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Original Research

Predicting Intra-Abdominal Adhesions in Repeat Cesarean Sections: Scar Tissue Characteristics, Striae Gravidarum, and Corset Use

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Abstract

Background: This study evaluated whether abdominal scar tissue characteristics, duration of corset use, and striae gravidarum (SG) density are associated with the severity of intra-abdominal adhesions (IAA) in repeat cesarean sections (CS). **Methods**: This study prospectively recruited 800 women in their third trimester of pregnancy who were admitted to our clinic for repeat CS. Data was collected on the number of previous CS, history of corset use after prior CS, and demographic characteristics. Abdominal scar characteristics were visually classified by surface appearance (dimpled, smooth, or raised) and pigmentation status (hyperpigmented or normal). SG density was determined using Davey's scoring system. IAA were classified intraoperatively according to the Nair classification system. **Results**: Among the 800 participants, 220 (27.5%) had no IAA, 296 (37.0%) had filmy adhesions, 136 (17.0%) had more than two dense adhesions, 124 (15.5%) had very dense adhesions, and 24 (3.0%) had a frozen pelvis. Univariate analysis showed significant associations between IAA scores and maternal age, height, body mass index (BMI) gravida, parity, and the number of previous CS ($p < 0.001$ for all). In multivariable analysis, the number of previous CS remained significantly associated with IAA scores. For each additional previous CS, the odds of developing dense adhesions increased nearly threefold (odds ratios [OR] = 2.85, 95% confidence intervals [CI]: 2.10–3.88, $p < 0.001$). In contrast, no significant associations were found between IAA scores and scar tissue characteristics, scar tissue pigmentation, SG density, history of corset use, or smoking ($p > 0.05$). **Conclusions**: Preoperative evaluation of scar tissue characteristics, SG density, and history of corset use did not predict the presence or severity of IAA before elective CS. However, a significant association was observed between the number of previous CS and IAA. No significant association was observed between smoking and IAA.

Keywords: abdominal scar characteristics; cesarean section; corset use; intra-abdominal adhesions; striae gravidarum

1. Introduction

The proportion of primary cesarean sections (CS) performed over the past decade has increased considerably [1], even though CS is widely accepted as a significant risk factor for the development of intra-abdominal adhesions (IAAs) [2]. IAAs represent a significant challenge for surgeons during abdominal operations and are associated with several short-term complications, including hemorrhage, injury to adjacent organs, prolonged operative times, and intestinal obstruction. In addition to these short-term complications, there is also the risk of long-term complications, such as chronic pelvic pain and infertility [3]. Although the pathogenesis of IAA formation is not yet fully understood, it is well established that adhesions develop due to an imbalance between the coagulation and fibrinolytic systems during the wound-healing process [4].

Several studies have shown that skin scar characteristics are associated with the presence and severity of pelvic adhesions [3–5]. Striae gravidarum (SG) reflect reduced skin elasticity, a common occurrence during pregnancy [6]. This phenomenon is accompanied by several alterations in structural connective tissue, which have been attributed to decreased elastin and fibrillin in the dermis [7]. The equilibrium between fibrin deposition and its subsequent degradation is crucial in facilitating normal peritoneal healing and adhesion formation. It is generally accepted that normal peritoneal healing is characterized by complete fibrin degradation [8]. Fibroblasts play an active role in both peritoneal adhesions and stria formation. Inappropriate fibrin degradation causes fibroblasts to produce collagen, and inadequate collagen degradation results in peritoneal adhesions. These intricate cellular and molecular processes are fundamentally driven by collagen synthesis and degradation orchestrated by fibroblasts and are not limited to the peritoneal cavity. These processes also manifest externally in dermal tissue repair, influencing the visible characteristics of skin scars and the development of SG. Evaluation of these external markers can therefore provide indirect insights into the underlying dynamics of wound-healing dynamics that contribute to the formation of IAA. It has been hypothesized that visible changes in skin connective tissue, such as scar characteristics and striae, could serve as indicators of a systemic or localized propensity for altered fibroblast activity and collagen remodelling, thus reflecting an internal predisposition for the development of IAA. Collagen is abundant in connective tissue and plays a pivotal role in the formation of striae. Therefore, the development of SG may share a similar etiopathogenesis with IAA [9].

Abdominal elastic corsets have been shown to reduce pain and stabilize the abdominal wall after laparotomy, leading many surgeons to recommend their use [10,11]. Although positive effects of corset use on wound healing have been described, decreased lung function has also been reported [11,12]. The use of corsets has been shown to accelerate wound healing and prevent seroma and wound haematoma, both of which are associated with prolonged healing and increased IAA [13–15]. Consequently, the use of a corset during the postoperative period may help to reduce the incidence of IAA. In contrast, evidence has emerged that the interaction between damaged surfaces, as well as the duration of this interaction, can contribute to the development of IAA [16]. However, the impact of corset use on IAA has not yet been comprehensively examined. The rationale for investigating corset use lies in its mechanical effect on the abdominal wall, which may influence tissue tension, blood flow, and inflammatory responses during wound healing. Such mechanical modulation may influence affect fibroblast activity and collagen deposition, thus impacting both the quality of the external scar and the formation of internal adhesions.

We hypothesize that visible changes in connective tissue, including striae and scar morphology, may serve as indirect markers of abnormal wound healing processes that also influence the development of IAA. Consequently, the aim of this study was to evaluate whether abdominal scar characteristics, history of corset use, and SG density are associated with the presence and severity of IAA. These findings may provide valuable information for surgeons performing repeat CS.

2. Materials and Methods

This prospective study was approved by the Harran University Ethics Committee on 9 November 2017 (decision number: E.42537). Between November 2017 and December 2022, a total of 800 patients with a documented history of at least one previous transverse CS were recruited. These patients underwent emergency or elective CS at our clinic and provided informed consent. Patients with a history of longitudinal skin incisions were excluded from the study. A comprehensive data collection process was conducted, including demographic and clinical characteristics. Certain details of the previous CS, such as uterine closure technique (single versus double-layer), type of suture material, duration of surgery, and whether the procedure was elective or emergency, could not be retrieved from patient records and were therefore excluded from the analysis. Demographic and clinical data collected included age, gravidity, parity, number of previous CS, smoking habits, and body mass index (BMI). BMI classification followed the World Health Organization (WHO) guidelines: <18.5 kg/m^2, underweight; 18.5–24.9 kg/m^2, normal weight; 25.0–29.9 kg/m^2, pre-obese; 30.0–34.9 kg/m^2, obesity class I; 35.0–39.9 kg/m^2, obesity class II; and $\geq$40, obesity class III. Gestational age was defined as preterm ($<$37 weeks) or term (37 weeks). Only patients with a previous transverse skin incision were included in the final analysis. Patients with a history of wound complications, pelvic inflammatory disease, endometriosis, abdominal surgery other than CS, chronic drug use (e.g., steroid, progesterone), or chronic diseases such as diabetes mellitus and connective tissue disease (e.g., Ehlers-Danlos syndrome, Marfan syndrome, lichen sclerosis) were excluded from the study, as these are known confounding risk factors for IAA. History of corset use was classified into two categories: not used or used for $<$2 weeks, and used for $>$2 weeks. Details regarding specific corset pressure settings and patient adherence use were neither standardized nor monitored.

Intraoperative adhesions were classified in a blinded manner by the operating surgeon according to the Nair classification system [17]: 0, no adhesion; 1, filmy adhesion; 2, $>$2 dense adhesions; 3, highly dense adhesions; and 4, frozen pelvis (Table 1). Frozen pelvis was defined as limited mobilization of the uterus during surgery due to dense adhesions to surrounding tissues, such as the bladder and bowel. According to the modified classification system, grades 0 and 1 were classified as filmy abdominal adhesion, and grades 2–4 were considered dense abdominal adhesions. No information was available regarding the use of anti-adhesive materials in previous CS for these patients.

Table 1. Nair adhesion classification.

Score	Degree of adhesion
0	No adhesion
1	Filmy adhesion
2	More than two adhesions
3	Very dense adhesions
4	Frozen pelvis

In the operating room, preoperative scar tissue was classified as pitted, flat, or raised. Additionally, the pigmentation of scar tissue was classified as the same as abdominal skin, or hyperpigmented. The Davey scoring system was employed for SG classification [18] due to its established application in similar studies and its practicality in objectively assessing striae severity in clinical settings. The abdomen was divided into 4 horizontal and vertical quadrants, and a score was assigned to each quadrant. For a single quadrant, 0 points were assigned for no striae, 1 point for 1–3 striae, and 2 points for 4 or more striae. The total score was calculated as the sum of the scores from the four quadrants. Patients with no striae were classified as the “no striae/mild” group, those with a total score of 1–2

Table 2. Relationship between demographic characteristics and adhesion scores.

Feature	Nair score = 0 (N = 220)	Nair score = 1 (N = 296)	Nair score = 2 (N = 136)	Nair score = 3 (N = 124)	Nair score = 4 (N = 24)	*p*-value
Age (years)	28.15 ± 3.05	29.35 ± 5.70	32.10 ± 5.60	33.05 ± 4.65	28.75 ± 5.80	<0.001 [a]
Gravida	4 (3–5)	4 (3–6)	5 (4–6)	5 (4–7)	5 (4–6)	<0.001 [b]
Parity	3 (2–4)	3 (2–4)	3 (2–5)	3 (2–5)	4 (3–5)	<0.001 [b]
Number of previous CS	2 (2–3)	2 (2–3)	3 (2–4)	4 (3–5)	4 (3–5)	<0.001 [b]
Weight (kg)	71.80 ± 7.65	72.10 ± 7.05	70.70 ± 8.15	72.20 ± 8.15	71.25 ± 8.05	0.085 [a]
Height (cm)	164.05 ± 5.85	162.70 ± 5.25	163.05 ± 5.50	164.80 ± 4.15	163.65 ± 2.55	<0.001 [a]
BMI (kg/m^2)	27.00 ± 2.05	27.85 ± 2.55	26.50 ± 2.05	28.85 ± 2.25	26.70 ± 2.35	<0.001 [a]

CS, cesarean section; BMI, body mass index; N, number of samples. [a] *p*-value based on Brown-Forsythe ANOVA due to violation of the homogeneity of variances. [b] *p*-value based on Kruskal-Wallis test.

were classified as "moderate striae", while those with a total score of 3–8 were classified as "severe striae". All patients were examined by the same investigator.

2.1 Surgical Technique

In all cases, a 14–16 French Foley catheter was inserted into the bladder. Next, 1 g of cefazolin sodium (IE Ulagay, Istanbul, Turkey) was administered for surgical prophylaxis prior to CS. Spinal or combined spinal-epidural anesthesia was used for the procedure. The option of general anesthesia was also available when medically necessary, or in accordance with patient preference. Skin cleansing was performed with povidone iodine (Poviodine, Diagnostikim, Turkey) prior to operation. The abdomen was entered through a Pfannenstiel incision 2 cm above the pubis symphysis, and a lower segment transverse incision (Kerr) was performed in the uterus. In the majority of cases, the uterus was removed outside the abdomen to allow better visualization of the uterine incision and to ensure more effective hemostasis. However, in some cases, it was sutured in the abdomen due to dense adhesions in the abdomen. The uterine incision was closed in a single layer with No. 1/0 Vicryl suture (Ethicon, Somerville, NJ, USA). Depending on the surgeon's preference, the parietal peritoneum was either left open or closed using No. 2/0 Vicryl suture. The fascia was sutured with No. 1/0 Vicryl, and sutures were removed as clinically indicated. The skin was also sutured subcutaneously using No. 2/0 sharp Vicryl.

2.2 Statistical Analysis

Data were analysed using the SPSS 26.0 statistical software package (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to evaluate the normality of data distribution. Statistical comparison of variables between two groups was conducted using the Student's *t*-test when data were normally distributed, and the Mann–Whitney U test when it showed non-normal distribution. To compare continuous variables across multiple Nair adhesion score groups (as presented in Table 2), ANOVA was used for normally distributed variables, and the Kruskal-Wallis test was used for non-normal distributions. Post hoc pairwise comparisons of continuous variables were not carried out when the ANOVA or Kruskal-Wallis tests revealed significant differences, thus limiting the detection of specific differences between groups. For categorical variables (as presented in Table 3), associations with adhesion scores were examined using the Chi-square test or Fisher's exact test, as appropriate. A p-value < 0.05 was considered to represent statistical significance. Multivariate logistic regression analysis was performed to evaluate independent associations of significant factors identified in univariate analysis (number of previous CS, maternal age, height, BMI, gravida, and parity) with the presence of dense IAA (Nair's score $\geq$2) while controlling for possible confounders. Odds ratios (OR) with 95% confidence intervals (CI) were also calculated.

3. Results

This study included 800 pregnant women with a history of previous transverse CS incisions who attended the Department of Obstetrics and Gynecology, Faculty of Medicine, between November 2017 and October 2022. All participants had undergone at least one prior CS and were planning a subsequent procedure.

According to the Nair classification system, the distribution of IAA among the study participants was as follows: 220 patients (27.5%) had no IAA (Nair Score = 0), 296 (37.0%) had filmy adhesion (Nair Score = 1), 136 (17.0%) had more than 2 dense adhesions (Nair Score = 2), 124 (15.5%) had very dense adhesions (Nair Score = 3), and 24 (3.0%) had frozen pelvis (Nair's Score = 4).

Statistical analysis of various demographic characteristics in relation to IAA is presented in Table 2. Nair adhesion score showed significant associations with maternal age, height, BMI, gravida, parity, and number of previous CS (each $p < 0.001$). A higher number of previous CS was associated with a higher adhesion score. No statistically significant difference in maternal weight was observed between the adhesion score groups ($p = 0.085$).

The relationships between other patient characteristics and adhesion scores are shown in Table 3.

Table 3. Comparison of Nair adhesion score with patient characteristics.

Feature	Category	N	Nair score = 0 (N = 220) (%)	Nair score = 1 (N = 296) (%)	Nair score = 2 (N = 136) (%)	Nair score = 3 (N = 124) (%)	Nair score = 4 (N = 24) (%)	*p*-value
Smoker	Yes	118	25 (21%)	39 (33%)	22 (18%)	23 (19%)	9 (7%)	0.224
	No	682	195 (28%)	257 (37%)	134 (19%)	118 (17%)	18 (3%)	
WHO BMI category	Normal weight	197	50 (25%)	63 (32%)	45 (23%)	35 (18%)	7 (3%)	0.454
	Pre-obesity	505	135 (27%)	198 (39%)	78 (15%)	78 (15%)	16 (3%)	
	Obesity class 1	98	29 (29%)	34 (35%)	15 (15%)	15 (15%)	4 (4%)	
Scar tissue feature	Flat	510	141 (27%)	194 (38%)	89 (17%)	73 (14%)	13 (2%)	0.397
	Pit from the surface	216	55 (25%)	79 (36%)	37 (17%)	39 (18%)	6 (3%)	
	Raised from the surface	74	16 (21%)	21 (28%)	13 (18%)	16 (21%)	4 (5%)	
Scar tissue colour	Normal	565	152 (27%)	212 (37%)	97 (17%)	86 (15%)	18 (3%)	0.891
	Hyperpigmented	235	62 (26%)	82 (35%)	40 (17%)	41 (17%)	7 (3%)	
Striae score	None-mild	364	94 (26%)	137 (37%)	62 (17%)	58 (16%)	13 (3%)	0.250
	Moderate	280	67 (24%)	114 (41%)	45 (16%)	46 (16%)	7 (2%)	
	Severe	156	52 (33%)	43 (27%)	31 (20%)	25 (16%)	5 (3%)	
History of corset use	$<$2 weeks of use or none	730	193 (26%)	271 (37%)	125 (17%)	122 (17%)	21 (3%)	0.443
	2 or more weeks of use	70	21 (30%)	25 (36%)	13 (18%)	7 (10%)	4 (6%)	
Gestational age	Preterm	194	51 (26%)	73 (37%)	33 (17%)	33 (17%)	4 (2%)	0.957
	Term	606	162 (26%)	223 (37%)	105 (17%)	97 (16%)	20 (3%)	

WHO, World Health Organization.

Note: Chi-square test was used for categorical variables, except for smoking, where Fisher's exact test was employed due to small expected cell counts. $p < 0.05$ indicates statistical significance.

Scar tissue characteristics were flat in 510 patients (63.75%), depressed in 216 patients (27.0%) and increased in 74 patients (9.25%). No statistically significant difference in IAA scores was observed among women with flat, depressed, or raised scar tissue (p = 0.397). Normal pigmentation was observed in 565 patients (70.63%), while 235 patients (29.37%) exhibited hyperpigmentation. No significant difference in IAA scores was found between women with normally pigmented or hyperpigmented scar tissue (p = 0.891). A total of 364 patients (45.5%) had no or very mild striae, 280 patients (35.0%) had moderate striae, and 156 patients (19.5%) had severe striae. No significant difference in IAA scores was observed according to the density of SG (p = 0.250). Following a previous CS, 730 patients (91.25%) reported having used a corset for $<$2 weeks or not at all, while 70 patients (8.75%) used a corset for $>$2 weeks. No significant difference in IAA scores was observed between these two groups of patients (p = 0.443). A total of 118 patients (14.75%) self-reported as smokers and 682 (85.25%) as non-smokers. No significant difference in IAA scores was found between smokers and non-smokers (p = 0.224). A total of 194 patients (24.25%) had preterm pregnancies and 606 patients (75.75%) had term pregnancies. No significant difference in IAA scores was observed between women with preterm or term pregnancies (p = 0.957).

Multivariate logistic regression analysis revealed that the number of previous CS was an independent predictor of dense IAA (Nair score 2). For each additional previous CS, the odds of developing dense adhesions increased almost threefold (OR = 2.85, 95% CI: 2.10–3.88, $p < 0.001$). Other factors that showed significant association in univariate analyses, such as maternal age, height, BMI, gravida and parity, did not show independent significance in the multivariate model.

4. Discussion

The present study confirmed that IAA is significantly associated with the number of previous CS. This finding was further strengthened by multivariate logistic regression analysis, which demonstrated that the number of previous CS remained an independent and robust predictor of dense IAA, even after controlling for demographic and clinical factors that showed significant association in univariate analysis. This underscores the cumulative impact of repeated surgical trauma on peritoneal healing and adhesion development, and strengthens its critical role in preoperative risk assessment. IAA are common after CS, and their increasing prevalence may be attributed to the rising number of CS procedures performed. Adhesion rates have been reported to range from 12%–46% in patients who have undergone two CS, and from 26%–75% in those with three previous CS [19,20]. Rashid and Rashid [21] found that the rate of IAA was 54% in patients who had undergone five or more CS, and 15% in patients who had undergone two or three previous CS. We previously reported [22] that women who had undergone three or fewer procedures had a significantly lower prevalence of IAA (19.4%) than those who had undergone four or more procedures (58.6%). In the present study, IAA was found in 73.3% of women. Although this rate may be considered high, it should be noted that our study was conducted in a tertiary hospital designed to provide care for patients with the most complex and serious health problems. Consequently, it is reasonable to infer that our study population consisted of individuals who were at high risk. Khlifi *et al*. [23] previously reported a similar IAA rate of 73.5%. However, other studies have reported lower intraperitoneal adhesion rates of 47.5%, 59.6%, and 54.3% during CS [9,24,25].

Striae, also known as stretch marks, are a common occurrence during pregnancy and are characterized by the appearance of red lines or streaks on the skin. Although these marks can be a source of concern for some pregnant women due to discomfort and aesthetic issues, it is important to note that they do not pose a significant health risk [26]. Various studies have been conducted to determine the accuracy of the stria score in predicting the presence of IAA prior to CS. Abbas *et al*. [27] reported a significantly higher incidence of pelvic adhesion in patients diagnosed with severe SG compared to those classified as none/mild SG. They hypothesized that preoperative evaluation of abdominal SG by Davey's score during repeat CS could serve as a valuable indicator of pelvic adhesion status prior to the planning of subsequent surgical interventions. Cakir *et al*. [28] found an increased prevalence of IAA in patients diagnosed with severe striae compared to those with mild or absent striae. Several studies have also shown that the SG score is not associated with the severity of IAA [29,30]. On the other hand, Dogan *et al*. [9] reported a decrease in the IAA score concurrent with an increase in the abdominal SG score during the preoperative period. Although they speculated that SG formation could be related to impaired fibroblast and collagen activities, defective fibroblastic activity could cause a decrease in adhesion formation in pregnant women. The discordant results between studies may be due to several factors, such as the use of different scoring systems, the CS technique used, racial differences between women who participated in the study, differences in the suture materials used in previous operations, and evaluations by different surgeons. Although previous studies have reported contradictory findings, the present study with a larger sample size did not find any significant association between SG and IAA.

IAA formation and skin scar tissue development may result from a common sequence of pathophysiological events. The presence of hypertrophic scar tissue is indicative of elevated collagen production. This phenomenon may be attributable to variability in the conversion of transforming growth factor-beta, a key mediator in the development of hypertrophic scar tissue and intraperitoneal adhesions [31,32]. Depressed abdominal scars resulting from prior CS have been associated with the prevalence and severity of IAA [23,33,34]. Based on the results of their study, Durai *et al*. [24] hypothesized that hypertrophic and hyperpigmented scar tissues were associated with a higher prevalence of IAA compared to flat or depressed scar tissues. In contrast, the present study found no significant associations between skin scar tissue characteristics and IAA. Similarly, Kahyaoglu *et al*. [34] reported that pigmentation status did not differ between women with and without adhesions. Furthermore, Taylan *et al*. [35] found no association between scar tissue characteristics and IAA, in accordance with the current study.

Contact of damaged surfaces with each other and the duration of this contact have been shown to promote IAA formation [16]. The current study is the first to evaluate IAA scores in relation to corset use. We found no significant difference in IAA scores between women who did or did not use corsets for more than two weeks. However, it is important to interpret these findings with caution given the relatively low prevalence of prolonged corset use in our cohort, with only 70/800 patients using corsets for >2 weeks. The relatively small size of the "prolonged use" subgroup in this study may have limited the statistical power needed to detect a true association, if one existed. Therefore, the findings of our study on corset use should not be definitively interpreted as an absence of effect. Further larger-scale studies with more balanced subgroup representation and long-term corset use are necessary to elucidate the potential impact of this factor on the formation of adhesions.

To the best of our knowledge, the presence of IAA in relation to both preterm and term pregnancies has not yet been evaluated. We compared IAA scores between preterm and term CS to investigate whether adhesions resulting from previous CS could affect uterine growth in subsequent pregnancies and contribute to preterm labor. However, we found no significant difference between preterm and term pregnancies in terms of IAA.

Endothelial cell permeability is induced by the release of vascular endothelial growth factor (VEGF) and is known to be directly affected by smoking. VEGF is a potent enhancer of vascular permeability and plays a central role in the postoperative formation of peritoneal adhesion [20]. The correlation between smoking and delayed wound healing is well established, suggesting that adhesion formation is likely to increase with each repeated CS. Condon *et al*. [36] found that nicotine consumption was associated with increased formation of postoperative peritoneal adhesions. Moreover, Sönmez *et al*. [37] reported that smoking increased the probability of IAA by 2.82-fold, and each CS by 2.73-fold. However, unlike previous studies that suggested an association between smoking and increased formation of adhesions, the present study found no significant difference in the incidence of IAA between smokers and non-smokers ($p = 0.224$). This discrepancy could be attributed to various factors, such as differences in study populations, evaluation of smoking habits, and specific surgical contexts. Further research is needed to clarify the exact role of smoking in the development of adhesions.

4.1 Strengths of This Study

1. Prospective design: The study was conducted prospectively, thus contributing to the reliability of the findings and minimising recall bias.

2. Large sample size: The inclusion of 800 pregnant women who underwent repeated CS increases the statistical power and generalizability of the study.

3. Ethical approval: The study was approved by the Harran University Faculty of Medicine Clinical Research Ethics Committee, ensuring compliance with ethical standards.

4. Comprehensive data collection: Demographic and clinical characteristics, including age, gravida, parity, number of previous CS, smoking habits, BMI, and gestational age were thoroughly recorded, allowing for a complete analysis.

4.2 Limitations of This Study

1. Missing surgical details: The lack of information on specific surgical techniques, suture materials, wound care, and the use of anti-adhesive materials in previous CS could introduce confounding factors.

2. Limited details on corset use: Our study recorded the duration of corset use, but lacked detailed information on how corset pressures were adjusted, the specific type of corset used, and patient compliance with consistent use. The lack of standardization and monitoring limited our ability to fully understand the nuanced relationship between corset use and the development of IAA, highlighting the need for more controlled studies in this field.

3. Absence of pre-study sample size calculation: A limitation of this study was the lack of a formal sample size calculation conducted prior to patient recruitment. However, the study enrolled a large cohort of 800 patients, comparable to or larger than most authoritative studies in this field [9,23–25,27–29,33–37]. While a prospective power analysis would have provided more justification for the sample size, we believe the substantial number of participants contributes to the robust nature of our findings, despite this limitation.

4. Unknown surgical details from previous CSs: A major limitation of this study was the lack of detailed information on surgical techniques used in previous CS, including uterine closure methods (single- versus double-layer), suture materials, total operation time, and whether the previous surgeries were elective or emergency. These factors are known to influence adhesion formation, and their absence from our dataset restricts causal inferences and the generalizability of our findings. Future research should aim

to collect these critical intraoperative and perioperative details to achieve a more comprehensive understanding of adhesion development.

5. Limited generalizability: The study was conducted in a tertiary hospital with a specific population, which may limit the generalizability of the findings to broader populations.

6. Absence of pairwise comparisons: Although intergroup differences were assessed using appropriate statistical tests, specific post hoc pairwise comparisons were not performed for variables showing significant overall differences among multiple groups (e.g., between Nair adhesion score groups). This limits a detailed interpretation of which specific groups differ from each other, and is a methodological limitation that could be addressed in future studies.

7. Impact of significant weight fluctuations: Our study did not specifically account for patients with a history of significant weight loss or gain outside of pregnancy that could independently influence striae formation or skin elasticity. This factor could potentially confound the relationship between SG and adhesions, and hence future studies should consider recording this information.

Despite these limitations, the prospective design of the study, the substantial sample size, and the comprehensive collection of data has allowed valuable analysis of the factors associated with IAA in women undergoing repeated CS.

4.3 Interpretation of Study Results

This prospective study examined the relationship between various factors and the severity of IAA after repeated CS. The findings provide several nuanced insights and implications for clinical practice.

1. Limited predictive value of scar characteristics and SG density: The results of this study challenge the common assumption that scar tissue characteristics and SG density could serve as reliable predictors of IAA. The lack of significant associations between scar appearance, pigmentation, SG density, and adhesion severity suggests that sole reliance on these visual and structural indicators may not be sufficient to predict the extent of IAA.

2. Corset use and duration: Investigation into the duration of corset use after previous CS revealed no discernible impact on IAA scores. This suggests that the therapeutic benefits of corset use, including pain reduction and stabilization of the abdominal wall, may not directly influence the formation or severity of IAA. Additional studies are warranted to further explore the nuanced relationship between corset use and the development of adhesions.

3. Number of previous CS as a risk factor for IAA: Our study highlights the importance of the number of previous CS as a significant risk factor for increased IAA severity. Clinicians should be fully aware of this factor when evaluating patients who undergo repeated CS, as it appears to play a crucial role in the likelihood of adhesion formation. Careful consideration of the cumulative impact of multiple CS should contribute to improved patient outcomes.

4. Preterm vs. term pregnancies: The lack of significant difference in IAA scores between preterm and term pregnancies suggests that the presence of adhesions does not substantially affect uterine growth or contribute to preterm labor. This finding provides reassurance regarding obstetric outcomes for adhesion-related complications between different gestational ages.

5. Implications for clinical practice: The results of this study highlight the complexity of factors that influence IAA and emphasise the need for a comprehensive approach to risk assessment. Clinicians should consider a combination of patient history, lifestyle factors, and surgical details rather than relying solely on visual indicators or specific interventions, such as corset use. Detailed assessment of the number of previous CS should be included in preoperative evaluations to improve patient care and outcomes.

6. Future research directions: The findings from this study prompt new research avenues to further refine risk assessment models and to explore the intricate mechanisms underlying IAA formation. Future investigations should examine the molecular and cellular pathways involved, as well as the impact of various surgical techniques, suture materials, and potential anti-adhesion interventions used in previous Cesarean procedures. Continued efforts to elucidate these complexities should advance knowledge in this field and improve clinical strategies for managing IAA in obstetric practice.

5. Conclusions

1. IAA rates: A high incidence of IAA (73.3%) was found among pregnant women with a history of at least one previous CS, highlighting the prevalence of this complication in the study population.

2. Association with the number of previous CS: A significant association was observed between the number of previous CS and the severity of IAA. Women with a higher number of previous CS exhibited higher adhesion scores, highlighting the cumulative effect of repeated Cesarean procedures.

3. Scar characteristics and pigmentation: Contrary to some previous studies, scar tissue characteristics (including flat, depressed, or raised features) and pigmentation status were not significantly associated with IAA scores in the present study. This suggests that the visual appearance of scars on the abdominal skin may not reliably predict the severity of adhesions.

4. No association with SG: This study found no significant association between SG density and IAA scores.

5. Duration of corset use: No significant difference in IAA scores was observed between women who used corsets for <2 weeks compared to those who used them for ≥ 2 weeks. This suggests the duration of corset use may not be a decisive factor in predicting the severity of adhesions.

6. Smoking and IAA rates: Unlike some previous literature, our study found no statistically significant difference in the prevalence of IAA scores between smokers and non-smokers. This suggests that smoking was not a significant predictive factor for the formation of adhesions in our patient cohort.

7. Preterm vs. term pregnancies: Interestingly, this study did not find a significant difference in IAA scores between women with preterm and term pregnancies, suggesting that the adhesions did not significantly affect uterine growth or contribute to preterm labor.

In conclusion, this study found that scar tissue characteristics, density of SG, and history of corset use were not predictive of IAA. However, the number of previous CS was strongly associated with an increased prevalence of IAA. This information may be useful in clinical practice.

Availability of Data and Materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Author Contributions

YZK, HU, Mİ, and ÖT contributed equally to the conception, design, and execution of this study. YZK and BK are responsible for data collection and statistical analysis analysis. HU and BK contributed to the interpretation of results and manuscript drafting. Mİ and ÖT provided critical revisions to the study design, assisted in data interpretation, and contributed to the final editing of the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki. This study was approved by the Harran University Ethics Committee with the decision number E.42537, obtained during the session held on 17 November 2021. Informed consent was obtained from all subjects who took part in the study.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

The authors acknowledge the use of AI-assisted technologies in the preparation of this manuscript. Specifically, Paperpal was utilized for language enhancement and grammar correction, and Google's Gemini was used to assist in structuring responses and improving phrasing. These tools primarily helped us with aspects such as spell check, grammar corrections, improved phrasing, and improved the overall flow of the text. The use of artificial intelligence did not alter the scientific content, findings, or conclusions of our study in any way. Our aim was to improve the linguistic quality of our article and to accelerate the writing process. All research data, analyses, and conclusions were conducted independently by us. With this declaration, we wish to state that AI tools were used solely as assistive aids, and the originality of our work has not been compromised.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/CEOG40126.

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