doi: 10.48095/cccg2025339

Robotic-assisted cesarean scar defect repair

Roboticky asistované chirurgické riešenie defektu jazvy po cisárskom reze

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Summary: The rising global incidence of cesarean deliveries has led to a marked increase in associated obstetric and gynecological complications, notably the cesarean scar defect. Clinical management decisions are predominantly guided by patient-reported symptoms, reproductive goals, and individual anatomical considerations. The literature currently lacks definitive guidelines recommending a singular optimal approach. The recent advent and incremental adoption of robotic surgery has introduced a promising new technique, characterized by enhanced surgical precision, improved visualization, reduced morbidity, and rapid patient recovery. Ultimately, embracing robotic-assisted surgery for cesarean scar defect repair represents a critical advancement in gynecological surgery.

Key words: cesarean scar defect – cesarean scar syndrome – scar defect repair – robotic-assisted scar repair – isthmocele repair

Súhrn: Rastúci celosvetový výskyt cisárskych rezov vedie k výraznému nárastu súvisiacich pôrodníckych a gynekologických komplikácií, najmä defektu jazvy po cisárskom reze. Manažment sa riadi prevažne symptómami, reprodukčnými plánmi a individuálnymi anatomickými faktormi. V literatúre v súčasnosti chýbajú definitívne usmernenia odporúčajúce jednotný optimálny prístup riešenia defektu jazvy po cisárskom reze. Zavedenie robotickej chirurgie prinieslo sľubnú novú operačnú techniku, ktorá sa vyznačuje zvýšenou chirurgickou presnosťou, lepšou vizualizáciou, zníženou morbiditou a rýchlym zotavením pacientky. V konečnom dôsledku predstavuje prijatie roboticky asistovanej chirurgie pri oprave defektu jazvy po cisárskom reze kritický pokrok v gynekologickej chirurgii.

Kľúčové slová: defekt jazvy po cisárskom reze – syndróm jazvy po cisárskom reze – oprava jazvy – roboticky asistovaná oprava jazvy – oprava istmokély

Introduction

The rising global incidence of cesarean deliveries has led to a marked increase in associated obstetric and gynecological complications, notably the cesarean scar defect (CSD) [1]. This complication significantly contributes to critical clinical scenarios such as placenta accreta spectrum disorders, cesarean scar pregnancies, uterine rupture, abnormal uterine bleeding, dyspareunia, chronic pelvic pain, and secondary infertility [2]. The gynecological symptoms are currently referred to as cesarean scar syndrome [3]. The condition was initially described as a uterine depression at the scar site by Poivedin et al. in 1969. Over subsequent decades, this anatomical abnormality has acquired multiple terms, including "isthmocele" and "niche", reflecting ongoing terminological evolution [4].

Currently, the cesarean scar defect is precisely defined as an anechoic indentation within the myometrium of the lower uterine segment measuring at least 2.0 mm in depth [1]. The Delphi consensus further refines this clinical entity as a symptomatic uterine niche presenting with clinical manifestations such as postmenstrual spotting, dysmenorrhea, infertility, and accumulation of uterine fluid, collectively termed cesarean scar disorder [4,5].

The prevalence of cesarean scar defects varies widely in published reports, ranging from 56% to 84%, influenced significantly by the diagnostic modalities and operational definitions employed across studies [6]. Two-dimensional transvaginal ultrasonography remains the primary diagnostic tool for detecting and assessing the severity of isthmocele. Clinical management decisions are predominantly guided by patient-reported symptoms, reproductive aspirations, and individual anatomical considerations. The pioneering surgical intervention addressing isthmocele was first reported by Fernandez et al. in 1996, marking the beginning of a broader exploration into therapeutic techniques [1].

Currently, several surgical modalities are utilized for cesarean scar defect repair, including hysteroscopy, vaginal approaches, traditional laparotomy, and minimally invasive laparoscopic techniques [2,4]. However, the literature currently lacks definitive guidelines recommending a singular optimal approach. The recent advent and incremental adoption of robotic surgery have introduced a promising new technique, characterized by enhanced surgical precision, improved visualization, reduced morbidity, and rapid patient recovery [4].

Given the scarcity of detailed studies specifically addressing robotic-assisted surgical repair for cesarean scar defects, this article aims to systematically review existing literature, provide a comprehensive overview of current robotic-assisted techniques, and highlight the distinct advantages and clinical potential of robotic surgical systems in the effective management and reconstruction of cesarean scar defects.

Material and methods

A systematic literature search was conducted utilizing the PubMed database to identify relevant publications addressing surgical interventions for CSD, with a particular emphasis on robotic-assisted techniques. The search strategy employed specific keywords, including "cesarean scar defect", "isthmocele", "niche", and "robotic-assisted surgery", ensuring comprehensive coverage of the available literature.

Our primary goal was to critically appraise and synthesize existing evidence supporting the application of robotic-assisted surgical repair for cesarean scar defects. After applying rigorous selection criteria focusing explicitly on robotic approaches, a total of thirteen peer-reviewed publications were identified, two of which represented comprehensive literature reviews. Despite the relatively limited volume of published data, the selected articles provided valuable insights into the technical feasibility, safety, clinical outcomes, and reproductive implications associated with robotic-assisted repair.

Cesarean scar defect repair

Traditionally, the surgical management of CSD, also known as isthmocele, has involved techniques such as hysteroscopic resection, laparotomy, laparoscopy, or vaginal surgical approaches. With recent advancements in surgical technology, robotic-assisted surgery has emerged as an innovative modality offering unique advantages, including enhanced precision, improved visualization, and minimal tissue trauma. Although currently underrepresented in the literature, emerging evidence suggests that robotic-assisted repair could become the gold standard due to its clinical outcomes and safety profile [7].

The optimal choice of surgical method for cesarean scar defect repair depends on multiple factors, including the anatomical characteristics of the defect, residual myometrial thickness, patient's reproductive plans, and surgical expertise [1]. Typically, laparoscopic resection and layered closure of the defect is favored when the residual myometrial thickness is less than 3 mm [8]. A prospective study by Dominguez et al. highlighted that laparoscopic repair significantly increased myometrial thickness postoperatively [9].

Conversely, for patients who do not desire future pregnancies and present with a niche thickness greater than 3 mm, hysteroscopic repair may be a preferred approach [10]. While hysteroscopy typically results in fewer intraoperative and postoperative complications [11], it is associated with longer hospital stays compared to other minimally invasive techniques [4].

For women aiming for future fertility, especially those with thin residual myometrium (< 3 mm), robotic-assisted laparoscopic repair is particularly beneficial [10]. This technique enables precise excision of the fistulous tract and robust multi-layer myometrial reconstruction, providing structural reinforcement essential for future pregnancies [11]. Robotic-assisted laparoscopic repair of cesarean scar defects has been demonstrated as safe and anatomically precise, yielding favorable reproductive outcomes ranging from 40% to 75%. Comparatively, hysteroscopic resection has demonstrated pregnancy rates of 50% to 100%, while traditional laparoscopic repair reported pregnancy success rates between 44% and 83.3% [4].

Nevertheless, robotic-assisted laparoscopic repair remains an optimal minimally invasive alternative, significantly enhancing surgical precision, reducing morbidity, and potentially improving long-term reproductive outcomes. Further robust studies and clinical trials are warranted to solidify its role as a preferred surgical technique in the comprehensive management of cesarean scar defects [12].

Discussion

The existing literature underscores the considerable potential of robotic-assisted surgical interventions in the management of CSD. Yalcinkaya et al. documented two cases involving patients with significant gynecological symptoms, including pelvic discomfort, hematocele, and secondary infertility, all attributed to ultrasound-confirmed defects of the lower uterine segment. Following robotic-assisted surgical repair, both patients experienced uncomplicated, regular menstrual cycles and achieved spontaneous pregnancies within 12 months postoperatively, illustrating the efficacy and safety of this minimally invasive approach [12].

Further evidence is presented in a systematic review by Gkegkes et al., encompassing 34 patients followed up until May 2022. Their findings revealed that nearly half (16 out of 34) of the patients who underwent robotic surgery successfully conceived postoperatively. This

strongly supports the viability and utility of uterus-preserving surgical strategies, even for patients exhibiting severe symptomatic conditions [5].

In a retrospective analysis, Hofgaard et al. evaluated 14 cases involving ectopic pregnancies situated within cesarean scars. Their comprehensive approach combined temporary intraoperative occlusion of uterine vasculature, excision of ectopic pregnancy tissue, and subsequent robotic-assisted niche reconstruction. Their findings affirm the effectiveness and favorable reproductive outcomes associated with simultaneous robotic removal of cesarean scar pregnancy and repair of the underlying niche. The authors suggest integrating this approach into fertility preservation counseling for affected women [13].

Complementing these findings, Schmitt et al. similarly emphasizes the safety and feasibility of robotic-assisted laparoscopic removal of residual cesarean scar pregnancies and concurrent niche repairs, particularly post-methotrexate therapy [14]. Supporting evidence from Cardaillac et al. further demonstrates significant postoperative enhancement of myometrial thickness and high rates of successful pregnancies and symptom relief among treated patients. A robotic removal of a casarean scar pregnancy with simultaneous repair of the defect is a feasible option with acceptable reproductive outcome and should be considered when counseling women with a wish for future childbirth and a thin, or absent, myometrium in the niche. Robot-assisted repair of the isthmocele significantly improved myometrial thickness (from 1.55 mm before surgery to 4.26 mm after surgery). Among 20 patients who still desired a child after surgery, 15 became pregnant and 14 had full-term live births. Among the nine patients who had surgery for disabling symptoms, five had no persistent symptoms, three reported global improvement [15].

A recent comprehensive review by Stavridis et al. synthesizes data from four contemporary studies focusing explicitly on robotic-assisted repair of cesarean scar disorders, both with and without concurrent pregnancy management. Their analysis indicates promising outcomes but underscores the necessity for further extensive clinical research to establish standardized protocols and long-term efficacy [4].

Innovative techniques enhancing the precision of robotic-assisted surgery, such as the use of indocyanine green and the robotic Firefly technology, have been highlighted by Hoffmann et al. [16].These advancements significantly improve intraoperative identification and repair accuracy. Sinha et al. further exemplify this advancement by demonstrating effective integration of the KOH Cup system with Firefly technology during uterine isthmocele repair, achieving high precision and patient safety with minimal postoperative hospital stay [17].

Collectively, global perspectives endorse robotic-assisted surgery as a minimally invasive, highly precise method with reduced morbidity compared to traditional approaches. Studies consistently highlight its superiority in terms of minimal tissue trauma, lower risk of adhesions, and improved cosmetic and clinical outcomes [18–20]. Continued technological advancements will likely further enhance these benefits, affirming robotic surgery's emerging status as a preferred method for managing cesarean scar defects [21].

Conclusion

Given the escalating global rates of cesarean deliveries, healthcare professionals will inevitably encounter CSD with increasing frequency, necessitating familiarity with advanced minimally invasive surgical approaches. Robotic-assisted surgery has emerged as a pioneering platform, significantly enhancing precision, reducing surgical morbidity, and facilitating rapid patient recovery. This advanced surgical modality not only improves anatomical reconstruction and symptom resolution but also potentially enhances reproductive outcomes for women seeking fertility preservation. Evidence indicates that robotic techniques offer substantial benefits in managing complex scar defects, especially in scenarios with minimal residual myometrial thickness or concurrent ectopic pregnancies. The integration of innovative technologies such as Firefly fluorescent imaging further refines surgical accuracy, promoting safer and more effective defect repairs. However, despite encouraging preliminary outcomes, the wider clinical adoption of robotic-assisted repair necessitates further robust clinical trials and longitudinal studies to validate long-term safety, efficacy, and standardized procedural guidelines. Future research should also explore the cost-effectiveness and patient-reported outcomes of robotic-assisted approaches compared to traditional laparoscopic and hysteroscopic techniques. Ultimately, embracing robotic-assisted surgery for cesarean scar defect repair represents a critical advancement in gynecological surgery, promising to substantially improve patient care and surgical outcomes.

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Submitted/Doručené: 12. 5. 2025
Accepted/Prijaté: 16. 5. 2025

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Publication ethics: The Editorial Board declares that the manuscript met the ICMJE uniform requirements for biomedical papers.
Publikačné etika: Redakčná rada potvrdzuje, že rukopis práce splnil ICMJE kritériá pre publikácie zasielané do biomedicínskych časopisov.
Conflict of interests: The authors declare they have no potential conflicts of interest concerning the drugs, products or services used in the study.
Konflikt záujmov: Autori deklarujú, že v súvislosti s predmetom štúdie/práce nemajú žiadny konflikt záujmov.