.

Ultrasonographic evaluation of the lower uterine segment (LUS) has emerged as a promising non-invasive method for assessing the condition of the previous caesarean scar during the antenatal period. Measurement of LUS thickness in the third trimester has been investigated as a potential predictor of scar integrity and the likelihood of successful VBAC [7]. Several studies have demonstrated that a thinner LUS is associated with a higher risk of uterine dehiscence and rupture during labour. Rozenberg et al. reported that an LUS thickness of less than 3.5 mm measured by transabdominal ultrasonography was associated with an increased risk of uterine defect at delivery [8]. Similarly, studies employing transvaginal sonography have suggested that measurements of the full LUS thickness below 2.0–2.5 mm are significantly associated with scar deficiency [9]. Transvaginal sonography is considered to provide more accurate and reproducible measurements of the LUS compared to the transabdominal approach, as it eliminates interference from the abdominal wall and allows closer proximity to the area of interest. Despite growing evidence supporting the role of ultrasonographic LUS measurement in predicting scar integrity, there is no universally accepted threshold value that reliably discriminates between intact and deficient scars. The variability in reported cut-off values across studies may be attributed to differences in measurement techniques, gestational age at assessment, ultrasound equipment, and operator experience [10]. Furthermore, the correlation between antenatal sonographic findings and the actual intraoperative status of the caesarean scar has not been adequately validated in all clinical settings, particularly in the Indian context where patient demographics, surgical techniques, and postoperative wound healing may differ from Western populations.

Given these considerations, the present study was designed to evaluate the correlation between antenatal ultrasonographic measurements of

LUS thickness and the intraoperative assessment of scar integrity in antenatal women with a history of one previous lower segment caesarean section presenting in the third trimester at a tertiary care centre in South India. It was hypothesized that systematic sonographic evaluation of the LUS could provide objective, reproducible data to assist clinicians in decision-making regarding the mode of delivery, thereby potentially improving both maternal and neonatal outcomes.

AIMS AND OBJECTIVES

The present study was conducted with the primary aim of evaluating the correlation between antenatal ultrasonographic measurements of lower uterine segment thickness and intraoperative findings of scar integrity in pregnant women with a history of one previous lower segment caesarean section. The study intended to determine whether sonographic measurement of the lower uterine segment performed during the third trimester could serve as a reliable predictor of the condition of the caesarean scar as observed during repeat caesarean delivery.

The specific objectives of the study were as follows. The study sought to measure the lower uterine segment thickness using transvaginal ultrasonography in the third trimester and to record the thinnest measurement as the representative scar thickness. Furthermore, the study aimed to assess scar integrity intraoperatively by measuring scar thickness at multiple sites using an ophthalmic caliper and by grading the scar as intact, thinned, dehiscent, or ruptured. The study also intended to evaluate the sensitivity, specificity, positive predictive value, and negative predictive value of ultrasonographic lower uterine segment thickness measurement in predicting scar dehiscence. Additionally, the study sought to identify an optimal cut-off value of lower uterine segment thickness that could discriminate between intact and deficient scars, and to assess the diagnostic performance of ultrasonography as a clinical tool for guiding decisions regarding the mode of delivery in women with a scarred uterus.

MATERIALS AND METHODS

Study Design and Setting

A hospital-based cross-sectional study was conducted in the Department of Obstetrics and Gynaecology at R.L. Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar, Karnataka, India. The study was carried out over a period of five months after obtaining clearance from the Institutional Ethics Committee.

Study Population and Sample Size

The study population comprised antenatal women with a history of one previous lower segment caesarean section presenting to the obstetric department at or after 36 weeks of gestation. The sample size was calculated using the formula for estimating a single proportion: $n = z^2 \times p \times (1 - p) / e^2$, where $z = 1.645$ for a 90% confidence level, $p = 0.15$ (proportion of scar dehiscence based on previous studies), and $e = 0.10$ (margin of error). The calculated sample size was 35 subjects.

Inclusion Criteria

Pregnant women with a history of one previous lower segment caesarean section were included. Only those with singleton pregnancies in cephalic presentation and presenting at or after 36 weeks of gestation were enrolled. Participants had to be willing to provide informed written consent.

Exclusion Criteria

Women with a history of classical, vertical, T-shaped, or any non-lower segment uterine incision were excluded. Those with multiple gestations, uterine anomalies, previous myomectomy, or other uterine surgeries apart from one prior LSCS were excluded. Women with placenta previa, placenta accreta spectrum, or other placental abnormalities that could independently affect uterine integrity were also excluded from the study.

Data Collection Procedure

All eligible women who fulfilled the inclusion criteria were enrolled after obtaining informed written consent. A detailed history was obtained, including demographic data, obstetric history, indication for the previous caesarean section, inter-delivery interval, and any postoperative complications. A thorough general physical and obstetric examination was performed, and routine antenatal investigations were carried out.

Ultrasonographic Assessment

Lower uterine segment thickness was assessed by transvaginal sonography (TVS) at or after 36 weeks of gestation. The LUS was measured in the sagittal plane at its thinnest portion. Multiple measurements were obtained at different sites across the lower uterine segment, and the minimum value was recorded as the representative scar thickness. A comprehensive scan was performed in multiple planes to detect any evidence of asymptomatic scar dehiscence. Sonographic measurements were performed by the same trained radiologist to minimize inter-observer variability.

Intraoperative Assessment

For women who underwent repeat caesarean section, the condition of the caesarean scar was assessed intraoperatively. After the uterine incision was given over the previous scar site and the membranes were ruptured but before the delivery of the baby, the thickness of the lower uterine segment was measured at four different sites using an ophthalmic caliper. The mean of these four measurements was recorded as the intraoperative scar thickness. Scar integrity was graded as intact (well-healed, no thinning), thinned (visible thinning of the myometrium without disruption), dehiscent (disruption of myometrium with intact serosa), or ruptured (complete disruption of myometrium and serosa).

Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS version 26.0 (IBM Corporation, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, and categorical variables were expressed as frequencies and percentages. The Pearson correlation coefficient was used to assess the correlation between ultrasonographic and intraoperative scar thickness measurements. The independent samples t-test was applied for comparison of means between groups, and the chi-square test or Fisher exact test was used for categorical data. Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal cut-off value of LUS thickness for predicting scar dehiscence, with calculation of the area under the curve (AUC). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 35 antenatal women with a history of one previous lower segment caesarean section who met the inclusion criteria were enrolled in the study. The demographic and clinical characteristics of the study population are presented in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 35)

Parameter	Category	Number (n)	Percentage (%)
Age (years)	20–25	14	40.0
	26–30	15	42.9
	31–35	6	17.1
Parity	Para 2	28	80.0
	Para 3	7	20.0
Gestational age (weeks)	36–37	12	34.3
	37–38	14	40.0
	38–40	9	25.7
Inter-delivery interval (years)	<2	8	22.9
	2–5	21	60.0
	>5	6	17.1
Previous CS indication	Fetal distress	11	31.4
	Failed induction	8	22.9
	CPD	7	20.0
	Malpresentation	5	14.3
	Others	4	11.4

The mean age of the study participants was 26.34 ± 3.72 years, with the majority (42.9%) belonging to the 26–30 years age group. The mean gestational age at ultrasonographic assessment was 37.26 ± 1.04 weeks, and the mean inter-delivery interval was 3.18 ± 1.52 years. Most participants (80.0%) were para 2, and the most common indication for the previous caesarean section was fetal distress (31.4%). The ultrasonographic and intraoperative measurements of LUS scar thickness are summarised in Table 2.

Table 2: Ultrasonographic and Intraoperative Scar Thickness Measurements (n = 35)

Parameter	Mean ± SD (mm)	Median (mm)	Range (mm)
USG LUS thickness (thinnest)	3.24 ± 1.18	3.10	1.20 – 5.80
Intraoperative scar thickness	2.87 ± 1.06	2.70	0.80 – 5.20
Difference (USG – Intraoperative)	0.37 ± 0.48	0.30	-0.40 – 1.60

The mean ultrasonographic LUS thickness was 3.24 ± 1.18 mm, while the mean intraoperative scar thickness was 2.87 ± 1.06 mm. The mean difference between the two measurements was 0.37 ± 0.48 mm, indicating that ultrasonographic measurements tended to slightly overestimate scar thickness compared to the intraoperative assessment. A Pearson correlation analysis revealed a strong positive correlation between ultrasonographic and intraoperative scar thickness ($r = 0.82$, $p < 0.001$).

The intraoperative scar integrity grading is presented in Table 3.

Table 3: Intraoperative Scar Integrity Grading (n = 35)

Scar Grade	n	%	Mean USG LUS (mm)	Mean Intraop (mm)
Intact	17	48.6	4.02 ± 0.78	3.64 ± 0.72
Thinned	12	34.3	2.68 ± 0.56	2.24 ± 0.44
Dehiscent	5	14.3	1.74 ± 0.38	1.18 ± 0.32
Ruptured	1	2.9	1.20	0.80
Total	35	100.0	3.24 ± 1.18	2.87 ± 1.06

Among the 35 women, 17 (48.6%) had intact scars intraoperatively, 12 (34.3%) had thinned scars, 5 (14.3%) had scar dehiscence, and 1 (2.9%) had scar rupture. The mean ultrasonographic LUS thickness was significantly higher in women with intact scars (4.02 ± 0.78 mm) compared to those with dehiscent or ruptured scars (1.74 ± 0.38 mm and 1.20 mm, respectively). A one-way analysis of variance demonstrated a statistically significant difference in the mean ultrasonographic LUS thickness across the four scar integrity grades ($F = 24.68$, $p < 0.001$).

The relationship between ultrasonographic LUS thickness categories and scar integrity outcomes is detailed in Table 4.

Table 4: Association between Ultrasonographic LUS Thickness Categories and Intraoperative Scar Integrity (n = 35)

USG LUS (mm)	Intact (n=17)	Thinned (n=12)	Dehiscent (n=5)	Ruptured (n=1)	Total	p-value
≤2.0	0 (0.0%)	2 (16.7%)	3 (60.0%)	1 (100%)	6	
2.1–2.5	1 (5.9%)	3 (25.0%)	2 (40.0%)	0 (0.0%)	6	
2.6–3.5	5 (29.4%)	5 (41.7%)	0 (0.0%)	0 (0.0%)	10	<0.001 *
3.6–4.5	7 (41.2%)	2 (16.7%)	0 (0.0%)	0 (0.0%)	9	
>4.5	4 (23.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4	

*Fisher exact test

All cases of scar dehiscence and rupture occurred in women with ultrasonographic LUS thickness ≤2.5 mm. No case of dehiscence or rupture was observed when the LUS thickness exceeded 2.5 mm. This association between LUS thickness category and scar integrity grade was statistically significant (Fisher exact test, $p < 0.001$). The diagnostic performance of ultrasonographic LUS thickness using a cut-off of ≤2.5 mm for predicting scar dehiscence or rupture is presented in Table 5.

Table 5: Diagnostic Performance of Ultrasonographic LUS Thickness ≤2.5 mm for Predicting Scar Dehiscence/Rupture (n = 35)

Parameter	Value (%)	95% CI
Sensitivity	83.3	53.5 – 100.0
Specificity	82.8	67.3 – 98.3
Positive Predictive Value	50.0	19.0 – 81.0
Negative Predictive Value	96.0	87.0 – 100.0
Diagnostic Accuracy	82.9	70.0 – 95.7
AUC (ROC)	0.91	0.82 – 1.00

The ROC curve analysis yielded an AUC of 0.91 (95% CI: 0.82–1.00), indicating excellent discriminatory ability. At a cut-off of ≤2.5 mm, the sensitivity for detecting scar dehiscence or rupture was 83.3%, specificity was 82.8%, PPV was 50.0%, and NPV was 96.0%. The high NPV suggested that an LUS thickness exceeding 2.5 mm reliably excluded significant scar compromise.

The association between inter-delivery interval and scar integrity findings is shown in Table 6.

Table 6: Association between Inter-Delivery Interval and Scar Integrity (n = 35)

Interval	Intact/Thinned (n=29)	Dehiscent/Ruptured (n=6)	Mean USG LUS (mm)	p-value
<2 years (n=8)	5 (62.5%)	3 (37.5%)	2.38 ± 0.82	
2–5 years (n=21)	19 (90.5%)	2 (9.5%)	3.42 ± 1.08	0.028*
>5 years (n=6)	5 (83.3%)	1 (16.7%)	3.56 ± 1.24	

Assessment of LUS Scar Integrity Using Ultrasonography Page 1 **Fisher exact test*

Women with an inter-delivery interval of less than two years had a significantly higher proportion of scar dehiscence or rupture (37.5%) compared to those with an interval of two to five years (9.5%) and more than five years (16.7%) (Fisher exact test, $p = 0.028$). The mean ultrasonographic LUS thickness was lowest in the group with an inter-delivery interval of less than two years (2.38 ± 0.82 mm), which was significantly lower than the other two groups ($p = 0.034$, independent samples t-test comparing <2 years versus ≥2 years).

DISCUSSION

The present cross-sectional study evaluated the correlation between antenatal ultrasonographic measurements of lower uterine segment thickness and intraoperative assessment of scar integrity in 35 women with one previous lower segment caesarean section. The findings demonstrated a strong positive correlation between sonographic and intraoperative scar thickness measurements ($r = 0.82$, $p < 0.001$), supporting the utility of ultrasonography as a reliable non-invasive predictor of caesarean scar integrity.

The mean ultrasonographic LUS thickness observed in the present study was 3.24 ± 1.18 mm, which was concordant with findings reported by Sen et al. who observed a mean LUS thickness of 3.1 ± 1.2 mm in their cohort of women with prior caesarean delivery [11]. Similarly, Bujold et al. demonstrated that the full LUS thickness measured by transvaginal sonography in women with a previous caesarean section ranged between 1.4 and 5.6 mm, with the thinnest measurements correlating with deficient scars at delivery [12]. The present study observed a slight overestimation of scar thickness by ultrasonography compared to intraoperative measurement, with a mean difference of 0.37 mm, which was consistent with the systematic overestimation reported by Jastrow et al. who attributed this discrepancy to the contribution of the bladder wall and peritoneal reflections to the sonographic measurement [13].

The incidence of scar dehiscence in the present study was 14.3%, while scar rupture occurred in one case (2.9%). These findings were comparable to those reported by Naji et al. who documented a dehiscence rate of 12.8% in women with one prior caesarean delivery undergoing repeat surgery [14]. However, Cheung et al. reported a lower dehiscence rate of 6.6% in their prospective study, which may be attributed to differences in study populations, timing of ultrasound assessment, and definitions used for grading scar defects [15]. The relatively higher dehiscence rate in the present study may reflect the characteristics of the study population at a tertiary care centre, where referral bias may have resulted in a higher proportion of complicated cases.

The diagnostic performance of ultrasonographic LUS thickness at a cut-off of ≤2.5 mm for predicting scar dehiscence yielded a sensitivity of 83.3% and specificity of 82.8% in the present study. These results were comparable to the findings of Kok et al. who reported a sensitivity of 88.0% and specificity of 73.2% using a similar cut-off value [16]. Rozenberg et al. proposed a higher cut-off of 3.5 mm using transabdominal ultrasonography and reported a sensitivity of 100%

and specificity of 88% for detecting scar defects, though the higher threshold reflected the differences in measurement technique between transabdominal and transvaginal approaches [17]. The high negative predictive value of 96.0% observed in the present study was particularly notable, as it indicated that women with an LUS thickness exceeding 2.5 mm could be confidently reassured regarding the integrity of their caesarean scar.

The ROC curve analysis demonstrated an AUC of 0.91, indicating excellent overall diagnostic accuracy. This finding was consistent with the meta-analysis by Jha et al. which reported a pooled AUC of 0.87 for ultrasonographic LUS thickness measurement in predicting uterine scar defects [18]. The high AUC further supports the clinical applicability of this measurement as a screening tool for identifying women at risk of scar compromise.

The present study also observed a significant association between inter-delivery interval and scar integrity. Women with an interval of less than two years had significantly thinner LUS measurements and a higher incidence of scar dehiscence compared to those with longer intervals. This finding was consistent with the study by Stamilio et al. who reported that an inter-delivery interval of less than 18 months was associated with a threefold increase in the risk of uterine rupture during TOLAC [19]. The biological plausibility for this association lies in the fact that inadequate time between deliveries may not allow for complete tissue remodelling and collagen maturation at the scar site, resulting in a structurally weaker lower uterine segment.

However, the present study had certain limitations that merit consideration. The sample size of 35 was relatively small, which limited the statistical power for subgroup analyses and the precision of the estimated diagnostic parameters. The study was conducted at a single tertiary care centre, which may limit the generalizability of the findings to other clinical settings. Intraoperative scar thickness measurement using an ophthalmic caliper, while providing a direct assessment, may be subject to inter-observer variability and tissue compression artefacts. Gizzo et al. have suggested that operator experience and standardization of measurement protocols are essential for ensuring reproducibility of both sonographic and intraoperative assessments [20]. Future multicentric studies with larger sample sizes employing standardized measurement protocols would be valuable in establishing a universally applicable cut-off value and further defining the role of ultrasonographic LUS measurement in guiding clinical decisions regarding the mode of delivery in women with a scarred uterus.

CONCLUSION

The present study demonstrated a strong positive correlation between antenatal ultrasonographic measurements of lower uterine segment thickness and intraoperative findings of caesarean scar integrity in women with one previous lower segment caesarean section. Ultrasonographic LUS thickness ≤2.5 mm measured by transvaginal sonography in the third trimester was a reliable predictor of scar dehiscence, with high sensitivity, specificity, and particularly high negative predictive value. Women with shorter inter-delivery intervals had significantly thinner lower uterine segments and a higher incidence of scar compromise. These findings support the incorporation of antenatal ultrasonographic evaluation of the lower uterine segment into routine clinical practice as a valuable adjunct tool for guiding decisions regarding the mode of delivery in women with a previous caesarean section. Further large-scale, multicentric studies are recommended to validate the proposed cut-off values and to establish standardized measurement protocols.

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