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Prediction of Intra-abdominal Adhesions at Repeated Cesarean Section by Scar Characteristics

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ABSTRACT

Background: Intra-abdominal adhesions are a common complication after cesarean section, influencing surgical time, blood loss, and outcomes, with reliable preoperative predictors still lacking.

Aim: To investigate **exterior** cesarean scar features as potential non-invasive indicators of intra-abdominal adhesions in females having recurrent cesarean procedures

Methods: This cross-sectional diagnostic-accuracy research included one hundred full-term pregnant women at Al-Galaa Teaching Hospital and Elsahel Teaching Hospital undergoing elective repeat cesarean sections. Participants have been classified into groups depending on the number of previous cesarean sections. Two blinded observers independently assessed external scar characteristics, including level, type, and pigmentation, using the Observer Scar Assessment Scale (OSAS) and standardized photography. The **Tulandi and Lyell** grading system was employed to assess adhesions during the intraoperative phase. Logistic regression analysis has been employed to evaluate predictors of adhesion presence.

Results: Adhesion prevalence was highest (69%) among women with exactly two prior cesarean sections, significantly higher than those with one (33%) or three or more cesarean sections (50%) ($p=0.006$). Depressed scar morphology was significantly associated with increased adhesion likelihood (OR = 2.80; 95% CI: 1.02–7.73, $p=0.047$). Adhesion severity showed strong correlations with increased operative time ($r=0.993$, $p<0.001$) and estimated blood loss ($r=0.995$, $p<0.001$). Regression analysis indicated that the number of previous cesarean sections significantly influenced adhesion formation ($p=0.011$), whereas age and BMI were not significant predictors.

Conclusions: Depressed cesarean scars are reliable, visually assessable predictors of intra-abdominal adhesions, highlighting their potential role in preoperative risk stratification and surgical planning.

Keywords: Cesarean section, intra-abdominal adhesions, scar characteristics, adhesion severity, surgical outcomes

INTRODUCTION

Intra-abdominal adhesions are fibrous bands that form between abdominal tissues and organs, primarily as a result of surgical intervention. They represent a significant clinical concern and are a leading cause of postoperative complications such as infertility, chronic pelvic pain, and intestinal obstruction [1, 2].

Additionally, adhesions complicate subsequent abdominal procedures, often resulting in increased operative time, a higher risk of inadvertent organ injury, and prolonged hospitalization [3].

The global cesarean section (CS) rate has risen markedly over recent decades, with certain regions reporting rates exceeding 30%. While CS is a critical intervention for decreasing maternal and neonatal morbidity and death when medically indicated, repeated cesarean deliveries significantly increase the risk of postoperative adhesion formation [4]. Studies have shown that the incidence of adhesions escalates with each subsequent CS, from approximately 24.4% after a second CS to 42.8% after a third [5]. In Egypt, the CS rate has reached concerning levels, with reports indicating that 72.2% of births were via cesarean delivery as of 2021. This substantial increase underscores the need for strategies to optimize delivery practices and minimize unnecessary surgical interventions [6]**.** The formation of intra-abdominal adhesions involves a complex biological cascade initiated by peritoneal injury, followed by inflammation, fibrin deposition, and its subsequent organization into fibrous tissues [7]**.**

Several contributing factors, such as surgical techniques, infection rates, tissue handling, and individual differences in healing responses influence the severity and extent of adhesion formation. Consequently, adhesions pose considerable surgical challenges during repeated cesarean deliveries, affecting both intraoperative management and postoperative recovery outcomes [8]**.**

Given the difficulties in predicting intra-abdominal adhesions preoperatively, recent research efforts have focused on identifying non-invasive predictive tools. External cesarean scar characteristics, including depression, pigmentation, and overall texture, have emerged as potential predictive markers for underlying adhesions [9, 10]**.** Preliminary studies have reported associations between specific scar features and intra-abdominal adhesions, suggesting their clinical utility as predictive markers [11]**.** However, current evidence regarding the reliability and accuracy of scar characteristics as predictors remains inconsistent and limited by methodological variability[12]**.**

Recent literature has highlighted substantial knowledge gaps and conflicting findings in this domain.

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For instance, research by **Jaafar *et al*.**[13] whom identified significant associations between certain skin markers and intra-abdominal adhesions; however, their predictive validity was modest [13]. Consequently, there remains a need for larger-scale studies employing standardized and reproducible assessment methods to clarify these preliminary observations and refine predictive accuracy.

Accurate preoperative identification of women at great possibility for intra-abdominal adhesions can substantially enhance clinical decision-making, surgical planning, and patient counseling. Therefore, this study aimed to systematically evaluate whether external cesarean scar characteristics can reliably expect the existence and severity of intra-abdominal adhesions in females having repeated cesarean section. By identifying such non-invasive predictive markers, this study sought to advance preoperative risk stratification, ultimately improving surgical management strategies and patient outcomes.

PATIENTS AND METHODS

Study Design and Setting

This cross-sectional diagnostic accuracy study was conducted at Al-Galaa Teaching Hospital and Elsahel Teaching Hospital in Cairo, Egypt. The primary aim was to assess the relationship between external cesarean scar features and the presence and severity of intra-abdominal adhesions in women undergoing repeat cesarean sections. External scar characteristics including level, type, and pigmentation were assessed preoperatively by two independent and blinded observers using the Observer Scar Assessment Scale (OSAS) and standardized photography, representing a non-invasive diagnostic tool. Intraoperatively, the presence and severity of adhesions were assessed using the Tulandi and Lyell grading system, which served as the gold standard reference.

Participants were classified into groups based on the number of previous cesarean sections, a key methodological component aimed at evaluating its potential role as a confounding or modifying factor. Logistic regression analysis was employed to determine the predictive value of external scar features for intra-abdominal adhesions.

Sample Size Determination

Calculation of sample size was depending on an anticipated adhesion prevalence of 38%, with a confidence level of ninety-five percent ($\alpha = 0.05$), statistical power of eighty percent ($\beta = 0.20$), and a margin of error of 10%. This produced a minimum needed sample size of 91 participants. To account for possible dropouts and increase statistical robustness, a total of 100 women were enrolled.

Participant Selection

Eligible participants were full-term pregnant women (≥37 weeks' gestation) with at least one previous cesarean delivery, scheduled for elective repeat cesarean section, and willing to give informed consent. Exclusion criteria involved any history of postoperative wound infection, wound dehiscence, endometriosis, corticosteroid use, or any condition known to affect wound healing or adhesion formation.

Scar Assessment and Group Stratification

All participants had a comprehensive clinical evaluation involving obstetric and surgical history, physical examination, and focused assessment of the abdominal scar. Scar characteristics—including level (flat, depressed, elevated), type, and pigmentation—were assessed using standardized digital photographs taken under uniform lighting and positioning. Two independent observers, blinded to intraoperative findings, evaluated the scar photographs using the validated Observer Scar Assessment Scale (OSAS) to ensure objectivity and minimize assessment bias. Inter-rater discrepancies were resolved by consensus.

Participants were then stratified into three groups based on the number of prior cesarean sections:

- **Group I**: 1 prior cesarean section
- **Group II:** 2 prior cesarean sections
- **Group III:** 3 or more prior cesarean sections

This stratification enabled a comparative analysis of adhesion prevalence and severity across varying surgical histories.

Surgical Procedure and Intraoperative Adhesion Assessment

All cesarean deliveries were performed by experienced obstetric surgeons following a standardized surgical technique. A Pfannenstiel skin incision was made approximately 3 cm above the symphysis pubis, followed by subcutaneous dissection and transverse opening of the rectus sheath. The rectus muscles were bluntly separated to access the peritoneal cavity, and the parietal peritoneum was incised.

Intra-abdominal adhesions have been evaluated intraoperatively using the Tulandi and Lyell adhesion grading system [14] at six predefined peritoneal sites, confirm exactly which six sites and whether pelvic/abdominal adhesions were pooled. This validated tool grades adhesions as follows:

- **Grade 0: No adhesions.**
- **Grade 1: Filmy adhesions, easily separable**
- **Grade 2: Dense, vascularized adhesions requiring sharp dissection.**

A cumulative adhesion score was calculated for each patient, ranging from 0 to 12. The assessments were performed by two surgeons who were blinded to preoperative scar evaluations to reduce observer bias and ensure independent assessment of intra-abdominal pathology.

Following fetal and placental delivery through a transverse lower uterine segment incision, the uterus was closed in two layers. The anterior abdominal wall was closed in layers, and the skin was approximated using subcuticular sutures.

Data Management and Statistical Analysis

Information was analyzed utilizing IBM SPSS software version 25.0. Continuous parameters have been represented as means ± standard deviation (SD), while categorical information was expressed as frequencies and percentages. Logistic regression analysis was employed to identify independent predictors of intra-abdominal adhesions, adjusting for relevant clinical variables. A p-value below 0.05 has been deemed statistically significant. Specify tests used for group comparisons (e.g., χ^2/Fisher's exact); for continuous variables use ANOVA/Kruskal–Wallis and include effect sizes with 95% CIs.

Ethical Considerations

The research protocol, including its title, was approved by the General Organization of Teaching Hospitals and Institutes (Approval No. 00107, dated 11 September 2024), confirming that both the study design and title adhere to ethical standards. Written informed consent was obtained from all participants prior to enrollment, ensuring patient confidentiality.

RESULTS

Table 1 shows that the study population had a mean age of 30.65 years (SD ± 5.37), ranging from 19 to 43 years, and a mean BMI of 24.48 kg/m² (SD ± 4.51). Gestational age was evenly distributed, with 34% of women delivering at 37 weeks, 34% at 38 weeks, and 32% at 39 weeks. Regarding obstetric history, 46% of participants (n=46) had undergone one prior cesarean section, 32% (n=32) had two prior cesarean sections, and 22% (n=22) had three prior cesarean sections.

Table 1. ??????????

Variable	Mean ± SD	Range (Min–Max)	n	%
Continuous Variables				
Age (years)	30.65 ± 5.37	19 – 43	–	–
BMI (kg/m²)	24.48 ± 4.51	12.2 – 35.3	–	–
Categorical Variables				
Gestational Age (weeks)				
• 37 weeks	–	–	34	34.0
• 38 weeks	–	–	34	34.0
• 39 weeks	–			

Table 2 shows that no statistically significant differences were observed among the three groups with respect to maternal age, BMI, or gestational age, indicating homogeneity of baseline characteristics across the cohorts. However, the prevalence of adhesions differed significantly (p = 0.006), being more frequent in women with two prior cesarean sections.

Table 2. Comparison between Number of Previous Cesarean Sections Groups

Variable	1 Previous CS (n = 46)	2 Previous CSs (n = 32)	≥3 Previous CSs (n = 22)	Test (statistic, df)	p-value
Age (years)	31.35 ± 4.99	29.19 ± 5.45	31.32 ± 5.87	ANOVA (F=1.76, df=2)	0.176
BMI (kg/m²)	25.25 ± 4.67	23.14 ± 4.72	24.82 ± 3.51	ANOVA (F=2.18, df=2)	0.119
Gestational Age (weeks)	38.02 ± 0.83	37.91 ± 0.78	38.00 ± 0.87	ANOVA (F=0.19, df=2)	0.824
Adhesions Present, n (%)	15 (32.6%)	22 (68.8%)	11 (50.0%)	χ^2 (χ^2=10.2, df=2)	0.006*
Total Adhesion Score	1.93 ± 3.51	3.69 ± 3.68	2.41 ± 3.19	K-W (χ^2=4.73, df=2)	0.095
Scar Level, n (%)				χ^2 (χ^2=1.45, df=4)	0.931
• Depressed	16 (34.8%)	11 (34.4%)	6 (27.3%)		
• Elevated	12 (26.1%)	7 (21.9%)	5 (22.7%)		
• Flat	18 (39.1%)	14 (43.8%)	11 (50.0%)		

◈ **Note:** Values are presented as mean ± SD for continuous variables, and n (%) for categorical variables. *p < 0.05 is considered statistically significant. If expected cell counts <5

However, a statistically significant increase in adhesion prevalence has been found among women with two prior cesarean sections (68.8%) in comparison with those with one (32.6%) or ≥3 previous CSs (50.0%) (p = 0.006). Although the mean adhesion score was greater in the two-CS group (3.69 ± 3.68), the variance was not statistically significant (p-value equal to 0.095), possibly due to variability or limited sample size. Additionally, the distribution of scar levels (flat, depressed, and elevated) was similar across the groups, with no significant association detected (p-value equal to 0.931)

Table 3 shows that the total adhesion score showed a moderate positive correlation with both operative time (ρ = 0.461, 95% CI: 0.02–0.75, p = 0.026) and estimated blood loss (ρ = 0.558, 95% CI: 0.15–0.81, p = 0.010). Both associations reached statistical significance

Table 3. Correlation Between Total Adhesion Score, Operative Time, and Estimated Blood Loss

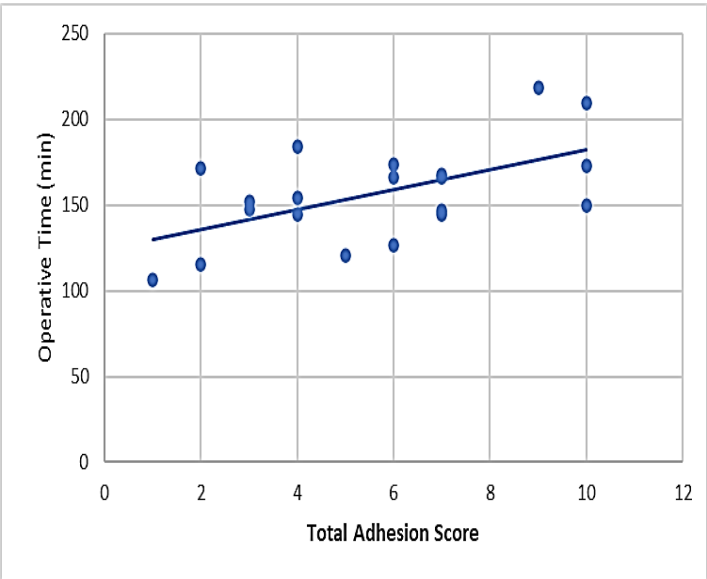
	Total Adhesion Score		
Variables	**Spearman's ρ**	**95% CI**	**p-value**
Operative Time (min)	.461*	0.02 – 0.75	0.026
Estimated Blood Loss (ml)	.558*	0.15 – 0.81	0.01

Note: Spearman correlation coefficients are reported.

Table 4 demonstrates that this logistic regression model assessed the impact of the number of prior cesarean sections, scar level, age, and BMI on the likelihood of intra-abdominal adhesions. The overall group effect was statistically significant (Wald = 8.992, p = 0.011), confirming that the number of prior cesarean sections was an important determinant of adhesion formation.

Specifically, women with two previous cesarean sections had more than a threefold higher risk of adhesions compared with those with only one cesarean (OR = 3.46, 95% CI: 1.34–8.94, p = 0.010). In contrast, women with three or more cesarean sections did not show a statistically significant increase (OR = 1.86, 95% CI: 0.67–5.14, p = 0.235).

Regarding scar morphology, the presence of a depressed scar significantly increased the odds of adhesions relative to an elevated scar (OR = 2.80, 95% CI: 1.02–7.73, p = 0.047), suggesting that external scar appearance may be a simple noninvasive marker of underlying adhesions. Flat scars, however, were not significantly different from elevated scars (p = 0.492). Neither age nor BMI were independent predictors of adhesion status (p = 0.270 and 0.686, respectively). Overall, the model demonstrated acceptable discrimination (AUC = 0.74) and good calibration (Hosmer–Lemeshow p = 0.601).



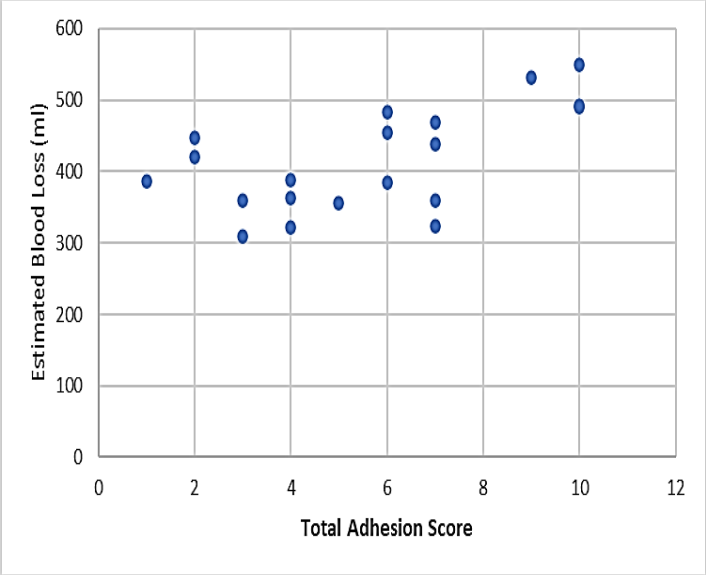


Table 4. Predictors of Intra-abdominal Adhesions (N = 100)

Predictor	B	SE	Wald	p-value	OR (Exp(B))	95% CI for OR
Group (overall)	—	—	8.992	0.011*	—	—
2 CS vs 1 CS	1.24	0.48	6.70	0.010*	3.46	1.34 – 8.94
≥3 CS vs 1 CS	0.62	0.52	1.41	0.235	1.86	0.67 – 5.14
Scar Level (overall)	—	—	3.979	0.137	—	—
Depressed vs Elevated (Ref)	1.03	0.52	3.96	0.047*	2.80	1.02 – 7.73
Flat vs Elevated (Ref)	0.38	0.55	0.47	0.492	1.46	0.50 – 4.32
Age (years)	–0.05	0.04	1.22	0.270	0.96	0.88 – 1.04
BMI (kg/m²)	0.02	0.05	0.16	0.686	1.02	0.93 – 1.13

*Statistically significant at P-value below 0.05.

DISCUSSION

The present study investigated noninvasive predictors of intra-abdominal adhesions in females having repeat cesarean sections, with particular emphasis on external cesarean scar characteristics. The outcomes revealed a significant correlation among the existence of a depressed scar and a higher prevalence of intra-abdominal adhesions, as well as a nonlinear pattern of adhesion risk in relation to the number of prior cesarean deliveries. In addition, adhesion severity showed strong correlations with both operative time and estimated blood loss, highlighting the notable clinical impact of adhesions during surgery.

Interestingly, adhesion prevalence peaked at 69% among women with exactly two prior cesarean deliveries, compared to 33% in those with one prior cesarean and 50% in those with three or more. This finding contrasts with the commonly reported linear increase in adhesion risk with each subsequent cesarean. Previous studies, including those by **Nuamah *et al.*** [14] **and Pokhrel *et al.*** [15], documented progressive increases in adhesion prevalence, reaching 62% and 74.3%, respectively, among women with multiple prior cesareans. The discrepancy observed in our cohort may be attributed to differences in surgical technique, postoperative care protocols, or individual healing responses. It is plausible that factors such as enhanced surgical proficiency in later cesareans or patient-specific biological thresholds could explain the peak in adhesion risk after the second cesarean, followed by a plateau or decline.

With regard to scar morphology, a depressed scar was related to nearly a threefold elevation in the odds of intra-abdominal adhesions compared to elevated scars (OR = 2.80; 95% CI: 1.02–7.73; p = 0.047). This observation aligns with previous results by **Altınboğa *et al.*** [16] and **Salim *et al.*** [10], which suggest that scar depression may serve as a surrogate marker for underlying fibrotic remodeling or impaired wound healing. Such depressed scars may indicate altered collagen deposition, exaggerated inflammatory responses, or insufficient tissue regeneration—all factors implicated in adhesion development. In contrast, flat and elevated scars did not appear to predict adhesions, suggesting that not all scar types reflect pathological tissue remodeling equally.

Although the mean adhesion score was higher in women with two previous cesareans (3.69 ± 3.68), this variance didn't reach statistical significance (p-value equal to 0.095), potentially because of limited statistical power. In comparison, **Mooij *et al.*** [17] reported severe adhesions in 56% and 64% of women undergoing second and third cesareans, respectively, indicating a progressive trend in severity even if prevalence fluctuates. This emphasizes the need for larger-scale studies to validate these observations.

We also found strong correlations between adhesion severity and key operative parameters, including operative time (r = 0.993, p-value below 0.001) and estimated blood loss (r = 0.995, p-value below 0.001). These correlations align with findings by **Nuamah *et al.*** [14] **and Pokhrel *et al.*** [15]**,** who documented longer operative times and greater perioperative blood loss in cases with severe adhesions. **Ram *et al.*** [18] also showed a significant correlation among adhesion severity and perioperative complications, further highlighting the importance of predicting adhesions preoperatively. Awareness of this relationship can improve surgical planning, resource allocation, and patient counseling.

Multivariate logistic regression revealed a significant overall influence of the number of prior cesarean sections on adhesion formation (p = 0.011), although comparisons between individual groups were not statistically significant, possibly due to sample size constraints. Demographic variables such as age and BMI were not independent predictors of adhesion risk, consistent with prior research [18,19]**.** This supports the view that biological and surgical factors exert greater influence than demographic characteristics in determining adhesion risk.

Overall, our findings corroborate previous evidence supporting scar depression as a reliable predictor of adhesion formation [10,16]**.** However, the nonlinear pattern of adhesion prevalence observed in this study contrasts with the predominantly linear trends reported in earlier

literature [14, 15, 20]. These differences may be explained by methodological variations, including adhesion grading methods, differences in patient populations, or variations in surgical practice.

From a pathophysiological perspective, the link between depressed scars and adhesions may reflect abnormal collagen deposition or disrupted tissue remodeling, potentially indicative of deeper fibrotic processes extending into the peritoneum[12]. Basic science literature supports this hypothesis, emphasizing the roles of collagen synthesis, cytokine activity, and inflammatory cell infiltration in the formation of postoperative adhesions.

Clinically, incorporating scar assessment into routine preoperative evaluation could serve as a simple, low-cost approach for stratifying patients according to adhesion risk. In resource-limited settings, where advanced imaging or intraoperative adjuncts are unavailable, this method could enhance surgical preparedness. Surgeons could adjust operative strategies, ensure the presence of more experienced staff, or consider using adhesion prevention barriers for high-risk patients based on scar morphology.

Several restrictions must be acknowledged. The single-center design might limit the generalizability of our results, particularly in light of Egypt's high cesarean section rates. The sample size, while sufficient for primary analyses, may be underpowered for subgroup analyses. Although scar assessments were conducted using the validated Observer Scar Assessment Scale (OSAS), they remain subjective, and inter-observer agreement was not formally evaluated. Future research could benefit from incorporating objective imaging modalities, such as ultrasound-based scar assessment or three-dimensional imaging. Finally, certain potential confounding factors—including surgical technique, suture material, and postoperative infection—were not fully adjusted for in the multivariate analysis, although partially controlled for via exclusion criteria, and should be considered in subsequent studies.

CONCLUSION

This study demonstrated that intra-abdominal adhesions are more prevalent in repeat cesarean section patients with depressed external scars, and that their presence is related to increased operative time and bleeding. These findings highlight the potential value of simple, noninvasive preoperative scar assessment as a tool for risk stratification. Future research should involve larger, multi-center cohorts and integrate scar characteristics with additional clinical, surgical, and imaging-based parameters to develop comprehensive risk prediction models. Such approaches may enhance surgical planning, reduce intraoperative complications, and ultimately improve maternal outcomes, particularly in settings with high cesarean section rate.

DECLARATIONS

- **Consent for publication:** I certify that each author has granted permission for the work to be submitted.
- **Funding:** None.
- **Availability of data and material:** Available.
- **Conflicts of interest:** None.
- **Competing interests:** None.

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