

Clinical and Sonographic Determinants of Cesarean Scar Niche Formation and Early Postpartum Symptoms: A Prospective Cohort Study

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Abstract

Objective: To determine the incidence of cesarean scar niche following cesarean delivery, to identify independent clinical and operative predictors of defect formation, and to characterize the relationship between niche morphology and postoperative symptom burden.

Methods: This prospective observational cohort study was conducted at a single tertiary center between May 2024 and December 2025. Women with at least one prior cesarean delivery attended a structured follow-up visit 3-6 months postpartum, including transvaginal ultrasound evaluation of the cesarean scar. Niche was defined as an anechoic indentation ≥ 2 mm in depth. Large niche was defined as residual myometrial thickness (RMT)/adjacent myometrial thickness (AMT) ratio ≤ 0.5 and/or RMT < 3 mm. Demographic, obstetric, operative, and symptom-related variables were compared between women with and without niche formation. Multivariable logistic regression identified independent predictors of niche formation.

Results: Among 381 women included, 243 (63.8%) had a cesarean scar niche, including 92 (24.1%) with a large niche. Women with niche formation had a higher body mass index (BMI) than those without ($p=0.032$). On multivariable analysis, higher BMI ($p=0.035$), emergent cesarean delivery ($p=0.033$), and hormonal contraceptive use ($p=0.047$) were independently associated with niche formation. Large niche was associated with diabetes mellitus ($p=0.017$) and lower fetal head station at surgery ($p=0.029$). Barbed versus Vicryl uterine closure was not associated with niche formation.

Conclusion: Cesarean scar niche is highly prevalent in the early postpartum period. Higher BMI and emergent cesarean delivery independently predicted niche formation, whereas diabetes mellitus and advanced fetal head station were associated with larger defects. Despite its high incidence, niche presence and severity were not associated with increased short-term postoperative symptoms.

INTRODUCTION

As cesarean section (CS) rates continue to rise globally, the long-term consequences of uterine incision healing have attracted increasing clinical and scientific attention. Among the recognized sequelae, cesarean scar defect (CSD), variably described as isthmocoele or uterine niche - has emerged as a distinct and clinically significant entity, with implications spanning gynecological symptomatology, reproductive function, and future obstetric outcomes[1–3]. CSD is defined as a myometrial discontinuity at the site of a prior uterine incision, manifesting sonographically as an anechoic or hypoechoic indentation of at least 2 mm depth within the anterior isthmus myometrium[4].

The reported prevalence of CSD varies widely, ranging from 7% to 70%, a disparity attributed to heterogeneity in diagnostic criteria, operator experience, and the timing of postpartum assessment[5]. Of clinical relevance, approximately 25% of women with CSD demonstrate large defects or sonographically suboptimal scar healing on postpartum transvaginal ultrasound[6, 7]. Moreover, 30–40% of affected women report associated symptoms, including postmenstrual spotting, dysmenorrhea, dyspareunia, and

chronic pelvic pain[8]. Beyond gynecological morbidity, CSD has been implicated in serious obstetric complications such as uterine dehiscence, uterine rupture, morbidly adherent placenta, and cesarean scar pregnancy, as well as secondary subfertility, underscoring its potential impact across the reproductive lifespan[9].

Two-dimensional transvaginal ultrasound (2D-TVS) remains the recommended first-line imaging modality for CSD diagnosis, typically demonstrating a hypoechoic or anechoic defect in the anterior isthmic myometrium. Standardized sonographic assessment, including measurement of residual myometrial thickness (RMT), niche depth, and width, is essential for risk stratification and treatment planning[10, 11].

Over the past decade, multiple studies have reported risk factors for CSD development, including number of prior cesarean deliveries, uterine retroflexion, prolonged labor, peripartum infection, emergent CS, uterine closure technique, maternal obesity, and gestational diabetes[8, 12, 13]. Nevertheless, the relative contributions of clinical, operative, and sonographic variables to defect diagnosis remain incompletely characterized.

Therefore, this study aimed to establish the incidence of CSD following cesarean delivery, to identify independent clinical and operative predictors of defect formation, and to explore the relationship between sonographic niche morphology and the nature and severity of postoperative symptoms.

MATERIALS AND METHODS

Study Design and Population

This single-center prospective observational cohort study was conducted between May 2024 and December 2025. Ethical approval was granted by the institutional review board. Written informed consent was obtained from all participants.

In May 2024, a specialized post-cesarean follow-up clinic was established at our institution. All women with at least one prior cesarean delivery were invited to attend a structured follow-up visit between 3 and 6 months postpartum. Notably, all cesarean sections in our institution are performed by an attending physician using a uniform protocol of surgery including closure of uterus with two layers of sutures and excluding endometrium. During this visit, participants were systematically interviewed regarding postoperative symptoms, including postmenstrual spotting, dysmenorrhea, dyspareunia, and chronic pelvic pain, with all findings documented in their electronic medical records. A targeted transvaginal ultrasound assessment of the cesarean scar was subsequently performed.

Demographic, antenatal, intrapartum, operative, and postpartum data were retrieved from electronic medical records. Variables collected included maternal age, body mass index (BMI), parity, indication for cesarean delivery, cervical dilatation at the time of cesarean, fetal station, duration of labor, suture material, postoperative complications, and breastfeeding status.

Women were excluded if adequate ultrasound visualization of the lower uterine segment could not be obtained, or if a subsequent pregnancy was confirmed at the time of the follow-up visit.

Cesarean Scar Ultrasound Assessment

All participants underwent transvaginal ultrasound performed by a trained physician using a Voluson E10 system (GE Healthcare, Austria) equipped with a 5–9 MHz three-dimensional transvaginal probe. A cesarean scar niche was defined as an anechoic indentation at the site of the cesarean scar measuring ≥ 2 mm in depth, from the endometrial surface to the apex of the defect.

The following parameters were systematically recorded:

- Niche depth (mm)
- Niche width (mm)
- Niche length (mm)
- Residual myometrial thickness (RMT) at the thinnest point
- Adjacent myometrial thickness (AMT)
- RMT/AMT ratio (healing ratio)

A large niche was defined as an RMT-to-AMT ratio ≤ 0.5 and/or RMT ≤ 3 mm, in accordance with previously published criteria[11].

Outcome Measures

The primary outcome was the incidence of cesarean scar niche detected on transvaginal ultrasound. Secondary outcomes included: identification of independent clinical and operative predictors of niche formation and large niche development, the association between sonographic scar morphology parameters and postoperative symptomatology and a comparison of scar characteristics between women undergoing elective versus emergent cesarean delivery.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 29 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD) or median [interquartile range (IQR)], as appropriate based on distribution normality assessed by the Shapiro–Wilk test and compared using the independent-samples t-test or Mann–Whitney U test, respectively. Categorical variables are presented as frequencies and proportions and were compared using the chi-square test or Fisher's exact test, as appropriate.

Univariable logistic regression analyses were performed to evaluate associations between candidate clinical variables and niche presence. Variables reaching statistical significance on univariable analysis, as well as clinically relevant covariates, were entered into multivariable logistic regression models to

identify independent predictors of niche formation and large niche development. All tests were two-sided, and a P value <0.05 was considered statistically significant.

RESULTS

During the study period, 381 women attended the clinic and underwent transvaginal ultrasound evaluation of the cesarean scar. A niche was identified in 243 participants (63.8%), while 138 (36.2%) had no detectable defect. Among women with a niche, 92 (37.9%) met criteria for a large niche, defined as an RMT/AMT ratio of ≤ 0.5 , while the remaining 151 (62.1%) were classified as non-large.

Baseline demographic and obstetric characteristics are presented in Table 1. Maternal age, parity, number of prior cesarean deliveries, diabetes, hypertensive disorders, endometriosis, thrombophilia, smoking status, and labor-related variables did not differ significantly between women with and without a niche. Women with a niche had a significantly higher BMI compared to those without (31.1 ± 6.0 vs. 29.1 ± 4.9 kg/m², $p = 0.032$).

Operative and perioperative characteristics are summarized in Table 2. On univariable analysis, no operative variable was significantly associated with niche formation, including repeat cesarean delivery, emergent cesarean delivery, cesarean performed during active labor, cervical dilatation at the time of surgery, fetal head station, or suture material (barbed vs. polyglactin).

A subgroup analysis comparing women with large versus non-large niches is presented in Table 3. Women with a large niche were more likely to have diabetes (9.7% vs. 2.6%, $p = 0.017$) and had a significantly more advanced fetal head station at the time of surgery ($p = 0.029$). No other baseline or operative variable differed significantly between these subgroups. Notably, symptom burden did not differ between women with large and non-large niches.

When women with a large niche were compared to all others - including those with no niche and those with a non-large niche - large niche was associated with higher rates of diabetes (9.7% vs. 4.1%, $p = 0.039$), more advanced fetal station at surgery ($p = 0.037$), and a lower rate of intraoperative incision extension (4.3% vs. 11.4%, $p = 0.045$) (Table 4). No significant differences in postoperative symptoms were observed between groups.

On multivariable logistic regression, three independent predictors of niche formation were identified: higher BMI (adjusted OR 1.07, 95% CI 1.00-1.14, $p = 0.035$), emergent cesarean delivery (adjusted OR 3.57, 95% CI 1.11-11.49, $p = 0.033$), and hormonal contraceptive use (adjusted OR 2.38, 95% CI 1.01-5.63, $p = 0.048$). Repeat cesarean delivery, active labor, barbed suture use, breastfeeding, and any niche related symptom were not independently associated with niche formation (Table 5).

DISCUSSION

In this prospective cohort, cesarean scar niche was identified in nearly two-thirds of women at 3–6 months postpartum, providing a well-powered framework for evaluating the clinical, operative, and sonographic determinants of defect formation and severity. Higher maternal BMI, emergent cesarean delivery, and hormonal contraceptive use were independently associated with niche formation, while diabetes mellitus and lower fetal head station at the time of surgery were associated with larger niche defects. Importantly, neither niche presence nor niche size was associated with increased short-term postoperative symptom burden.

Higher maternal BMI and emergent cesarean delivery emerged as independent predictors of niche formation, underscoring the contribution of both patient-related metabolic factors and intrapartum circumstances to impaired scar healing. These findings are consistent with prior studies demonstrating associations between obesity, labor-related variables, and suboptimal myometrial repair[8, 14]. At the level of large niche formation, diabetes mellitus and a lower fetal head station at the time of surgery were associated with more severe defects, further supporting the role of metabolic comorbidity and advanced labor conditions in compromised uterine healing.

Notably, uterine closure using barbed sutures was not associated with niche formation in our cohort. This is consistent with emerging evidence suggesting that surgical technique alone may not be the primary determinant of niche development, and that intrinsic patient characteristics and obstetric factors may play a more dominant role[15]. It should be acknowledged, however, that other potentially relevant surgical variables, most notably single- versus double-layer uterine closure, could not be evaluated in the present study, as all cesarean deliveries were performed with two-layer closure. This factor has previously been identified as an independent predictor of niche formation and warrants consideration in future comparative studies[16].

The observed association between hormonal contraceptive use and niche formation warrants careful interpretation. From a mechanistic standpoint, exogenous sex steroids are known to influence endometrial proliferation, vascularization, and local inflammatory pathways, effects that could plausibly modulate uterine scar healing, although direct evidence in this context remains limited[17, 18]. However, this association is likely susceptible to confounding by indication- women experiencing early postoperative bleeding abnormalities, which may themselves reflect underlying scar pathology, are more likely to initiate hormonal therapy, thereby introducing potential reverse causation. Furthermore, hormonal contraceptive use suppresses menstrual bleeding, which may obscure symptom-based ascertainment of niche and influence clinical detection. Accordingly, this finding should be interpreted with caution and warrants prospective evaluation with detailed exposure characterization.

Despite the high incidence of niche in our cohort, neither its presence nor its size was associated with an increased burden of postoperative symptoms. These findings align with prior reports demonstrating that a substantial proportion of women with niche remain asymptomatic[19], and with prospective data indicating that only a minority of affected women report clinically significant complaints[20]. Nevertheless, our findings contrast with studies reporting significant associations between niche and

symptoms such as postmenstrual spotting, dysmenorrhea, and dyspareunia[21], as well as meta-analytic data suggesting an increased risk of chronic pelvic pain among affected women[22]. These discrepancies most likely reflect heterogeneity in study populations, variability in the definition of symptomatic niche, differences in timing of postpartum assessment, and potential selection bias toward symptomatic patients in referral-based cohorts. Indeed, while estimates suggest that 30–40% of women with niche may report symptoms, the causal relationship remains uncertain, and not all sonographically detected defects are of clinical relevance.³

This study has several notable strengths. The prospective design, standardized follow-up protocol at 3–6 months postpartum, and use of structured symptom assessment alongside detailed transvaginal sonographic evaluation allowed for comprehensive characterization of both clinical and morphological outcomes. The inclusion of both elective and emergent cesarean deliveries enhances the generalizability of the findings, and the application of multivariable logistic regression enabled identification of independent predictors while accounting for potential confounders.

Several limitations merit acknowledgment. First, the observational study design limits the ability to establish causal relationships, and the association between hormonal contraceptive use and niche formation is particularly susceptible to confounding by indication, as well as variability in contraceptive type, dose, and timing of initiation. Second, symptom assessment was based on patient-reported outcomes collected at a single postpartum time point, which may be subject to recall and reporting bias. Third, sonographic evaluation was performed at a single postpartum interval, precluding assessment of niche evolution over time. Fourth, although the overall sample size was adequate for primary analyses, the study may have been underpowered to detect independent predictors of large niche formation in multivariable models. Finally, while suture material was recorded, more nuanced aspects of intraoperative technique - including closure configuration, suture tension, and the extent of myometrial tissue incorporated, were not systematically documented, precluding a comprehensive evaluation of the operative factors that may contribute to niche development.

CONCLUSIONS

Cesarean scar niche is a common finding in the early postpartum period. Higher maternal BMI and emergent cesarean delivery independently predicted niche formation, whereas diabetes mellitus and advanced fetal head station at the time of cesarean delivery were associated with large niche formation. No association was observed between uterine closure using barbed (STRATAFIX) versus Vicryl sutures and niche formation, suggesting that suture material alone may not substantially influence cesarean scar healing.

Despite the high incidence of niche in our cohort, neither niche presence nor niche severity was independently associated with postoperative symptom burden, suggesting that structural sonographic findings and clinical symptomatology may reflect partially distinct pathophysiologic processes.

These findings may have implications for postpartum counseling and targeted sonographic surveillance, particularly among women with metabolic comorbidities or those undergoing emergent cesarean delivery. Further large-scale prospective studies with standardized imaging protocols and longitudinal follow-up are needed to clarify the long-term gynecologic and reproductive significance of early niche formation and to better characterize the mechanisms underlying impaired post-cesarean myometrial healing.

Declarations

Conflicts of interest:

None to declare.

What does this study add to the clinical work

Cesarean scar niche was common after cesarean delivery and associated with obesity and emergent surgery, but not with increased short-term postoperative symptoms.

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Author Contribution

M.N & L.M, C.S- Protocol/project development, Data collection or management, Data analysis, Manuscript writing/editing, L.K, E.W, R.K, S.G, O.G- Protocol/project development, Patient handling, Manuscript revisions, E.W & R.S- Protocol/project development, Supervision, Administration, Manuscript revisions. All authors reviewed the manuscript.

Data Availability

All data supporting the findings of this study are available upon a reasonable request from the corresponding author

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Tables

Tables 1 to 5 are available in the Supplementary Files section.

Supplementary Files

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