Thai Journal of Obstetrics and Gynaecology
September 2023, Vol. 31, No. 5, pp. 350-358.

OBSTETRICS

Prevalence of and Factors Associated with Large Cesarean Scar Defects in Women at Six Weeks Postpartum

Napat Nitayaphan, B.MedSci., M.D.*,
Wipada Laosooksathit, M.D.*,
Kittipong Kongsomboon, M.D., Ph.D.**,
Maethaphan Kitporntheranunt, M.D.*

** Department of Obstetrics and Gynecology, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand*
*** Department of Preventive and Social Medicine, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand*

ABSTRACT

Objectives: To demonstrate the prevalence and factors associated with a large Cesarean scar defect (CSD) in Thai postpartum women.

Materials and Methods: This was a cross-sectional study. The participants were enrolled for a postpartum sonographic examination at the sixth-week follow-up from August to December 2021. CSD was measured using a two-dimensional transvaginal ultrasound device. A large CSD was defined as having a height of ≥ 50% of the total myometrial thickness. The sonographer was blinded to the obstetric history until all parameters had been recorded.

Results: At six weeks postpartum, CSD was identified in 94 participants. There were 64 and 30 participants in the primary and repeat Cesarean section (CS) groups, respectively. The overall prevalence of large CSD was 22.3%. A large CSD was seen in 15.6% (10/64) and 36.7% (11/30) of the patients in the primary and repeated CS groups. The factors associated with large CSD were repeated CS (p = 0.002), cervical dilatation ≥ 6 cm at the time of CS (p = 0.023), and uterine retroflexion (p = 0.015) groups, with odds ratio of 8.85 (95% confidence interval (CI) 2.29-34.15), 5.84 (95%CI 1.28-26.71) and 4.40 (95%CI 1.33-14.55), respectively.

Conclusion: The overall prevalence of large CSDs was 22.3%. Repeated CS, uterine retroflexion, and cervical dilatation ≥ 6 cm at the time of CS had higher odds of developing a large CSD.

Keywords: cesarean section, uterine scar defect, ultrasound, postpartum.

Correspondence to: *Maethaphan Kitporntheranunt, M.D., Department of Obstetrics and Gynecology, Faculty of Medicine, Srinakharinwirot University, 62 Moo 7, Klong 16, Rangsit-Nakhon Nayok road, Ongkharak, Nakhon Nayok, 26120, Thailand. E-mail: mtp_swu@hotmail.com, sumate@g.swu.ac.th*

Received: 30 September 2022, **Revised:** 20 Janurary 2023, **Accepted:** 30 January 2023

ความชุกและปัจจัยที่สัมพันธ์กับร่องแผลเป็นมดลูกขนาดใหญ่จากการผ่าคลอดที่หกสัปดาห์หลังคลอดบุตร

ณภัทร นิตยพันธ์, วิภาดา เหล่าสุขสถิตย์, กิตติพงษ์ คงสมบูรณ์, เมธาพันธ์ กิจพรธีรานันท์

บทคัดย่อ

วัตถุประสงค์: *เพื่อศึกษาความชุกของร่องแผลเป็นมดลูกขนาดใหญ่และปัจจัยที่สัมพันธ์ในสตรีไทยหลังคลอด*
วัสดุและวิธีการ: *การวิจัยนี้ศึกษาแบบภาคตัดขวาง โดยผู้เข้าร่วมวิจัยจะได้รับการตรวจคลื่นเสียงความถี่สูงทางช่องคลอดแบบสองมิติ โดยนิยามร่องแผลเป็นมดลูกขนาดใหญ่เมื่อพบร่องที่มีความลึกมากกว่าหรือเท่ากับร้อยละ 50 ของความหนาชั้นกล้ามเนื้อมดลูกทั้งหมด ซึ่งผู้ตรวจคลื่นเสียงความถี่สูงจะไม่ทราบประวัติทางสูติกรรมของผู้เข้าร่วมวิจัย*
ผลการศึกษา: *ที่ 6 สัปดาห์หลังคลอด สามารถตรวจพบร่องแผลเป็นที่มดลูกบริเวณที่ผ่าตัดคลอดทั้งหมด 94 ราย โดยมีกลุ่มผ่าตัดคลอดครั้งแรก 64 ราย และกลุ่มผ่าตัดคลอดซ้ำ 30 ราย และมีความชุกร่องแผลเป็นขนาดใหญ่ทั้งหมดร้อยละ 22.3 โดยพบในกลุ่มผ่าตัดคลอดครั้งแรกร้อยละ 15.6 (10/64 ราย) และในกลุ่มผ่าตัดคลอดซ้ำร้อยละ 36.7 (11/30 ราย) ปัจจัยที่สัมพันธ์กับการพบร่องแผลเป็นขนาดใหญ่ ได้แก่ การผ่าตัดคลอดซ้ำ (p = 0.002) ปากมดลูกเปิดขยายมากกว่าหรือเท่ากับ 6 เซนติเมตร (p = 0.023) และ มดลูกคว่ำหลัง (p= 0.015) โดยเพิ่มความเสี่ยงเป็น 8.85 เท่า (95% confidence interval (CI) 2.29-34.15), 5.84 เท่า(95%CI 1.28-26.71) และ 4.40 เท่า (95%CI 1.33-14.55) ตามลำดับ*
สรุป: *ความชุกของร่องแผลเป็นมดลูกขนาดใหญ่หลังผ่าตัดคลอดบุตรร้อยละ 22.3 โดยมีปัจจัยที่สัมพันธ์ได้แก่ การผ่าตัดคลอดซ้ำ มดลูกคว่ำหลัง และ ปากมดลูกเปิดขยายมากกว่าหรือเท่ากับ 6 เซนติเมตรขณะผ่าคลอด*

คำสำคัญ: *ผ่าตัดคลอด ร่องแผลเป็นมดลูก คลื่นเสียงความถี่สูง หลังคลอดบุตร*

Introduction

Cesarean section (CS) is a lifesaving procedure which is mandatory in certain situations. The CS rate has increased worldwide in recent decades[1]. Cesarean scar defect (CSD), also known as uterine isthmocele or uterine niche, is an iatrogenic complication exclusive to CS. It is a discontinuity of the myometrium and behaves like a reservoir pouch at the site of a previous cesarean scar. The prevalence of CSD has been increasing with the CS rate, with a rate of 64.5% CSD at 6-12 months postpartum. Early scanning is recommended to locate the scar defect when it is more prominent[2].

A large CSD correlates with a higher prevalence of symptoms, such as postmenstrual spotting and chronic pelvic pain[3]. The range of associated complications is vast, ranging from abnormal uterine bleeding to life-threatening conditions such as uterine rupture and cesarean scar pregnancy[4]. Women with a large CSD are also reportedly at risk of uterine dehiscence[5] or placenta accreta spectrum[6-8]. These complications are associated with high morbidity and mortality.

Large CSDs have usually been investigated at six months postpartum. A recent study has followed CSD from six weeks to one year and concluded that its presence is consistent[9]. CSD is multifactorial and involves the interplay between genetic factors, maternal health, local microenvironment, suturing techniques, uterine habitus, and number of surgeries[10]. We aimed to investigate the effect of repeated CS on CSD, as it may alter myometrial healing. Previous reports have demonstrated the pathophysiology of repetitive tissue trauma in wound healing and inflammation[11]. We postulate that a large CSD can be detected as early as six weeks postpartum.

The primary outcome was the prevalence of a large CSD at six weeks postpartum. The secondary outcome was the association between repeated CS and a large CSD.

Materials and Methods

Participants

This was an analytical cross-sectional study. The project was approved by the institutional ethics committee (No: SWUEC-006/64) and was registered with the Thai Clinical Trials Registry (No: TCTR20210420004). Postpartum women who had undergone CS between August and December 2021 were recruited in the postpartum ward after the surgery. Information regarding the study was thoroughly explained to all participants. All participants provided informed consent to participate in the study after CS before they were discharged. All surgeons employed the same surgical technique. A low transverse incision and two-layer suturing technique (locking the first layer and non-locking the second layer) was performed in all patients.

A pilot study was conducted with 25 participants. The sample size was calculated using a two-independent proportion formula, where p1 represented patients with large CSDs after primary CS (0.05 [1/18]), p2 represented patients with large CSDs after repeated CS (0.28 [2/7]), and the ratio was 0.38. A total of 94 participants were recruited.

$$n_1 = \left[\frac{z_{1-\frac{\alpha}{2}}\sqrt{\bar{p}\bar{q}(1-\frac{1}{r})}+z_{1-\beta}\sqrt{p_1q_1+\frac{p_2q_2}{r}}}{\Delta} \right]^2$$

The participants were Thai and had undergone CS at our institution. The inclusion criteria were as follows: singleton pregnancy with a low transverse uterine incision, no history of uterine surgery other than CS, absence of uterine abnormality, absence of placenta previa or abnormally adherent placenta, and consent to participate. The exclusion criteria were as follows: failure to obtain all sonographic parameters, postpartum metritis, late postpartum hemorrhage, and loss to follow-up at 6 weeks (Fig. 1). All the surgeons employed similar surgical techniques and used monofilament sutures (1-0 chromic catgut) to repair the uterine incision.

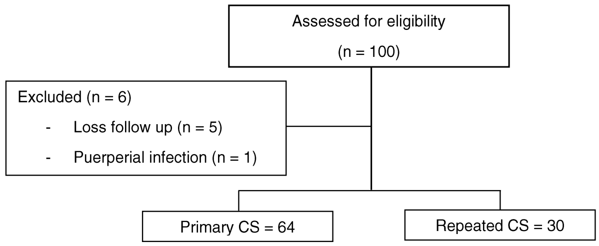


Fig. 1. Consort flow chart

Assessment of CSD

The sonographer was blinded to the patient's information during ultrasonography. Ultrasonography was performed by one sonographer (NN), who has completed a pelvic ultrasound workshop and is certified by a maternal-fetal medicine specialist. All measurements were reported on two-dimensional (2D) static images and were approved without disagreement. After ultrasonography, patient demographics, antenatal care information, inpatient records, and operative notes were collected. Transvaginal ultrasound (TVS) examinations were performed at six weeks postpartum using a Voluson™ P8 machine (GE Healthcare, Bangkok, Thailand). This timing allowed better visualization of the CSD without the additional need for instillation ultrasound. Uterine habitus was defined as retroflexion and anteflexion.

Sonographic protocol

The ultrasound protocol was adapted from that of Osser et al (2009)[12]. The TVS probe was pressed firmly into the cervix, without excessive pressure, to visualize the uterus in the midsagittal plane. The lower uterine segment occupied approximately ¾ of the ultrasound screen. The uterine incision site was examined for CSD. We collected the uterine position and CSD parameters (Fig. 2, 3). An indentation of at least 2 mm at the incision site was considered CSD. CSD parameters included the base, height (H), residual myometrial thickness (RMT), and total myometrial thickness (TMT). First, a line was drawn at the base of the triangular defect, which represented the base. Subsequently, the CSD apex was identified; a perpendicular line from the apex to the base of the CSD represented the CSD height. The RMT was defined as the distance from the apex of the CSD to the uterine serosa. The TMT was the normal uninvolved myometrium, located just cephalad to the scar defect and defined as the distance from the base of the CDS to the uterine serosa. Non-instillation ultrasonography was performed. Therefore, the shape of the CSD could not be categorized.

The percentage of the CSD height was calculated as (H/TMT) × 100. A value ≥ 50% was considered a 'large CSD'[4, 13]. Large CSDs were the focus of this study because they are associated with more severe complications[2].

In patients with large CSDs, we advised outpatient follow-up for six months and early first-trimester scanning in a subsequent pregnancy.

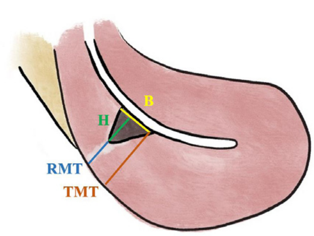
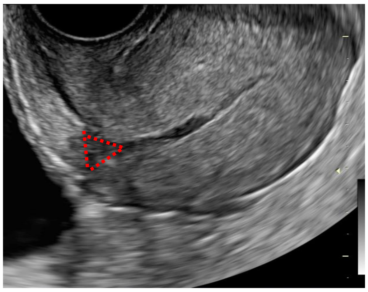
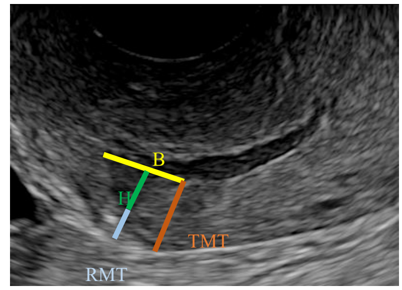


Fig. 2. Uterine niche measurements. The following measurements were performed: B = the scar base, H = niche height, RMT = residual myometrial thickness, and TMT = total myometrial thickness.



3a



3b

Fig. 3. Transvaginal ultrasonography. (a) A triangular niche formed at the uterine incision (denoted by the dotted line). (b) Measurement parameters.
B = base of the scar, H= height of the scar, RMT= residual myometrial thickness, TMT= total myometrial thickness.

Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (version 27; SPSS Inc., Chicago, IL, USA). Differences in ultrasonographic findings were calculated using the chi-square, Fisher's exact, and independent t-tests, as appropriate. The effects of factors associated with a large CSD were adjusted using multiple logistic regressions. Statistical significance was set at $p < 0.05$.

Results

A total of 94 participants provided informed consent to participate in the study. The baseline characteristics and demographic data are presented in Table 1. The majority (68.1%) of participants had primary CS, in which the indications for emergency CS were cephalopelvic disproportion (CPD), failed induction, abnormal fetal presentation, and abnormal fetal tracing. CPD was the highest in the primary emergency CS group (47.1 %). Thirteen participants underwent elective primary CS due to abnormal fetal presentations (38.5%), fetal macrosomia (7.7%), and maternal requests (53.8%). Labor was not augmented or induced with oxytocin in any patient in the repeated CS group. No participant had a cervical dilatation of ≥ 6 cm at the time of CS in the repeated CS group. All the women in the repeated CS group were scheduled for an elective CS. If labor commenced before the scheduled date, they underwent emergency CS. Cervical dilatation of 6 cm was chosen because it is the cut-off value for active labor[14]. The operative time in the primary CS population (54.8 ± 12.8 minutes) was shorter than that in the repeated CS population (70.5 ± 21.0 minutes).

Ultrasound findings of women with primary CS and repeated CS at six weeks after surgery are shown in Table 2. We observed 57 participants with anteflexed uteri and 37 with retroflexed uteri. The mean height and base in the repeated CS group (7.53 mm and 8.43 mm, respectively), were higher than those of the primary CS group (4.63 mm and 6.05 mm, respectively) ($p < 0.001$). The mean TMT in the primary and repeated CS groups was 13.24 mm and 15.21 mm, respectively ($p = 0.01$). The TMT in the primary CS group was lower because 13 of the 64 (20.0%) women had advanced labor. The mean RMT in the primary CS group (8.16 mm) was higher than that in the repeated CS group (5.42 mm) ($p < 0.001$). Large CSDs were detected in 10 (15.6%) and 11 (36.7%) women in the primary and repeated CS groups ($p = 0.02$). The overall prevalence of large CSD was 22.3%. A total of three (4.7%) and five (16.7%) patients in the primary and repeated CS groups were found to have thin RMTs ($p = 0.05$). The factors associated with large CSDs are shown in Table 3 and include the number of CS ($p = 0.002$), cervical dilatation ≥ 6 cm at the time of CS ($p = 0.023$), and uterine retroflexion (p = 0.015). These factors had a statistically significant relationship to large CSDs. Repeated CS, cervical dilatation ≥ 6 cm at the time of CS, and uterine retroflexion showed 8.85 (95% confidence interval (CI) 2.29-34.15), 5.84 (95%CI 1.28-26.71), and 4.40 (95%CI 1.33-14.55) odds of a person developing a large CSD, respectively.

Table 1. Baseline characteristics (total n = 94).

Parameters	Primary CS (n = 64)	Repeated CS (n = 30)
Age*	29.2 ± 6.0	33.8 ± 4.8
Age < 35 years	52 (81.2%)	14 (46.7%)
Age ≥ 35 years	12 (18.8%)	16 (53.3%)
Pre-pregnancy BMI*	24.7 ± 4.7	23.6 ± 7.0
BMI < 25 kg/m^2	41 (64.1%)	19 (63.3%)
BMI ≥ 25 kg/m^2	23 (35.9%)	11 (36.7%)
Gestational age at delivery (weeks)*	38.6 ± 1.0	38.4 ± 0.9
Pregestational diabetes	1 (1.6%)	0
Gestational diabetes	16 (25.0%)	6 (20.0%)
Maternal anemia (Hb < 11 g/dL)	6 (9.4%)	4 (13.3%)
Emergency Cesarean	51 (79.7%)	15 (50.0%)
Oxytocin use during labor	30 (46.9%)	0
Cervical dilatation at the time of decision for CS		
< 6 cm	51 (79.7%)	30 (100.0%)
≥ 6 cm	13 (20.3%)	0
Operator		
Attending physician	15 (23.4%)	9 (30.0%)
Resident	49 (76.6%)	21(70.0%)
Operative time (minutes)*	54.8 ± 12.8	70.5 ± 21.0
Postpartum hemorrhage (> 1,000 mL)	9 (14.1%)	1 (3.3%)

* mean ± standard deviation
CS: cesarean section, BMI: body mass index, Hb: hemoglobin

Table 2. Ultrasound findings of the patients (total n = 94).

Findings	Primary CS (n = 64)	Repeated CS (n = 30)	p value
Uterine position			
Anteflex	34	23	0.030*
Retroflex	30	7	
Scar defect parameters			
Height (mean ± SD, mm)	4.63 ± 2.20	15 ± 3.26	< 0.001**
Base (mean ± SD, mm)	6.05 ± 1.84	8.43 ± 3.26	
Myometrial thickness			
TMT (mean ± SD, mm)	13.24 ± 3.31	15.21 ± 3.82	0.010**
RMT (mean ± SD, mm)	8.16 ± 3.40	5.42 ± 2.40	
Number of large scar defects	10	11	0.020*
Number of thin RMT	3	5	0.050***

* Chi-square test, **Independent t-test, ***Fisher's exact test
CS: cesarean section, SD: standard deviation, RMT: residual myometrial thickness, TMT: total myometrial thickness
Thin RMT is defined as myometrial thickness ≤ 3 mm.

Table 3. Factors that correlate with large Cesarean scar defect.

Parameters	Crude Odds	95%CI	p value	Adjusted OR*	95%CI	p value
Repeated CS	3.14	1.15 - 8.53	0.026	8.85	2.29 - 34.15	0.002
Cervical dilatation ≥ 6 cm	2.54	0.73 - 8.81	0.142	5.84	1.28 - 26.71	0.023
Uterine retroflexion	2.56	0.95 - 6.89	0.063	4.40	1.33 - 14.55	0.015

* Adjusted for uterine version, age, body mass index (obesity), maternal diabetes (pregestational diabetes and gestational diabetes), urgency, postpartum hemorrhage, surgeon, cervical dilatation, oxytocin use during labor, gestational age, repeat or primary CS, and total operative time.
CI: confidence interval, OR: odds ratio, CS: cesarean section

Discussion

The prevalence of large CSD was 22.3% at six weeks postpartum in our study. It was 15.6% in the primary CS group and 36.7% in the repeat CS group. Multivariate analysis demonstrated that repeated CS, uterine retroflexion, and cervical dilatation ≥ 6 cm at the time of CS were associated with large CSDs.
Our study verified that patients with repeated CS had higher odds ratio of developing a large CSD. Repeated CS has been reported to result in prominent CSDs; however, the measurements were performed 3 months postpartum or even later(13, 15, 16). Our findings at 6 weeks postpartum were consistent with those of previous studies. Repetitive trauma favors the development of scarred tissue, chronic inflammation, altered cytokines, and poor vascularization(11, 17). A compromised healing cascade results in the discontinuation of the myometrial tissue, leading to a large CSD. Moreover, in repeated CS, the epithelized ends of the scarred myometrium are difficult to recognize. This results in incomplete repair of the myometrial tissue, favoring the development of a large CSD(18).

The scar maturation process at the incision site post-CS starts at approximately 3 months. The complete anatomical involution of the uterus takes approximately six months(19). At 6 weeks, intrauterine fluid is still present, which could assist in CSD visualization. Owing to the considerable uterine involution, performing ultrasonography after 3-6 months usually requires gel or normal saline instillation. We performed non-instillation ultrasonography at six weeks postpartum to adequately locate and identify large CSDs. This early detection of large CSDs may impact patient medical care and future fertility planning. However, there is no standardized optimal timing for postpartum CSD evaluation.

Previous studies have measured uterine defects at 3, 6, or 12 months postpartum(12, 15, 20). At 6 weeks postpartum, the uterus has not fully involute, and scar healing at the uterotomy incision is still in progress. Gull et al reported that CSD presence does not change from 6 weeks to 1 year; however, the scar shape may change owing to maturation(9). A study from Taiwan compared post-CS uterine scars and myometrial thickness at 6 weeks and 6 months; no difference in the scar dehiscence risk or significant changes in the myometrial thickness were found. Therefore, CSD can be evaluated as early as six weeks(21).

We used 2D ultrasonography for CSD measurements in this study, as per current consensus(12, 22). One study compared 2D and three-dimensional (3D) ultrasonography for CSD evaluation and found comparable results (23). 3D ultrasonography is considered a promising tool for visualizing CSD as it can evaluate its volume and shape(24). Further studies are required to demonstrate the superiority of 3D ultrasound over 2D ultrasound in CSD measurements.

In our study, uterine retroflexion was correlated with a large CSD. During retroflexion, the uterus is under tension. If the abdominal wall has adhesions, the counteracting force becomes more prominent. This tension disrupts healing at the hysterotomy site. Furthermore, the lower segment of the retroflexed uterus is more stretched and less perfused(13). This uterine habitus is a result of genetic build or pelvic pathology, such as pelvic adhesions caused by a previous surgery.

We found that performing CS in women with cervical dilatation ≥ 6 cm increased the risks of large CSDs. During advanced labor, there is stretching and thinning of the lower uterine segment. The uterus is repaired without including all the myometrium as the approximation of underlying muscles is incomplete. This leads to myometrial retraction at the scar site, ultimately resulting in a large CSD[18].

The major strengths of this study were the ability to detect large CSDs early and confirmed their association with repeated CS. To our knowledge, this is the first study to verify that more than one CS was associated with a large CSD at six weeks postpartum. The findings of this study could ultimately prevent adverse consequences, especially in patients of childbearing age. Additionally, we employed a single sonographer. Therefore, there were no inter-observer variations in the measurements.

This study had some limitations. The scar defects were assessed at a single point in time. Follow-up measurements to observe scar maturation would be beneficial. Since the scar measurements were performed only once, intra-observer agreement was not calculated. We performed a non-instillation ultrasound, which may not allow a comprehensive depiction of the scar morphology compared to a gel or normal saline instillation ultrasound. Moreover, our institution does not provide vaginal birth after cesarean delivery, and participants with advanced cervical dilatation, which was significantly associated with large CSDs, were all in the primary CS group.

Our study findings have several clinical applications. The study results could enhance treatment strategies and prevent CSD-related complications. Recognizing the condition as early as six weeks postpartum allows safer shared-care decisions between the patient and physician. The treatment strategies may include fertility planning, preconception counseling, and appointments for CSD follow-up. Therefore, CSD detection combined with proper treatment can improve the patient's quality of life.

In the future, transvaginal ultrasonography may be considered during postpartum visits in high-risk groups, such as patients with repeated CS and those who underwent CS during advanced labor. Patients with large CSDs could be offered close follow-up and treated as necessary. Those planning for future pregnancies should be advised for preconception care, followed by an early first-trimester scan to ensure normal intrauterine pregnancy. Currently, there is no definite protocol for CSD monitoring post-CS and in patients with large CSDs. We hope to be part of the new medical care guidelines that would focus on such patients.

We also hope to follow-up postpartum patients for a longer time, to obtain a complete picture of CSD progression. Estimation of inflammatory markers at the CSD site could also be performed to confirm the altered environment and ultimately help develop appropriate treatment protocols.

Conclusion

The prevalence of large CSDs at six weeks postpartum was higher in patients with repeated CS, uterine retroflexion, and cervical dilatation ≥ 6 cm at the time of CS.

Acknowledgments

We would like to thank the nurses at the postpartum clinic for their help with the data collection. This study was funded by the Faculty of Medicine, Srinakharinwirot University, Thailand (No: SWU 418/2564).

Potential conflicts of interest

The authors declare no conflicts of interest.

References

1. Betrán AP, Ye J, Moller AB, Zhang J, Gülmezoglu AM, Torloni MR. The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. PLoS One 2016;11:e0148343.

2. van der Voet LF, Bij de Vaate AM, Veersema S, Brölmann HA, Huirne JA. Long-term complications of caesarean section. The niche in the scar: a prospective cohort study on niche prevalence and its relation to abnormal uterine bleeding. BJOG 2014;121:236-44.
3. Bij de Vaate AJ, Brölmann HA, van der Voet LF, van der Slikke JW, Veersema S, Huirne JA. Ultrasound evaluation of the Cesarean scar: relation between a niche and postmenstrual spotting. Ultrasound Obstet Gynecol 2011;37:93-9.
4. Kulshrestha V, Agarwal N, Kachhawa G. Post-caesarean niche (isthmocele) in uterine scar: an update. J Obstet Gynaecol India 2020;70:440-6.
5. Vikhareva Osser O, Valentin L. Clinical importance of appearance of cesarean hysterotomy scar at transvaginal ultrasonography in nonpregnant women. Obstet Gynecol 2011;117:525-32.
6. Nitayaphan N, Kitporntheranunt M. Cesarean scar defect and its complications. J Med Assoc Thai 2021;104:91-6.
7. Timor-Tritsch IE, Monteagudo A, Calì G, D'Antonio F, Kaelin Agten A. Cesarean scar pregnancy: diagnosis and pathogenesis. Obstet Gynecol Clin North Am 2019;46:797-811.
8. Jordans IPM, Verberkt C, De Leeuw RA, Bilardo CM, Van Den Bosch T, Bourne T, et al. Definition and sonographic reporting system for Cesarean scar pregnancy in early gestation: modified Delphi method. Ultrasound Obstet Gynecol 2022;59:437-49.
9. Hanacek J, Vojtech J, Urbankova I, Krcmar M, Křepelka P, Feyereisl J, et al. Ultrasound cesarean scar assessment one year postpartum in relation to one- or two-layer uterine suture closure. Acta Obstet Gynecol Scand 2020;99:69-78.
10. Buhimschi CS, Zhao G, Sora N, Madri JA, Buhimschi IA. Myometrial wound healing post-Cesarean delivery in the MRL/MpJ mouse model of uterine scarring. Am J Pathol 2010;177:197-207.
11. Esendagli G, Yoyen-Ermis D, Guseinov E, Aras C, Aydin C, Uner A, et al. Impact of repeated abdominal surgery on wound healing and myeloid cell dynamics. J Surg Res 2018;223:188-97.
12. Osser OV, Jokubkiene L, Valentin L. High prevalence of defects in Cesarean section scars at transvaginal ultrasound examination. Ultrasound Obstet Gynecol 2009;34:90-7.
13. Ofili-Yebovi D, Ben-Nagi J, Sawyer E, Yazbek J, Lee C, Gonzalez J, et al. Deficient lower-segment Cesarean section scars: prevalence and risk factors. Ultrasound Obstet Gynecol 2008;31:72-7.
14. Cunningham FG, Leveno KJ, Dashe JS, Hoffman BL, Spong CY, Casey BM, editors. In: Williams Obstetrics, 26th ed. New York: McGraw Hill; 2022.
15. Regnard C, Nosbusch M, Fellemans C, Benali N, van Rysselberghe M, Barlow P, et al. Cesarean section scar evaluation by saline contrast sonohysterography. Ultrasound Obstet Gynecol 2004;23:289-92.
16. Vervoort AJ, Uittenbogaard LB, Hehenkamp WJ, Brölmann HA, Mol BW, Huirne JA. Why do niches develop in Caesarean uterine scars? Hypotheses on the aetiology of niche development. Hum Reprod 2015;30:2695-702.
17. Diegelmann RF, Evans MC. Wound healing: an overview of acute, fibrotic and delayed healing. Front Biosci 2004;9:283-9.
18. Siraj SHM, Lional KM, Tan KH, Wright A. Repair of the myometrial scar defect at repeat caesarean section: a modified surgical technique. BMC Pregnancy Childbirth 2021;21:559.
19. Dicle O, Küçükler C, Pirnar T, Erata Y, Posaci C. Magnetic resonance imaging evaluation of incision healing after cesarean sections. Eur Radiol 1997;7: 31-4.
20. Vikhareva Osser O, Valentin L. Risk factors for incomplete healing of the uterine incision after caesarean section. BJOG 2010;117:1119-26.
21. Dosedla E, Calda P. Can the final sonographic assessment of the cesarean section scar be predicted 6 weeks after the operation? Taiwan J Obstet Gynecol 2016;55:718-20.
22. Jordans IPM, de Leeuw RA, Stegwee SI, Amso NN, Barri-Soldevila PN, van den Bosch T, et al. Sonographic examination of uterine niche in non-pregnant women: a modified Delphi procedure. Ultrasound Obstet Gynecol 2019;53:107-15.
23. Alalfy M, Osman OM, Salama S, Lasheen Y, Soliman M, Fikry M, et al. Evaluation of the Cesarean scar niche in women with secondary infertility undergoing ICSI using 2D sonohysterography versus 3D sonohysterography and setting a standard criteria; Alalfy Simple Rules for scar assessment by ultrasound to prevent health problems for women. Int J Womens Health 2020;12:965-74.
24. Marjolein Bij de Vaate AJ, Linskens IH, van der Voet LF, Twisk JW, Brölmann HA, Huirne JA. Reproducibility of three-dimensional ultrasound for the measurement of a niche in a caesarean scar and assessment of its shape. Eur J Obstet Gynecol Reprod Biol 2015;188: 39-44.