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Modern Methods for Diagnosis and Monitoring of Uterine Scar After Cesarean Section

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Abstract: Timely evaluation of the uterine scar after cesarean section plays a crucial role in preventing both obstetric and gynecological complications. Over the past decades, the rate of cesarean delivery has been steadily increasing worldwide, leading to a growing number of women with a uterine scar. This makes accurate assessment of its condition highly relevant in everyday clinical practice. This review discusses current approaches to evaluating the uterine scar, focusing on both instrumental and clinical methods. Particular attention is given to ultrasound, sonohysterography, hysteroscopy, and magnetic resonance imaging, as well as to the importance of early diagnosis and postoperative monitoring of healing processes. In routine practice, transvaginal ultrasound remains one of the most practical and informative tools, allowing detailed assessment of residual myometrial thickness and scar morphology. At the same time, modern approaches increasingly emphasize dynamic follow-up and the use of combined diagnostic strategies that integrate clinical findings, imaging results, and patient-related risk factors. Such an approach improves diagnostic accuracy and helps optimize patient management.

Keywords: Uterine Scar, Cesarean Section, Ultrasound, Diagnosis, Monitoring, Isthmocele

Introduction

Over the past few decades, the number of cesarean sections has been steadily increasing across the world [1]. This trend is associated not only with broader medical indications but also with changes in obstetric strategies and, in some cases, patient preference. As a result, more and more women are living with a uterine scar, making its evaluation an important issue in modern obstetrics and gynecology.

It is important to understand that not every uterine scar is functionally adequate. In some cases, the healing process is incomplete, leading to the formation of a defective scar [2]. Such changes can significantly affect both fertility and the course of future pregnancies. For example, women with scar defects may have a higher risk of uterine rupture, abnormal placentation, and preterm birth [3] [4].

At the same time, problems related to a uterine scar are not limited to pregnancy. Many women experience symptoms such as irregular menstruation, postmenstrual spotting, chronic pelvic pain, or even infertility [5] [6]. These manifestations may significantly affect quality of life and often require additional diagnostic evaluation.

For this reason, timely diagnosis and proper follow-up are extremely important [7]. Early identification of scar defects allows clinicians to choose the most appropriate management strategy and reduce the risk of complications in both gynecological and obstetric practice.

Formation of the Uterine Scar

The formation of a uterine scar after cesarean section is a complex and multi-stage biological

process. It begins with an inflammatory phase, during which immune cells are activated and prepare the tissue for healing. This phase plays an essential role in removing damaged tissue and preventing infection [8].

This is followed by a proliferative phase, when new tissue is formed. Fibroblasts actively synthesize collagen, and new blood vessels develop, ensuring adequate blood supply to the healing area [8]. However, the newly formed tissue at this stage is still structurally weak.

Finally, a remodeling phase occurs, during which the structure of the tissue becomes more stable. Collagen fibers are reorganized, and the scar gradually gains strength. Despite this, the regenerated tissue rarely achieves the same properties as the original myometrium.

However, this process does not always go perfectly. One of the key factors influencing healing is the surgical technique [2] 8]. The way the uterus is sutured, how accurately the tissues are aligned, and how carefully the operation is performed all play a significant role.

In addition, individual patient factors should not be underestimated. Conditions such as anemia, obesity, diabetes, and connective tissue disorders can slow down the healing process [2]. Repeated cesarean sections further increase the risk, as the tissue is subjected to repeated trauma [9].

If healing is incomplete, a niche, also known as an isthmocele, may form in the area of the scar. This is a small indentation in the uterine wall where menstrual blood can accumulate. Over time, this may lead to chronic inflammation, abnormal uterine bleeding, and disruption of normal uterine function [6] [10].

Ultrasound as the Main Diagnostic Method

Ultrasound examination remains the primary method for evaluating the condition of a uterine scar [3] [9]. It is widely used because it is safe, accessible, and provides sufficiently accurate information.

In everyday clinical practice, transvaginal ultrasound is usually preferred [11]. Compared to transabdominal scanning, it allows much better visualization of the lower uterine segment and provides more accurate measurements.

During the examination, several important parameters are assessed. One of the key indicators is residual myometrial thickness, which reflects how much healthy muscle tissue remains in the scar area [12]. A thinner layer is generally associated with a higher risk of complications.

In addition to thickness, doctors also evaluate the shape and size of the niche, including its depth, width, and length [12] [13]. The presence of hypoechoic or fluid-filled areas may indicate structural abnormalities and communication with the uterine cavity. Another important aspect is the contour of the scar and the surrounding myometrium. Irregularities in structure or heterogeneity of the tissue may suggest impaired healing or fibrosis. One of the key advantages of ultrasound is the possibility of repeated examinations. Since the method is non-invasive and safe, it can be used for dynamic monitoring [11].

Sonohysterography

When standard ultrasound does not provide sufficient information, sonohysterography can be used. This method involves introducing a small amount of sterile fluid into the uterine cavity, which significantly improves visualization of its internal contours by enhancing contrast between the endometrium and the uterine walls [14]. As a result, even subtle structural abnormalities can be identified more clearly.

In clinical practice, this technique is especially useful for detecting small niches that may not be clearly visible on conventional ultrasound. It also helps determine whether the defect communicates with the uterine cavity, which is important for understanding symptoms such as

abnormal uterine bleeding or infertility [14] [10]. In addition, sonohysterography allows more accurate assessment of the size, depth, and shape of the defect.Due to its higher diagnostic accuracy in certain clinical situations, sonohysterography is often considered a second-line method. It is particularly indicated in patients with inconclusive ultrasound findings or persistent clinical symptoms. Despite its minimally invasive nature, the procedure is generally well tolerated and can be performed on an outpatient basis.

Hysteroscopy

Hysteroscopy is another important method that allows direct visualization of the uterine cavity [15]. Unlike ultrasound, which provides an indirect image, hysteroscopy enables the physician to assess the scar defect visually and in real time, offering a more precise evaluation of its morphology, size, and location.One of the major advantages of hysteroscopy is that it can also be used for treatment. For example, fibrotic tissue can be removed, and minor defects can be corrected during the same procedure [15]. This dual diagnostic and therapeutic role makes hysteroscopy particularly valuable in patients with symptomatic scar defects, such as abnormal uterine bleeding or infertility.

In addition, hysteroscopy allows assessment of the relationship between the niche and the uterine cavity, as well as identification of associated intrauterine pathology, including adhesions or endometrial abnormalities, which may contribute to clinical symptoms.

However, since hysteroscopy is an invasive procedure, it is usually reserved for selected cases. It is most commonly indicated when non-invasive methods provide insufficient information or when therapeutic intervention is required. Despite its invasiveness, the procedure is generally safe when performed by experienced specialists.

Magnetic Resonance Imaging (MRI)

MRI is typically used in more complex cases where a detailed assessment of the myometrium is required [16]. It provides high-resolution images with excellent soft tissue contrast, allowing for precise evaluation of deeper uterine layers that may not be clearly visualized on ultrasound. This method is particularly valuable in situations where ultrasound findings are inconclusive or when there is a need to assess the extent and exact localization of a scar defect. MRI also enables better differentiation between fibrotic tissue, normal myometrium, and areas of thinning, which can be important for planning further management, including surgical intervention.

In addition, MRI may be useful in evaluating associated conditions, such as adenomyosis or abnormal placentation, which can further complicate the clinical picture. Its multiplanar imaging capability provides a more comprehensive view of uterine anatomy and structural abnormalities [16]. Although MRI is highly informative, it is not commonly used as a first-line method due to its higher cost and limited availability. Therefore, it is generally reserved for selected cases where additional diagnostic clarification is required beyond standard ultrasound assessment.

Standardization and Modern Approaches

One of the ongoing challenges in this field is the lack of standardized diagnostic criteria [12] [13]. Different clinicians may measure and interpret findings in slightly different ways, which can lead to variability in diagnosis and influence clinical decision-making. Such inconsistencies may affect the assessment of scar integrity and complicate the comparison of results across different studies and clinical settings.

To address this issue, recent studies have focused on developing standardized approaches to ultrasound evaluation [12]. These include unified methods for measuring residual myometrial

thickness, as well as clearly defined parameters for describing niche characteristics, such as depth, width, and length. The use of standardized terminology and measurement techniques improves reproducibility and enhances diagnostic reliability.

In addition, increasing attention is being paid to the combined use of quantitative and qualitative assessment. Alongside numerical measurements, features such as tissue echogenicity, vascularization, and overall scar morphology are also taken into account. This comprehensive evaluation provides a more accurate understanding of the structural and functional condition of the uterine scar.

Furthermore, modern approaches emphasize the importance of integrating imaging findings with clinical data, including patient symptoms and reproductive history. Such an integrated strategy allows for a more individualized assessment and supports more informed clinical decision-making.

Early Diagnosis and Monitoring

Early detection of impaired healing remains a challenge in clinical practice [17], as early structural changes in the uterine scar are not always accompanied by pronounced clinical symptoms. In many cases, pathological healing processes develop gradually and may only become clinically evident at a later stage, which complicates timely diagnosis and increases the risk of adverse outcomes.

The most effective approach is usually based on a combination of clinical observation and imaging methods. Such an integrated strategy allows clinicians to correlate subjective complaints and objective clinical findings with structural changes detected on imaging, thereby improving diagnostic accuracy and enabling earlier identification of high-risk patients.

In the early postoperative period, clinicians monitor factors such as body temperature, pain intensity, uterine involution, and signs of inflammation [2] [17]. These parameters provide important information about the course of the healing process and may indicate the presence of complications such as infection or delayed tissue repair. Ultrasound examination during this period may also be used to assess the initial formation of the scar and detect early abnormalities.

Long-term follow-up is equally important, especially for women planning future pregnancies. Regular monitoring allows for evaluation of scar remodeling over time, identification of delayed complications, and assessment of uterine wall integrity before conception. This approach contributes to more informed clinical decision-making and helps reduce the risk of obstetric complications in subsequent pregnancies.

Preconception Assessment

Preconception evaluation is a key stage in the management of women with a uterine scar [3] [7]. It helps determine whether the scar is sufficiently strong to withstand a future pregnancy and allows timely identification of potential risk factors that may affect maternal and fetal outcomes.

At this stage, a comprehensive assessment is usually performed, including detailed medical history, clinical examination, and imaging studies, primarily transvaginal ultrasound. Particular attention is paid to residual myometrial thickness, scar morphology, and the presence of niche formation, as these parameters may be associated with an increased risk of complications such as uterine rupture, cesarean scar pregnancy, or abnormal placentation [2].

In addition to structural evaluation, clinicians also consider other important factors, including the number of previous cesarean sections, interpregnancy interval, and the presence of comorbid conditions. All these aspects contribute to an individualized risk assessment and help guide further management. In some cases, surgical correction of the defect may be recommended before conception, especially in symptomatic patients or in those with significant scar defects. Such interventions may improve uterine integrity and potentially reduce the risk of complications during

subsequent pregnancy.

Overall, careful preconception assessment plays a crucial role in optimizing reproductive planning, improving pregnancy outcomes, and ensuring patient safety.

Conclusion

In modern clinical practice, assessment of the uterine scar after cesarean section is based primarily on ultrasound imaging, which is widely recognized as the first-line diagnostic method due to its safety, availability, and high informative value. Transvaginal ultrasound remains one of the most practical and reliable techniques, as it allows detailed visualization of the lower uterine segment and provides accurate measurements of residual myometrial thickness and scar morphology.

Additional techniques such as sonohysterography, hysteroscopy, and magnetic resonance imaging (MRI) are used when more detailed evaluation is required or when ultrasound findings are inconclusive. These methods offer complementary information, enabling better characterization of scar defects, including their size, depth, and relationship with the uterine cavity. In particular, sonohysterography enhances visualization of niche structures, hysteroscopy allows direct assessment and possible treatment, while MRI provides high-resolution imaging of deeper tissue layers.

A comprehensive approach that integrates imaging findings with clinical data and dynamic follow-up remains the most effective strategy. Such an approach makes it possible not only to identify structural abnormalities but also to assess their clinical significance, taking into account patient symptoms and reproductive plans. This, in turn, contributes to more accurate diagnosis, individualized patient management, and improved reproductive and obstetric outcomes.

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