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Original Research Article

Assessment and comparison of clinical scar tenderness and imaging scar thickness for prediction of intraoperative scar integrity in pregnant patients with previous cesarean section

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ABSTRACT

Background: Caesarean delivery rates have significantly risen over the past few decades, leading to an increase in the number of women with previous caesarean scars. In subsequent pregnancies, the integrity of uterine scar becomes an essential factor in decision making regarding the mode of delivery. Accurate assessment of scar integrity enables obstetricians to predict and mitigate the risks associated with vaginal birth after caesarean delivery. Several studies have independently demonstrated the reliability of scar tenderness and scar thickness in assessing uterine scar integrity; however, this study compares both these parameters for better prediction of the intraoperative scar integrity.

Methods: 100 patients with history of previous LSCS were assessed for scar tenderness and third trimester's sonographic LUS scar thickness and later on were taken up for caesarean section. Findings were correlated with intra-operative scar condition, whether the scar was intact or was compromised (scar dehiscence or rupture).

Results: Scar thickness <2.5 mm demonstrated a sensitivity of 50%, specificity of 85%, positive predictive value of 60%, negative predictive value of 80%. Scar tenderness alone showed sensitivity of 66% and specificity of 71%, PPV of 60% and NPV of 82%. However, when both parameters were considered as combined criteria, the sensitivity improved to 74% and specificity increased to 96%, a higher PPV of 93% and an NPV of 86%.

Conclusions: Combined assessment of clinical and sonographic parameters provides a more reliable method for identifying women at risk of uterine scar compromise during subsequent deliveries.

Keywords: Scar dehiscence, Scar rupture, Scar tenderness, Scar thickness

INTRODUCTION

The rising global trend of caesarean section (CS) deliveries has led to a significant increase in the number of women presenting in subsequent pregnancies with a uterine scar, thereby posing important clinical challenges in obstetric management.¹ The World Health Organization has estimated that nearly one in five births worldwide now occurs through caesarean section, and this proportion is expected to continue to increase in coming decades.² With the growing prevalence of women with a scarred uterus, the issue of scar integrity in subsequent pregnancies has

become a vital determinant in decision making regarding the mode of delivery.

Uterine rupture or dehiscence, although uncommon, remains one of the most feared complications in women attempting vaginal birth after caesarean (VBAC) due to its association with high maternal and perinatal morbidity and mortality.³ Thus, predicting the risk of scar compromise is essential for both maternal and fetal safety. Clinical parameters, such as scar tenderness, have been traditionally used as simple bedside tools to assess uterine scar strength, but their predictive value is limited due to subjective variability and lack of reproducibility.⁴

Advances in imaging have enabled the use of ultrasonographic measurement of the lower uterine segment (LUS) thickness as an objective method to evaluate uterine scar integrity. Several studies have demonstrated that thinning of the LUS, particularly to a measurement of less than 2.0-2.5 mm, is associated with an increased likelihood of scar dehiscence or rupture during labour.^{5,6} Rozenberg et al. first demonstrated that LUS thickness measured by transabdominal ultrasonography could predict uterine rupture with reasonable accuracy.⁷ Subsequent meta-analyses have supported this association, though cut-off values and predictive reliability vary across studies.⁸

Despite the availability of these assessment tools, no single parameter has been universally accepted as definitive in predicting scar integrity. Scar tenderness, though simple and inexpensive, lacks sufficient specificity, whereas ultrasonographic scar thickness, while objective, can be influenced by operator skill, fetal position, and probe orientation.⁹ Therefore, there is a growing interest in evaluating the combined role of both clinical and imaging modalities to improve predictive accuracy.

This study was undertaken to assess and compare the role of clinical scar tenderness and ultrasonographic LUS scar thickness in predicting intraoperative scar integrity in women with a previous caesarean section, and to determine whether a combined assessment enhances diagnostic accuracy.

METHODS

This was a prospective observational study conducted from June 2023 to April 2025 in the department of obstetrics and gynecology in collaboration with radiology department at a tertiary care hospital in Kishanganj, Bihar. The study included all pregnant women with a history of previous lower uterine segment caesarean section (LSCS) admitted for delivery during the study period. The sample size was calculated based on the prevalence of scar dehiscence/rupture reported in prior literature, assumed to be 20%. Using the formula:

Expected sample size (calculation):

$$n = \frac{Z_{1-\alpha/2}^2 P(1-P)}{d^2}$$

$$Z_{1-\alpha/2}^2 = 1.96$$

$$P = 20\% = (\text{i.e. } 0.2)$$

$$1-P = 0.8$$

$$\text{Relative precision (d)} = 8\% \text{ i.e. } (0.08)$$

$$n = \frac{(1.96)^2 \times 0.2 \times (1 - 0.2)}{(0.08)^2}$$

$$n = \frac{(1.96)^2 \times 0.2 \times (1 - 0.2)}{(0.08)^2}$$

$$n = \frac{0.612656}{0.0064}$$

n = sample size was 96.04.

Rounded sample size was 100.

The required sample size was approximately 96, which was rounded to 100 participants.

Exclusion criteria

Previous LSCS presenting in active labour, placenta previa, any disorder of placenta accreta spectrum, uterine scar of unknown etiology, multiple gestations and malpresentations.

Methodology

Eligible patients were briefed about the study, and informed consent was obtained. Demographic and obstetric details including maternal age, parity, gestational age, body mass index, number of previous miscarriages, and prior caesarean sections were recorded in a structured proforma. Clinical examination was performed, and scar tenderness was assessed after bladder evacuation by gentle superficial palpation of the lower abdomen above the symphysis pubis during uterine quiescence. A visible wince was considered a positive sign.

Ultrasonographic assessment of lower uterine segment (LUS) scar thickness was carried out using both transabdominal and transvaginal approaches with high-resolution probes. A two-layered appearance was noted, consisting of an outer echogenic myometrial layer and an inner less echogenic layer (inner myometrium and decidualized endometrium). Measurements were taken in both longitudinal and transverse planes, and three sagittal measurements were averaged. Full LUS thickness was defined as the distance from the amniotic cavity to the bladder wall. Myometrial thickness was measured as the thinnest part of the myometrium overlying the scar.

Scar thickness was classified into three categories: <2.5 mm, 2.5-3.5 mm, 3.5 mm.

For statistical purposes, women were grouped into <2.5 mm and ≥ 2.5 mm.

All patients were taken up for LSCS and intraoperative evaluation of the scar was done and categorized as intact, dehiscent (uterine window), or ruptured.

Scar rupture: complete disruption of all uterine layers including serosa with clinical maternal and/or fetal compromise.

Scar dehiscence: incomplete or occult disruption without immediate clinical consequences.

Scar dehiscence and rupture were grouped into a single group as compromised scar for statistical purpose.

Maternal outcomes (hospital stay, blood transfusion requirement, infection) and neonatal outcomes (stillbirth, neonatal death) were recorded.

Statistical analysis

Data were compiled in Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean±standard deviation, and categorical variables as frequencies and percentages. Chi-square test was used to compare proportions, and Pearson correlation was applied for correlation between variables. Sensitivity, specificity,

positive predictive value (PPV), and negative predictive value (NPV) were calculated for scar tenderness, scar thickness, and combined assessment. Graphical representations were made in Microsoft Excel. A p value <0.05 was considered statistically significant.

RESULTS

The demographic characteristics of the study participants are shown in Table 1. The majority of women (42%) were in the age group of 25-29 years, followed by 30% in the 30-34 years group, 18% between 20-24 years, and 10% were aged 35 years or more. Most participants (65%) were unbooked at the time of admission, while 35% were booked cases. Regarding gestational age at the time of caesarean section, 45% were between 37 and 37+6 weeks, 40% between 38 and 38+6 weeks, and 15% between 36 and 36+6 weeks. In terms of obstetric history, 55% of women were gravida three or more, while 45% were second gravida. Parity distribution showed that 60% of participants had parity one, 30% had parity two, and only 10% had parity three or more.

Table 1: Demographic characteristics of study participants.

Parameters	Category	Number (%)
Age (years)	20-24	18 (18)
	25-29	42 (42)
	30-34	30 (30)
	≥35	10 (10)
Booking status	Booked	35 (35)
	Unbooked	65 (65)
Gestational age (weeks)	36-36+6	15 (15)
	37-37+6	45 (45)
	38-38+6	40 (40)
Gravida	2	45 (45)
	≥3	55 (55)
Parity	1	60 (60)
	2	30 (30)
	≥3	10 (10)

Table 2: Clinical and ultrasound findings.

Parameters	Category	Number (%)
Scar tenderness	Present	40 (40)
	Absent	60 (60)
LUS thickness	<2.5 mm	25 (25)
	2.5-3.5 mm	60 (60)
	>3.5 mm	15 (15)

The clinical and ultrasound findings are detailed in Table 2. Scar tenderness was present in 40% of patients, while 60% had no tenderness. Sonographic evaluation of the lower uterine segment revealed that 60% of patients had a scar thickness between 2.5-3.5 mm, 25% had less than 2.5 mm, and 15% had more than 3.5 mm.

Table 3: Intra-operative scar integrity.

Scar Status	Number (%)
Intact	70 (70)
Dehiscence	25 (25)
Rupture	5 (5)



Figure 1: Scar dehiscence.



Figure 2: Scar rupture.

Table 4: Correlation of clinical scar tenderness with intra-operative findings.

Scar Tenderness	Intact (n=70)	Compromised (n=30)	Relative Risk (95% CI)
Present (n=40)	20	20 (15D, 5R)	2.33 (0.93-5.85)
Absent (n=60)	50	10 (10D, 0R)	

Table 5: Correlation of scar thickness with intraoperative findings.

Thickness	Intact (n=70)	Compromised (n=30)	Relative Risk (95% CI)
<2.5 mm (n=25)	10	15 (12D, 3R)	3.5 (1.31-9.33)*
≥2.5 mm (n=75)	60	15 (13D, 2R)	

The intraoperative assessment of scar integrity is shown in Table 3. Seventy percent of women had intact scars, 25% had scar dehiscence, and 5% had complete rupture.

The correlation of scar tenderness with intra-operative findings (Table 4) showed that among the 40 women with tenderness, 20 (50%) had compromised scars, including 15 cases of dehiscence and 5 ruptures, while the remaining 20 had intact scars. In contrast, among the 60 women without tenderness, 50 (83.3%) had intact scars and 10 (16.7%) had dehiscence, with no rupture reported. The relative risk of scar compromise in the presence of scar tenderness was 2.33 (95% CI: 0.93-5.85)

Similarly, the correlation of scar thickness with intraoperative findings (Table 5) demonstrated that among the 25 patients with thickness <2.5 mm, 15 (60%) had compromised scars (12 dehiscence and 3 rupture), while only 10 had intact scars. In comparison, among the 75 patients with thickness ≥2.5 mm, 60 had intact scars and 15 had compromised scars (13 dehiscence and 2 rupture). The relative risk of scar compromise with scar thickness <2.5 mm was 3.5 (95% CI: 1.31-9.33), which was statistically significant.

Subgroup analysis of scar thickness (Table 6) confirmed this finding. Scar thickness <2.5 mm was significantly associated with compromised intraoperative scar integrity

when compared with both 2.5-3.5 mm ($\chi^2=10.56$, $p=0.0012$) and >3.5 mm ($\chi^2=9.0$, $p=0.003$). However, the difference between 2.5-3.5 mm and >3.5 mm was not statistically significant ($\chi^2=2.08$, $p=0.14$).

Table 6: Association of scar thickness subgroups with intraoperative findings.

Comparison	χ^2	P value
<2.5 mm versus 2.5-3.5 mm	10.56	0.0012
<2.5 mm versus >3.5 mm	9.0	0.003
2.5-3.5 mm versus >3.5 mm	2.08	0.14

Finally, the diagnostic accuracy of clinical and imaging predictors is summarized in Table 7. Scar tenderness alone showed a sensitivity of 66% and specificity of 71%, with a positive predictive value (PPV) of 60% and a negative predictive value (NPV) of 82%. Scar thickness <2.5 mm had a sensitivity of 50% and specificity of 85%, with PPV of 60% and NPV of 80%. When both parameters were combined, diagnostic performance improved substantially, with sensitivity increasing to 74% and specificity to 96%, yielding a PPV of 93% and NPV of 86%. The detection rate was highest with the combined criteria (74%), while the false positive rate was lowest (3%), confirming the superior predictive ability of combined assessment.

Table 7: Diagnostic accuracy of clinical and imaging predictors.

Parameters	Sensitivity (95% CI)	Specificity (95% CI)	PPV	NPV	Detection rate	False positive rate
Scar tenderness	66% (50-84%)	71% (60-82%)	60%	82%	66%	28%
Scar thickness <2.5 mm	50% (32-67%)	85% (77-93%)	60%	80%	50%	15%
Combined criteria	74% (53-94%)	96% (90-100%)	93%	86%	74%	3%

DISCUSSION

In this prospective study, most women undergoing evaluation for previous caesarean scars were in the young reproductive age group, with the majority between 25-29 years. This pattern is consistent with Vedantham et al and Gupta et al, who reported that women assessed for scar integrity or trial of labor after caesarean (TOLAC) were predominantly in their third decade of life.^{11,12}

With respect to antenatal care, 65% of women were unbooked, reflecting poor follow-up despite high-risk status. Paquette et al emphasized that timely antenatal evaluation, including scar assessment, reduces maternal and neonatal complications, underlining the need for better booking and surveillance practices in similar populations.¹³

Scar evaluation was mostly performed near term, with the majority assessed between 37-38 weeks. This aligns with Alalaf et al and Afzal et al, who found that late third-trimester assessment, particularly at 36-38 weeks, was most predictive of intraoperative scar integrity and safe for decision-making.^{14,15} Gravida and parity distributions showed that multiparity was common, though similar to earlier studies, these factors were not significantly associated with scar outcomes.

Clinical scar tenderness was observed in 40% of participants and was significantly associated with intraoperative compromise ($\chi^2=15.48$, $p=0.0004$). Our results agree with Patil et al, who reported that tenderness had high specificity but moderate sensitivity, and with Paquette et al, who highlighted its role as a clinical warning sign for scar complications.^{13,16}

Ultrasound-based scar thickness showed that 25% of women had scars <2.5 mm, which was strongly associated with intraoperative dehiscence or rupture (RR=3.5; 95% CI: 1.31-9.33). These findings are consistent with Vedantham et al, Alalaf et al, and Afzal et al, all of whom demonstrated that LUS thickness below 2.3-2.5 mm significantly increases the risk of scar defects.^{11,14,15}

Intraoperatively, 25% of women had scar dehiscence and 5% had rupture, rates comparable to Alalaf et al, who reported similar proportions of uterine defects.¹⁴ Notably, rupture was confined to those with both scar tenderness and very thin scars, highlighting the predictive synergy.

When predictive accuracy was assessed, scar tenderness alone had sensitivity 66% and specificity 71%, while ultrasound thickness <2.5 mm had sensitivity 50% and specificity 85%. However, when both parameters were combined, sensitivity improved to 74% and specificity to 96%, with PPV of 93% and NPV of 86%. These findings are in agreement with Patil et al and Paquette et al, who stressed that combined clinical and imaging assessment provides the most reliable prediction of scar integrity.¹⁶ Afzal et al also supported this combined approach, noting that scar thickness alone lacked sufficient specificity.¹⁵

Taken together, our study confirms that while both scar tenderness and ultrasound thickness are useful predictors, neither is sufficient in isolation. Their combination yields superior predictive accuracy and can guide safer obstetric decision-making in women with previous caesarean delivery.

CONCLUSION

The present study demonstrates that both clinical scar tenderness and ultrasonographic measurement of lower uterine segment scar thickness are valuable antenatal predictors of intraoperative scar integrity. Scar thickness less than 2.5 mm and the presence of scar tenderness were significantly associated with a higher risk of scar dehiscence and rupture. Individually, each parameter showed moderate sensitivity and specificity; however, when combined, they offered substantially improved predictive accuracy, with high detection rate (74%), excellent specificity (96%), and a very low false-positive rate (3%). These findings emphasize that a combined assessment of clinical and sonographic parameters provides a more reliable method for identifying women at increased risk of uterine scar compromise during subsequent deliveries. Early identification can assist clinicians in tailoring intrapartum management, improving maternal and fetal outcomes, and reducing unexpected intraoperative complications.

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