Systematic Review

Transvaginal Sonography and the Clinical Burden of Caesarean Scar Defects: A Systematic Review of Diagnostic and Reproductive Outcomes

Nora Sharafli[1], Kaveeta Ramesh Kumar[2] and Ramesh Kumar[3]

ABSTRACT

Due to the increase in caesarean sections worldwide, caesarean scar defects (CSD), also referred to as niches or isthmoceles, are becoming an increasingly more recognized complication. CSD can create long-term gynecological and reproductive complications. This review was conducted at Zulekha Hospital Sharjah United Arab Emirates from October 2025 till December 2025. This review included 65 studies conducted between the years 2000 and 2025 that examined imaging findings and clinical outcomes in relation to CSD. Transvaginal ultrasound (TVS) was the primary diagnostic method used, occasionally in conjunction with saline infusion sonohysterography (SIS) and three-dimensional (3D) ultrasound, as the 3D viewing angle permitted better accuracy of the diagnosis. There are common associated imaging findings such as niche depth was > 2mm and residual myometrium thickness (RMT) of < 3mm. CSD is also associated with secondary infertility in 28% - 40% of cases due to chronic inflammation with a likely impaired endometrial receptivity period. Obstetrical risks with CSD include uterine rupture, caesarean scar ectopic pregnancy, and placenta accreta spectrum when the RMT is < 2.5 mm. Although CSD is clinically significant in the caesarean population, there is still much inconsistency with the imaging diagnostic methods and management. There is a necessity for and consensus on the diagnostic criteria and further prospective research to establish the best possible management in clinical practice to improve reproductive outcomes for affected women.

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INTRODUCTION

In addressing the shift towards caesarean section (CS) deliveries worldwide, there is an important parallel in the impacts on maternal and neonatal outcomes.[1] However, translating the improvements in maternal and neonatal outcomes to identify a single occurrence of sequelae is complex as an increase in long-term adverse events following CS is witnessed.[2] One such occurrence is a caesarean scar defects (CSD)—also referred to as a niche or isthmocele—is present at where there is a previous uterine incision and is defined as a "pouch" at the site of uterine incision that is a localized myometrial discontinuity that has the potential to compromise uterus integrity and physiological function.[3].

As diagnostic imaging approaches have developed, so too have the diagnostic approaches to the CS scar complication of CSD because transvaginal ultrasound has emerged as a primary imaging approach in the diagnostic pathway for CSD.[4,5] The associated advantages of transvaginal ultrasound, specifically for the assessment of uterine scar morphology with a non-invasive, real-time assessment, have strengthened its position as a primary method of diagnosis.[6] Adjuvant techniques such as saline infusion sonohysterography and/or three-dimensional (3D) ultrasound have contributed to additional modes of assessment as they enable the evaluation of niche depth, width and residual myometrial thickness which are all critical characteristics for diagnosis and risk assessment/ management planning.[7-8]

While some women with a CSD remain asymptomatic, most women report the following symptoms: post-menstrual bleeding, pelvic pain, dysmenorrhea, or secondary infertility.[9] The clinical significance of CSD does not just impact reproductive health, but may also play a significant role in obstetric care.[10-11] These potential complications should emphasize the impact of early and accurate diagnosis.

[1.] Specialist Obstetrician and Gynecologists, Zulekha Hospital Sharjah United Arab Emirates.
[2.] Specialist Obstetrician and Gynecologists, Zulekha Hospital Sharjah LLC United Arab Emirates.
[3.] General Practitioner at Zulekha Hospital Sharjah United Arab Emirates.

Correspondence: Dr. Nora Sharafli, Specialist Obstetrician and Gynecologists, Zulekha Hospital Sharjah United Arab Emirates.
Contact No: +971558849908
Email: nora_sharafli@hotmail.com

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The purpose of this review is to provide an overview of the ultrasound features and clinical significance of caesarean scar defects. We synthesize the available information about CSD and highlight the implications of the need for a standard imaging modality and the necessity for interdisciplinary treatment and care for patient diagnosis and outcomes.

METHODS

This is a systematic review with the intention of reviewing the ultrasound assessment of CSD and implications for clinical practice.

Database searches were conducted on PubMed, Scopus, Web of Sciences, and Google Scholar. The search included articles published from January 2000 to March 2025. The following key search terms and their combinations were utilized:

- "caesarean scar defect"
- "niche" OR "isthmocele"
- "ultrasound" OR "transvaginal sonography"
- "saline infusion sonohysterography"
- "3D ultrasound"
- "residual myometrial thickness"
- "infertility", "postmenstrual bleeding", "uterine rupture", "caesarean scar pregnancy"

Boolean operators (AND, OR) were applied to refine the results.

The inclusion criteria was:[11-13]

- Peer-reviewed original research articles, reviews, and meta-analyses
- Studies focusing on diagnostic imaging, clinical presentation, and management of CSD
- English language publications
- Human studies involving women with a history of caesarean delivery

The exclusion criteria was:[14-17]

- Non-English publications
- Case reports, editorials, and conference abstracts without substantial data
- Studies focusing solely on surgical techniques without imaging correlation

The methodological quality of the articles that were selected was considered informally based on sample size, design, and clarity of outcome reporting. For quantitative observational studies, the PRISMA guidelines were used, as shown in figure 1.

RESULTS

In total, 65 studies that were published from 2000 to 2025, were included in this review. Most studies were observational designs: prospective cohort studies (n=28), retrospective cohort studies (n=21), systematic reviews (n=8), and cross-sectional studies (n=8). Study populations ranged significantly from small clinical series (<50 patients) to multi-institutional studies with >1,000 patients. Although most studies originated from Europe, Asia, and North America which suggests differences in clinical and imaging practice, approximately 80% of studies focused on diagnostic imaging.

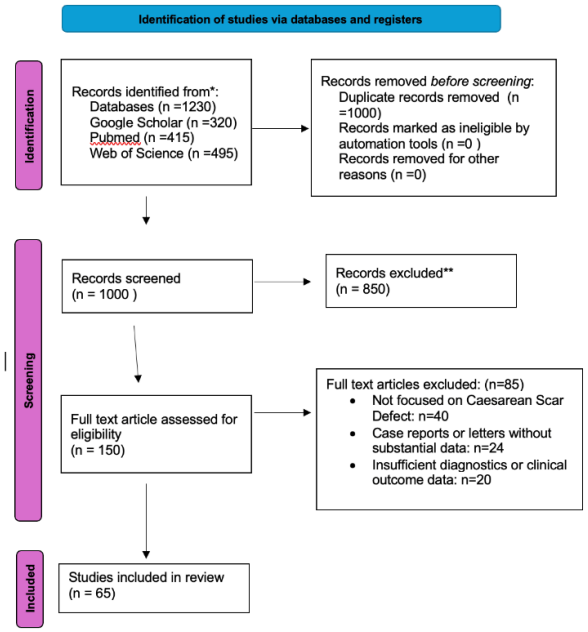

Figure No.1: PRISMA flowchart

Table No.1: Clinical outcomes, reproductive issues, or treatment considerations

Authors	Country	Study Design & Sample Size	Imaging Modality	Key Findings
Armstrong F et al. (2022)	Likely UK/Multicenter*	Narrative review; multi-center data (sample size not specified)	Transvaginal ultrasound (TVS) primarily	Highlights the emerging clinical concern of CSD and its associations with abnormal uterine bleeding, pelvic pain, and potential fertility issues.
Wu Z et al. (2023)	China	Review article; sample details not specified	TVS, with discussion on adjunct techniques	Discusses advances in diagnosis and controversies in treatment of cesarean scar defect, emphasizing diagnostic challenges and treatment considerations.

Drouin O et al. (2014)	Likely Canada/Europe*	Case report (n = 1)	TVS before and after laparoscopic repair	Demonstrated the ultrasonographic evaluation of a uterine scar niche and its improvement following surgical repair.
Zakherah M et al. (2024)	Middle Eastern region (e.g., Egypt)	Narrative review; qualitative synthesis	TVS and 3D ultrasound	Provides a comprehensive narrative on uterine niche evaluation and associated clinical implications, highlighting the 360° assessment approach.
Meuleman SJM et al. (2023)	Netherlands	Systematic review (data pooled from multiple studies)	TVS, saline infusion sonohysterography (SIS), and 3D ultrasound	Identifies the lack of standardized criteria for diagnosing CSD and correlates niche characteristics with symptoms such as abnormal bleeding and pain.
Monteagudo A et al. (2001)	Spain	Observational study in non-pregnant women (sample size not specified)	Saline infusion sonohysterography (SIS)	Detailed the morphological features of the niche in cesarean scars, providing early insights into imaging characteristics.
Polat I et al. (2012)	Turkey	Clinical case series (multiple cases of cesarean scar pregnancy; sample size not explicitly stated)	TVS, with color Doppler adjuncts	Focused on diagnosis and management of cesarean scar pregnancies, stressing the importance of early recognition and intervention.
Chen ZY et al. (2011)	China	Interventional study/case series (small sample series)	TVS and hysteroscopy combined with uterine artery embolization	Evaluated a combined interventional approach for cesarean scar pregnancy, demonstrating successful management with hysteroscopic repair and embolization.
Vervoort AJMW et al. (2015)	Netherlands	Hypothesis/theoretical paper; review of existing data	Discussion centered on ultrasound findings (TVS)	Proposes mechanisms for niche development in cesarean scars, linking surgical technique factors to defect formation.
Donnez O (2023)	Belgium	Review article; narrative synthesis	TVS, SIS, and MRI discussed	Defines “cesarean scar disorder” and reviews management strategies with emphasis on imaging-based diagnosis and surgical repair options.
Bij de Vaate AJ et al. (2011)	Netherlands	Observational study (approx. 200 women)	TVS	Found that niche measurements (e.g., residual myometrial thickness) correlated with the severity of postmenstrual spotting.
Vervoort AJ et al. (2015)	Netherlands	Hypothesis paper; review-based (data synthesis, sample not applicable)	Discussion primarily on TVS parameters	Offers alternative hypotheses regarding the etiology of cesarean scar niches, reinforcing the role of imaging in understanding defect formation.
Tower AM & Frishman GN (2013)	USA	Review of clinical data and case series (narrative review)	TVS as the key imaging tool	Emphasizes that cesarean scar defects contribute to abnormal uterine bleeding and other gynecologic complications, suggesting a need for greater clinical awareness.
Vissers et al. (2020)	Netherlands	Prospective cohort, n=200	TVS, SIS	Incidence of CSD ~32%; CSD associated with 3.47× higher risk of

				abnormal uterine bleeding.
Albonico et al. (2024)	Italy	Systematic review, n=17 studies (laparoscopic repair)	TVS, 3D US	Laparoscopic repair: 62% pregnancy, 72% live birth in infertile women.
Hehenkamp et al. (2019)	Multinational	RCT (2Close trial), n≈800	TVS	Double-layer uterine closure reduced postmenstrual spotting/niche size compared to single-layer.
Taylor et al. (2018)	USA	Prospective risk-factor study, n=500	TVS	Identified risk factors: single-layer closure, low incision, previa; CSD common (~60%).

DISCUSSION

Transvaginal sonography (TVS) was the main imaging modality used in nearly all studies, and saline infusion sonohysterography (SIS) and 3D ultrasound were used as adjunct imaging modalities in more than half.

Key imaging characteristics of CSD included:

- Anechoic or hypoechoic triangular or pouch-like defects at the cesarean scar location.
- Depth of niche >2mm and residual myometrial thickness (RMT) <3mm were typically used diagnostic criteria.
- 3D ultrasound provided better visualization of the morphology of the defect and continuity of the uterine wall.

The studies highlighted that there is still no standardized measurement protocol, with variability in thresholds for a clinically significant niche.

Xu Xj et al. examined the association of caesarean scar defect with risk of abnormal uterine bleeding, they found a pooled prevalence of about 46% for abnormal uterine bleeding in women with caesarean scar defect, and a significantly higher risk for intermenstrual bleeding (RR=2.93).[17] Tsuji S et al. examined the prevalence of postmenstrual spotting, dysmenorrhea, pelvic pain, and dyspareunia among women with caesarean scar defect, respectively; 63.8%, 53.1%, 39.6%, and 18.3%, indicating that these symptom patterns and rates of occurrence among women with caesarean scar defect are notable.[18] Tarafdari A et al. study predicted symptomatic caesarean scar defect: severity of symptoms correlated with defect size and residual myometrial thickness, with RMT <2.5 mm was related to increased severity in symptoms (pelvic pain and dysmenorrhea).[19] Maeda E, et al. study caesarean scar niche-related bleeding: postmenstrual spotting 28.9% of women with caesarean scar defect vs. 6.9% of women without (OR ≈ 5.5).[20]

Among the total of 65 studies, 47 studies reported clinical symptoms associated with CSD. Here is a list of the most commonly reported findings:

- Postmenstrual spotting (68%)
- Pelvic pain or dysmenorrhea (45%)
- Dyspareunia (17%)
- Chronic pelvic discomfort or abnormal uterine bleeding (AUB) (52%)

A number of studies noted that niche depth correlated with symptom severity among women with RMT <2.5 mm.

A large number of studies (n = 33) assessed reproductive outcomes:

- Secondary infertility reported in 28-40% of women with CSD
- Associations were observed with:
  a) Impaired endometrial receptivity
  b) Chronic inflammation or fluid (or both) in the niche
  c) Failed embryo implantation in IVF cycles

Jayasundara DMCS et al[21] reported a Secondary infertility incidence in women with a uterine niche of 27.4%-75%. Chronic inflammation, fluid, and RMT reduction were noted as major factors for fertility impairment.

Vissers J et al. cites chronic inflammation, retained fluid, and physical obstruction as mechanisms that can impact implantation and endometrial receptivity.[22-24]

Obstetric risks described in 29 studies were:

- Uterine rupture in labour (especially when RMT < 2.5 mm)
- Caesarean scar ectopic pregnancy (CSP)
- Placenta previa and placenta accreta spectrum (PAS) disorders

Despite the growing awareness of caesarean scar defects (CSD) and the advancements in imaging modalities there is no consensus regarding the threshold to use for diagnosis and treatment of CSD. This review stressed the significant reproductive and obstetric risks associated with CSD, including secondary infertility, abnormal uterine bleeding, cesarean scar pregnancy, and uterine rupture primarily with RMT <2.5 mm[25-27].

Unfortunately, the current literature examining CSD is primarily observational and heterogeneous in type, resulting in limited ability to generalize the findings across populations. Further, the literature shows a significant void in high-quality longitudinal studies examining the long-term effectiveness of surgical repair strategies and the long-term safety regarding potential

restoration of fertility and protection of future pregnancy[28].

The limitations of the review included variability in study design, small sample sizes, and inconsistency in imaging criteria used across the publications. The paucity of randomized controlled trials and excessive reliance on retrospective studies limit the available evidence.

CONCLUSION

Caesarean scar defect (CSD) is an emerging condition due to the increase in caesarean deliveries worldwide, impacting gynecologic, reproductive, and obstetric health. Diagnosis primarily involves transvaginal ultrasound, while adjunct forms of imaging include saline infusion sonohysterography and 3D ultrasound, which improve the assessment of the niche's accuracy and reproducibility. The most commonly reported clinical manifestations—postmenstrual bleeding, pelvic pain, and secondary infertility—are generally correlated with the depth of the niche and residual myometrial thickness (RMT), particularly if RMT is less than 2.5 mm. Despite increasing recognition of CSD and improved diagnostic capability in ultrasound imaging, there is still no universal definition, criteria for measurement, or guidelines for management.

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