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Pictorial Review

Caesarean-section scar endometriosis (CSSE): clinical and imaging fundamentals of an underestimated entity

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Caesarean-section scar endometriosis (CSSE) is a form of extra-pelvic endometriosis developing through endometrial cell implantation anywhere along the route of a previous caesarean section (CS) surgery, including the skin, subcutaneous tissue, abdominal wall muscles, intraperitoneally, and the uterine scar itself. Synchronous intra-abdominal endometriosis is not a prerequisite. Given the rising prevalence of CS, CSSE may be underrepresented in the literature and occur more frequently than previously thought. Locating a painful soft-tissue mass-like lesion along the path of a previous CS scar is the most indicative sign that should initially alarm physicians towards suggesting CSSE, especially if symptoms are typical (cyclically reoccurring with menstruation). The detection of hyperintense (haemorrhagic) foci on T1 fat-saturated sequences will strongly support the diagnosis on magnetic resonance imaging (MRI), the most sensitive imaging method for CSSE assessment. A non-specific, contrast-enhancing, hypodense nodule with spiculate edges may be suggestive if the lesion was originally detected on computed tomography (CT). Although ultrasound is frequently the first imaging method used, the findings are non-specific; therefore, making it more useful for ruling out other differentials and for image-guided biopsy. In any case, histopathology provides the definitive diagnosis. Surgical excision is the mainstay of treatment; however, minimally invasive, percutaneous techniques have also been implemented successfully.

Introduction

Endometriosis is a condition in which endometrial glands and stroma are seen in sites other than their expected location, the cavum uteri.[1] It is a chronic, disabling condition that causes pelvic pain and reproductive dysfunction, which may affect up to 10% of childbearing-age women.[2] Typically, endometriosis can manifest as superficial peritoneal lesions, ovarian lesions (the most common and usually referred to as endometriomas), and deep-infiltrating lesions (lesions with >5 mm of subperitoneal invasion or infiltration into the muscularis propria of the

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pelvic organs).[3,4] Just as the normal endometrium does, the ectopic endometrial tissue undergoes cyclical episodes of bleeding as a response to the hormonal menstrual changes.[5] Lesions formed may be cystic, solid, or mixed. The disease is mainly encountered in the pelvis, while extra-pelvic locations are rare and might include the upper abdomen, diaphragm, chest, abdominal wall, and more commonly, abdominal wall scars.[6,7] Abdominal wall scar endometriosis is most prevalent at caesarean section (CS) scar sites; however, it may also occur following hysterectomy, amniocentesis, in a laparoscopic trocar tract, and with various other procedures.[7,8] On this note, endometriosis of the abdominal wall is rather uncommon in patients who have never undergone surgery.[9] Fig. 1 displays various sites at which endometrial deposits may be encountered.

This review aims to acquaint physicians with the seemingly uncommon condition of CS scar endometriosis (CSSE), with the primary purpose of conveying the clinical aspects and key imaging features that should alert radiologists towards its diagnosis.

Epidemiology, Pathogenesis, and Pathology

The reported incidence of CSSE ranges from 0.2% to 0.95% of all women who have undergone a caesarean delivery.[7,10–12] On average, patients presenting with CSSE have a mean age of 32 ± 4 years, ranging from 21 to 43 years old[8]; however, it has been speculated that the condition may be underestimated and that the prevalence will escalate along with the increasing numbers of caesarean surgeries performed.[12] Although several theories exist, as patients with CSSE do not necessarily suffer from concomitant peritoneal endometriosis, the disease is mostly believed to originate from the iatrogenic inoculation of endometrial tissue at the incision site.[8,13–15] On this note, no significant correlation has been observed between endometriosis of the abdominal wall and endometriosis with intrapelvic localisation.[15] With regards to incision types, the two most common abdominal skin incisions for CS are the Pfannenstiel incision and the vertical midline incision, with the former perhaps posing a greater risk of CSSE than the latter.[8] Regardless of the incision type chosen, following CS, endometrial cells may be implanted and found in the skin, subcutaneous tissue, abdominal wall muscles, intraperitoneally, and even within the uterine scar itself,[16] thus CSSE may be encountered in these locations. A definitive diagnosis of CSSE can only be made by histopathology if the scar lesion demonstrates any two of the following three components: endometrial-type glands, endometrial-type stroma, and haemosiderin-laden macrophages.[17] This may be achieved through excisional or image-guided tissue biopsy, although fine-needle aspiration cytology (FNAC) may also prove helpful.[11,17] Fortunately, a careful history and clinical and radiological manifestations may frequently strongly suggest the diagnosis prior to resection and/or tissue sampling.

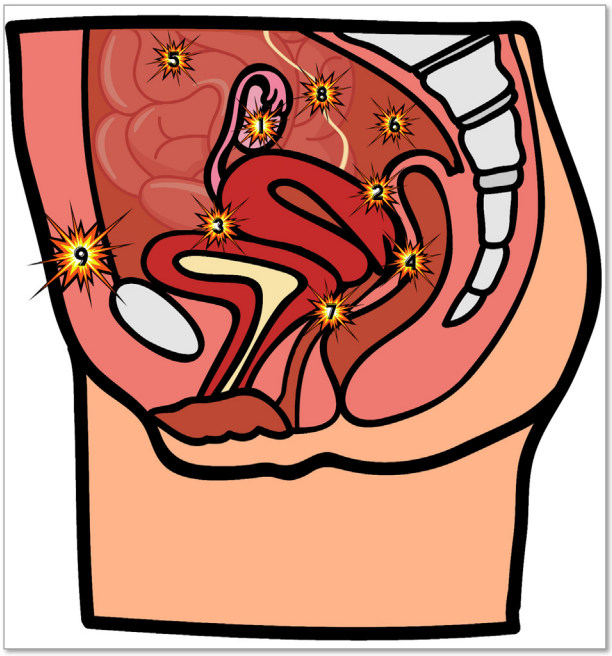

Figure 1 Illustration demonstrates various typical and atypical sites of superficial and deep endometrial deposits: (1) ovaries (typically referred to as "endometrioma") and fallopian tubes; (2) uterine (outer/serosal surface), retrocervical, and uterosacral/broad/round ligaments; (3) urinary bladder fundus; (4) rectal wall, rectosigmoid wall, or wall of other large bowel loops; (5) wall of small bowel loops; (6) peritoneum and peritoneal surfaces; (7) vagina, vesicovaginal space, rectovaginal space; (8) ureters; (9) abdominal wall. Abdominal wall endometriosis includes endometriosis situated within scars of the abdominal wall, with the most prevalent aetiology being a previous CS surgery.

Clinical manifestations

Clinical symptoms of endometriosis may be contingent on the sites affected by the condition. Endometriosis of the abdominal wall, and as a result, CSSE, is an unusual condition and, as such, may be challenging to diagnose.[18] The most prevalent characteristic among patients suffering from CSSE is a palpable abdominal lesion situated in or around the CS incision, which may be painful.[8] Patients' pain has been reported to be cyclical in nature in up to 73.3–86.9% of cases and unrelated to the patient's menstrual cycle in up to 13.1–26.6% of cases.[8,19] Dysmenorrhoea has also been reported in up to 32.3% of cases.[8] In addition, the lesion may cause obvious hyperpigmentation of the overlying skin owing to haemosiderin from previous haemorrhages.[20,21] Nonetheless, some women may present with continuous symptoms,[11] while others might not report any symptoms at all,[1] and lesions may be detected incidentally on imaging. In any case, a past medical history of CS is essential to raise suspicion for CSSE. In that respect, one study estimated that women, on average, start experiencing symptoms approximately 3.6 years after CS[15]; another study has observed this period to be 31.4 ± 28.2 months[22]; and a different study has found those numbers to be 28.3 ± 25 months.[8]

Clinically, in the setting of a palpable lesion at the site of a CS scar, the differential diagnosis should include a wide

range of conditions such as incisional hernias, lipomas, abscesses, haematomas, granulomas at injection sites, desmoid tumours, metastasis, keloid scars, suture granulomas, etc.[12,23]; however, a combination of clinical and imaging data will often narrow down the differential diagnosis, as will be analysed later.

Imaging manifestations

Several imaging techniques, such as ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI), may be implemented in the evaluation of CSSE. The imaging characteristics may vary based on the menstrual cycle, the disease duration, the amount of implanted tissue (stromal and glandular), the volume of haemorrhage/bleeding, and the presence of concomitant inflammation.[24,25] Preferably, imaging studies are suggested to be undertaken during the menstrual cycle.[26] A helpful imaging clue that should initially raise suspicion for CSSE are lesions detected along the expected route of a previous CS and along the visible abdominal wall scar (Fig 2).

Ultrasound

Ultrasound may often be the initial technique employed for the assessment of a palpable and/or painful lesion situated within the abdominal wall or within a surgical scar.[27] Considering its vast availability and cost-effective performance, this comes as no surprise. During ultrasound imaging with a high-frequency (7.5–12 MHz) probe, CSSE may have a solid, nodular, heterogeneous hypoechoic appearance with some hyperechoic strands and/or a hyperechoic ring at its periphery (possibly due to an inflammatory reaction; Fig 3). In addition, internal or pedicular vascularity may also be displayed upon colour-Doppler imaging evaluation.[16,28,29] Moreover, it can demonstrate spiculate margins,[28] while on occasion, cystic areas representing blood pools may also be observed, especially if lesions are large in size.[11,28]

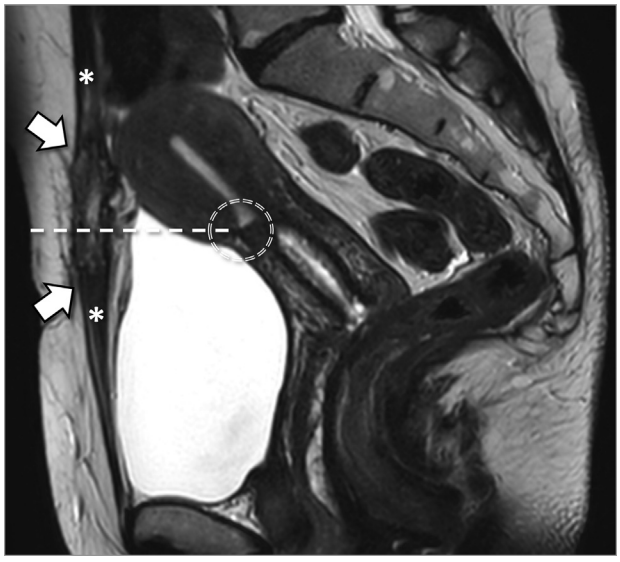

Figure 2 Sagittal T2 MRI image demonstrates findings of a previous CS, as evidenced by the uterine scar (dashed circle). Endometrial cells may be implanted and discovered anywhere along the expected route of a previous CS (as indicated by the dashed line), which may occur within the uterine scar itself, intraperitoneally, in the abdominal wall muscles, in the subcutaneous tissue, or in the skin. In this case, there is a heterogeneous signal intensity endometrial implant (fat arrows) within the rectus abdominis muscles (asterisks), located at the same height (as indicated by the dashed line) as the uterine scar. One must always keep in mind that at the time of CSSE detection, the uterus may be smaller and in a different orientation than when caesarean surgery (hence endometrial cell implantation) was performed. Thus, CSSE may not always be located at the exact same height as the uterine scar. Of interest, in this case, there is concomitant junctional zone thickening, indicating synchronous uterine adenomyosis.

Limitations

With regards to solid infiltrating endometriotic plaques, ultrasound has its limitations, especially if lesions are deeply located and not superficially located within the abdominal wall.[16] The ultrasound findings described are generally non-specific and inconclusive, and as a result, a broad spectrum of abdominal wall mass-causing conditions ought to be included in the radiological differential diagnosis.[11] Thus, ultrasound will mostly be helpful for image-guided tissue biopsy of CSSE suspicious lesions (Fig 3) and for confirming or ruling out other conditions included in the differential diagnosis such as a lipoma, a suture granuloma, or an incisional or other type of abdominal wall hernia.[27] In most other cases, further imaging will be required.

CT

CSSE may be frequently discovered inadvertently in women undergoing CT for other purposes, such as conditions that may present as a more serious disease[27] and may even mimic an acute abdomen.[30] CT seems to be more useful for eliminating some of the aetiologies included in the differential diagnosis (such as incisional hernia) as well as evaluating the disease extent and size prior to potential surgery.[31] Nonetheless, when encountered on CT, CSSE lesions may appear as a solid mass of soft-tissue density, typically with mild to moderate enhancement following intravenous contrast material injection.[25] Additionally, it will be located within the vicinity and/or along the route of the previous CS scar and may demonstrate concomitant spiculate margins (Figs 3 and 4). Increased attenuation relative to muscle can also be depicted, but CSSE attenuation may present variations.[27]

Limitations

Due to its limited contrast resolution and its radiation exposure, CT is not advised to identify abdominal wall endometriosis, hence CSSE.[32] Thus, given the aforementioned limitations and the non-specificity of the imaging findings, it may be challenging to differentiate CSSE from a simple scar and other pathologies on unenhanced and contrast-enhanced CT; therefore, clinical and imaging correlation iessential.[33] S.

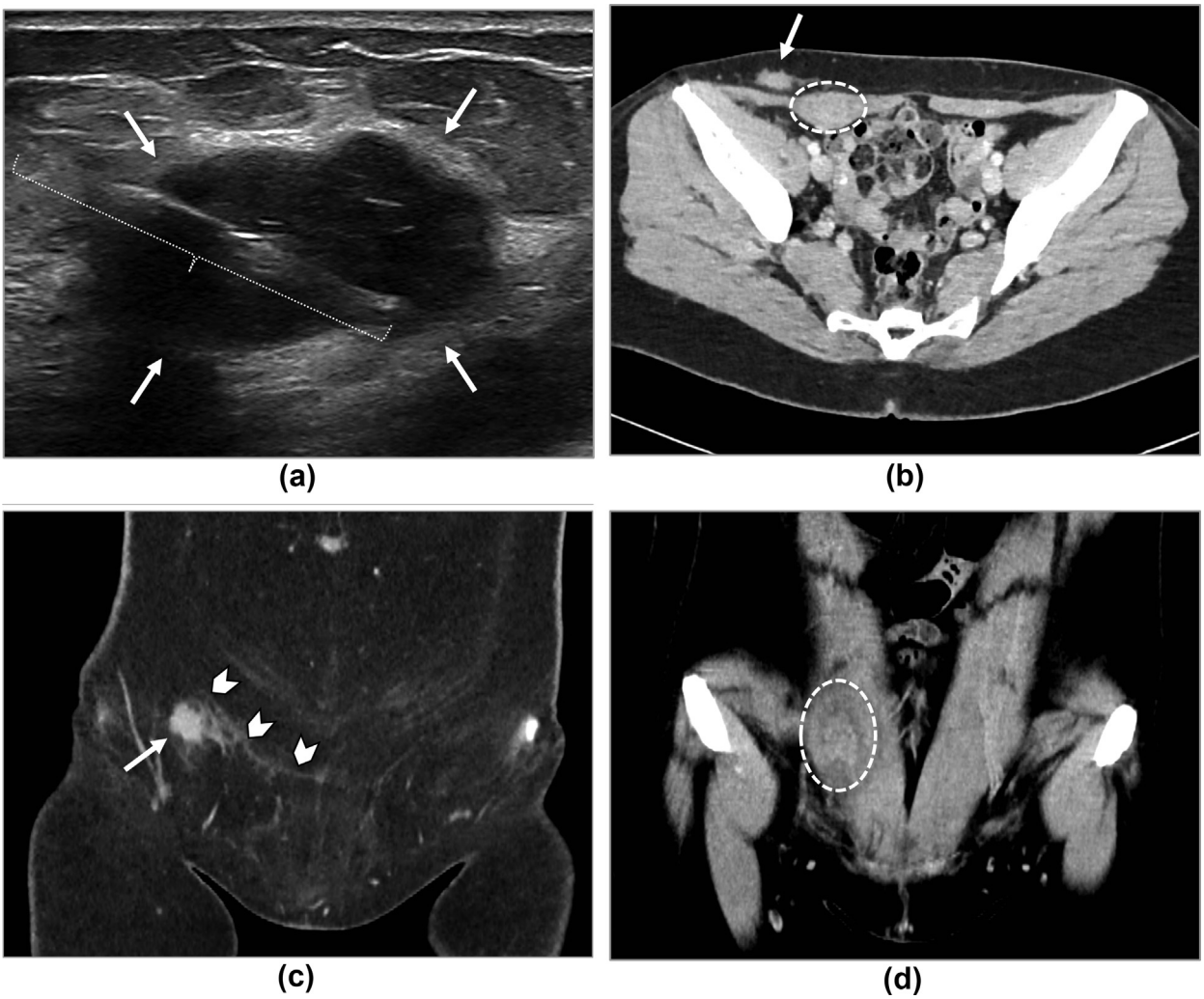

Figure 3 A 32-year-old woman with a history of CS surgery 4 years prior and symptomatic CSSE. (a) Image of a ultrasound-guided core needle biopsy of a subcutaneous CSSE lesion (arrows) displays the needle (bracket) within the lesion, which appears solid, heterogeneously hypoechoic, and with a periphery of increased echogenicity possibly due to a synchronous inflammatory reaction. The lesion was initially detected on a contrast-enhanced CT examination performed in order to exclude appendicitis due to the patient's presentation to the emergency department with intense abdominal right lower quadrant pain for the past 2 days (b–d). (b) Axial CT image demonstrated a contrast-enhancing solid-appearing soft-tissue nodular lesion within the subcutaneous tissue, with concomitant spiculate margins (arrow), as well as an asymmetric enlargement of the right rectus abdominis muscle sheath (dashed oval) located at the same height. (c) Coronal CT image displays the aforementioned characteristics of the subcutaneous nodule (arrow), which is now clearly seen to be situated within the course of a previous surgical incision (arrowheads). (d) Different coronal image (mildly thickened 3 mm section) of the same patient better depicts a subtle contrast-enhancing lesion (dashed oval) within the right rectus abdominis muscle sheath that caused the previously perceived asymmetric enlargement. The appendix appeared to be of normal calibre with air within its lumen, thus excluding the possibility of appendicitis. No other significant abnormal findings were detected. Originally, there was no clinical suspicion of CSSE at the time of presentation. The patient's abdominal pain was perceived as intra-abdominal, and a subtly palpated nodule on physical examination was overlooked as a possible unrelated lipoma; however, considering the CT findings, a more detailed history revealed that the patient had experienced fluctuating symptoms in the past few months that were related to her menstrual cycle. Due to their milder nature, the patient had not sought medical attention and had attributed them to menstrual cramps. Finally, the constellation of clinical and imaging findings was suggestive of CSSE situated within the rectus abdominis muscle and within the subcutaneous fatty tissue, which was confirmed by ultrasound-guided biopsy of the subcutaneous lesion (arrows) (a).

MRI

MRI is recognised as the reference standard of non-invasive imaging for identifying and classifying endometriosis and for disease mapping and preoperative planning.[34,35] MRI can provide improved sensitivity while confidently tracing the CSSE lesion to the incisional scar of a previous CS. Meanwhile, it is superior to ultrasound as image acquisition is more repeatable and has a greater field of view, thus facilitating the identification of additional sites of endometriosis,[34] and it is advantageous to CT because of its lack of ionising radiation and its superior characterisation of tissue properties.[27] Furthermore, MRI offers a more precise depiction of abdominal wall involvement than CT or ultrasound.[36]

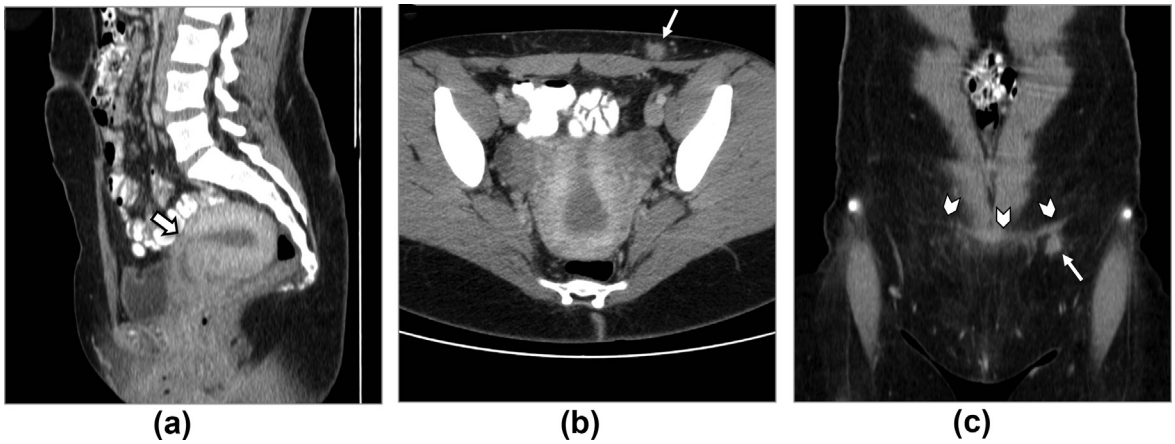

Figure 4 Contrast-enhanced CT of a 31-year-old woman with symptomatic CSSE. The examination was undertaken due to a painful, palpable lesion in the proximity of the abdominal skin scar from a previously performed (3 years ago) CS surgery, which raised the clinical suspicion for an incisional incarcerated hernia. (a) Sagittal image depicts thinning of the lower part of the anterior wall of the uterus (fat arrow) as evidence of a previous CS. (b) Axial image illustrates a solid, enhancing soft-tissue nodule with streaky margins along its periphery (arrow). (c) Coronal image displays the aforementioned nodule (arrow) at the edge of the Pfannenstiel incision from the previous CS scar. There was no evidence of a hernia, thus ruling out the initially suspected scenario of incarceration. The findings were consistent with CSSE situated in the subcutaneous fatty tissue.

At MRI, CSSE lesions will demonstrate imaging characteristics similar to those of solid infiltrating endometriosis at other locations.[37]

The role of conventional techniques

On T2 sequences, they may present poorly defined margins and hypointense signal owing to fibrosis and smooth muscle production,[37,38] but may also demonstrate iso- or mildly hyperintense signal compared to muscle tissue.[26] Small foci of hyperintense signal in T2 sequences may also be concurrently present within CSSE lesions, reflecting ectopic endometrial glands, thus further aiding in the establishment of the diagnosis.[37] Non-fat-saturated T2 sequences are preferable to fat-saturated ones,[34] as hypointense fibrotic lesions will be more obvious due to the improved contrast with the surrounding tissues.

On T1 sequences, signal intensity may be equal to or slightly increased in comparison to muscle tissue, with synchronous presence of hyperintense foci suggestive of subacute bleeding within the above-mentioned ectopic endometrial glands.[26,38] In the absence of bleeding, the lesions may demonstrate a homogeneously intermediate T1 signal,[39] and the foci may appear hypointense if present,[38] thus making them less conspicuous on T1-weighted imaging. It is important to note that the aforementioned T1 hyperintensities will maintain that appearance on both non-fat saturated and fat-saturated T1-weighted sequences, as they are the result of haemorrhage.

On another note, CSSE lesions may display decreased signal intensity in their periphery/rim both on T1 and T2 images, most probably as a result of fibrosis and the buildup of hemosiderin from multiple haemorrhages.[40]

Moreover, at least parts of the CSSE lesions will showcase increased uptake of the paramagnetic contrast medium on T1 fat-suppressed images as a result of the underlying inflammation, fibrosis, and glandular tissue.[39,41]

Illustrative examples of the role of conventional MRI techniques can be seen in Fig 5 and in Electronic Supplementary Material Figs. S1 and S2).

The role of advanced techniques

Dynamic MRI has also been evaluated and proven as a plausible means of supporting the diagnosis of endometriosis in suspected cases.[42] Importantly, if lesions have underlying haemorrhage that makes their signal intensity uniformly high on T1-weighted fat-suppressed images, then it can be challenging to verify possible contrast enhancement simply upon visual inspection. Subtraction techniques and/or time–intensity curves generated by the dynamic contrast-enhanced evaluation may prove to be of invaluable assistance in these cases (Electronic Supplementary Material Fig. S3).

Additionally, other advanced techniques, such as diffusion-weighted imaging (DWI), may also assist in the diagnosis of CSSE. In addition to endometriomas, infiltrating implants of endometrial tissue, such as those observed with CSSE, are among some of the benign conditions that may display diffusion restriction (Fig 6).[37] This is presumed to be caused by haemorrhagic components and blood clots present in endometrial lesions, which lead to an increase in T1 signal intensity and a decrease in apparent diffusion coefficient (ADC) values.[43,44] More specifically, a study by Balaban *et al.* reported mean ADC values of endometriomas of approximately $(1.15 \pm 0.2) \times 10^{-3}$ mm^2/s at a b-value of 1,000,[45] while another study by Busard *et al.* reported the mean ADC value of abdominal wall endometriosis lesions (thus CSSE) to be 0.93×10^{-3} mm^2/s with b-values up to 1,200.[26] In any case, it is not recommended to draw diagnostic conclusions based solely on DWI and ADC results.[44]

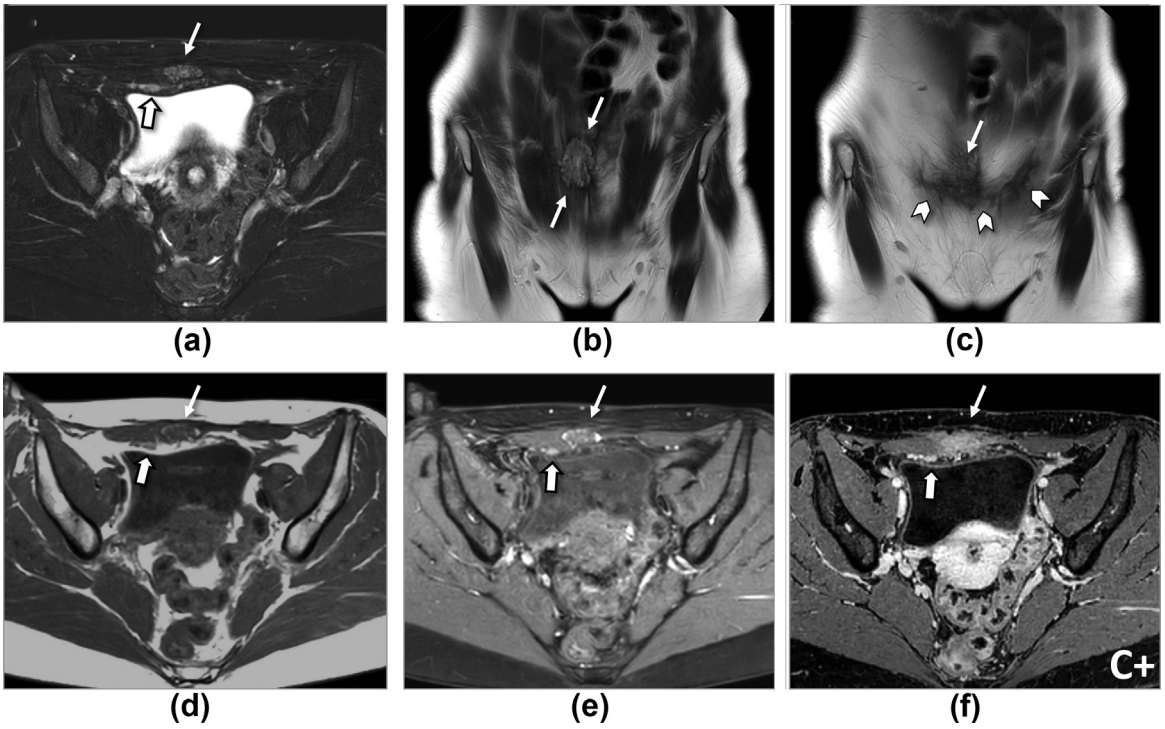

Figure 5 MRI examination of a 41-year-old woman with symptomatic CSSE. The patient was referred to our department due to discomfort and soreness during her perimenstrual period and mentioned a history of CS six years prior. (a) Axial fat-saturated T2 image and (b) coronal T2 image demonstrate tissue of heterogeneous signal intensity, with concomitant hyperintense foci, a low signal intensity rim, and mildly spiculate margins, within the right rectus abdominus muscle sheath (thin arrows). (c) Different coronal T2 image in a more ventral location illustrates the immediate relation of the lesion (thin arrow) with the incision scar from the aforementioned CS (arrowheads). (d) Axial non-fat-saturated T1 image and (e) axial fat-saturated T1 image show multiple foci of high signal intensity within and around the periphery of the lesion (thin arrow), which do not demonstrate signal suppression following fat saturation techniques, thus indicating their haemorrhagic nature. (f) Axial fat-saturated T1 image following intravenous gadolinium contrast media injection depicts contrast enhancement of the lesion (thin arrow). Fat arrow displays a small, subtle, well-circumscribed nodular heterogeneous lesion with mildly increased T2 signal intensity (a) and increased signal intensity on T1 non-fat-saturated (d) and fat-saturated images (e). The nodule appears to be situated intraperitoneally, immediately dorsal to the ventral abdominal wall, and at the same height as the previous rectus abdominis muscle sheath lesion. Due to the intrinsically and homogeneously high T1 signal of the nodule, contrast-enhancement was difficult to detect simply upon visual inspection; however, as can be seen in Electronic Supplementary Material Fig. S3, it was easily detectable through the generated time–intensity curve following dynamic contrast-enhanced evaluation. The findings were in keeping with rectus abdominis muscle and intraperitoneal CSSE.

Furthermore, due to their increased sensitivity to the susceptibility effects of haemosiderin, T2*-weighted sequences may also prove helpful by augmenting the recognition of previous haemorrhagic products.[39]

Interestingly, a study by Raafat *et al.* has suggested T2* and DWI sequences to substantially enhance the diagnostic accuracy of MRI studies for the detection of ectopic haemorrhagic endometrial lesions.[46]

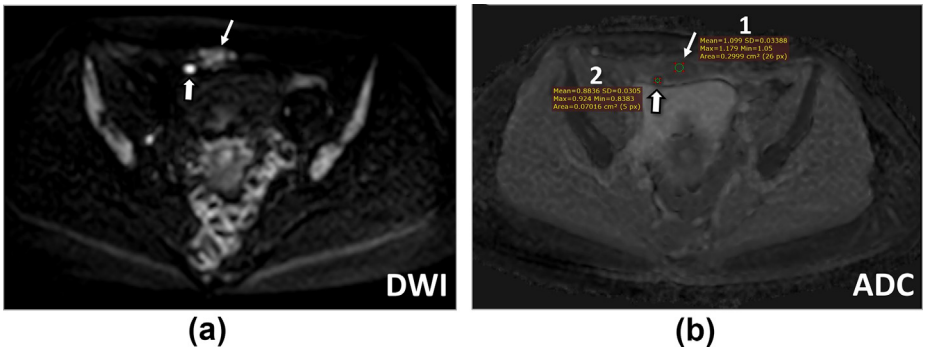

Figure 6 Same patient as in Fig 5 and Electronic Supplementary Material Fig. S3. (a) DWI and (b) ADC demonstrate diffusion restriction of both endometriotic lesions. The rectus abdominis muscle sheath lesion (thin arrow) displays ADC values of 1.09×10^{-3} mm^2/s (1), while the intraperitoneal endometriotic nodule (fat arrow) displays ADC values of 0.88×10^{-3} mm^2/s (2). Interestingly, in this case, the intraperitoneal nodule was missed at first when the standard MRI sequences were read, but it was easy to detect once the DWI images were studied.

Protocol considerations

The suggested MRI protocol should at minimum consist of T2-weighted and T1-weighted fat-suppressed sequences.[39] This is because suppressing the fatty tissue (which also demonstrates high T1 signal intensity) enables the easier detection of non-fat-containing T1 hyperintense lesions by enhancing the dynamic range of T1 sequences, thus increasing its sensitivity in detecting endometriosis and CSSE lesions.[37,47] Concurrently, T1-weighted fat-suppressed sequences also increase the specificity of MRI as lesions containing fat are eliminated from the differential diagnosis.[48] Optionally, advanced techniques such as DWI, T2*, and contrast-enhanced dynamic evaluation with or without subtraction may be included in the protocol as they may enhance diagnostic accuracy. In addition, it is important to note that the field of view (FOV) of the MRI study should be focused on the localisation of the suspected lesion on physical examination, which will most often be the abdominal wall.[23] If the examination is erroneously focused on the pelvic organs, saturation bands could obscure abdominal wall CSSE lesions.

Limitations

Nevertheless, MRI has its limitations as well. Small, plaque-like endometrial implants may be hard to detect, especially if located superficially in the peritoneum, while lesions lacking pigmentation will not appear hyperintense on T1-weighted images, thus making them less evident and inadequately evaluated if not overlooked.[34,39,40] Laparoscopy may therefore be the reference standard for the identification and staging of intraperitoneal CSSE lesions, just as it is for endometrial lesions situated elsewhere within the abdominal cavity,[6] but for CSSE lesions located within the abdominal wall, laparoscopy will clearly be inadequate.

The key clinical features and imaging findings of a typical CSSE lesion are summarised in Table 1.

Differential diagnosis

As mentioned previously, there is a wide range of conditions that ought to be included in the differential diagnosis of a suspected CSSE lesion, but a combination of clinical and imaging information will frequently narrow it down considerably.

If clinical examination and Valsalva manoeuvres are unclear, incisional or abdominal wall hernias may be easily diagnosed with imaging studies by the demonstration of an abdominal wall defect and a bowel or fat-containing herniated sac.[49]

Similarly, lipomas are also clearly diagnosed in imaging studies by the demonstration of fatty tissue lesion characteristics. In addition, they will not cause pain or any other symptoms.[23]

Moreover, just like anywhere else in the body, an abscess would be expected to occur in a febrile patient with leucocytosis and increased inflammatory markers (i.e., C-reactive protein), and on imaging studies, it would appear as a fluid collection with peripheral contrast enhancement with or without the concomitant presence of an air–fluid level within it.[50] This would typically be expected to occur within the first month following CS, although extremely rare cases of CS-related abscesses occurring 10 years post-operatively have also been described.[51]

Table 1
Key clinical and imaging features of a typical caesarean-section scar endometriosis (CSSE) lesion.

Clinical features	Past medical history of CS surgery (mandatory) Palpable lesion situated in or around the CS incision Pain/symptoms cyclically reoccurring with menstruation		
Imaging findings	US	Solid, nodular, hypoechoic lesion with a peripheral echogenic rim Spiculate margins Cystic areas may be present Internal/pedicular vascularity may be noted Adjacent to or along the route of a CS scar	
	CT	Solid mass of soft-tissue density Spiculate margins Mild to moderate contrast enhancement Within the vicinity or along the route of a CS scar	
	MRI	T2-weighted imaging	Hypointense Small hyperintense foci Low signal rim Poorly defined margins
		T1-weighted imaging (non-fat saturated and fat saturated)	Intermediate or mildly hyperintense Hyperintense-haemorrhagic foci Low signal rim
		Intravenous contrast (Gadolinium) Contrast-enhanced dynamic MRI	Usually demonstrates contrast enhancement May prove useful specifically for lesions with intrinsically high T1 signal
		Diffusion-weighted imaging	May demonstrate restricted diffusion
		T2*-weighted imaging	May further enhance haemosiderin detection

CS, caesarean-section; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging.

Additionally, a CS-related haematoma would also be expected to occur within the immediate perioperative period, and when CSSE usually develops (after at least several months, as mentioned previously), it would have been resolved.[29] As a result, in the absence of recent CS surgery, anticoagulant therapy, or a recent trauma within or near the scar, this diagnosis could be more confidently excluded. During the acute stage, CT may reveal a well-demarcated, hyperdense collection that may exhibit active contrast medium extravasation (if significant). The MRI findings will rely significantly on the haemorrhage chronicity.[23]

On another note, injection site granulomas may also be excluded based on an absent history of injection therapy of the ventral abdominal wall or within the vicinity of the CS scar and may appear as fluid-like collections or sometimes demonstrate calcifications.

Abdominal desmoid tumours are uncommon, mesenchymal, soft-tissue tumours that may be difficult to exclude clinically unless cyclical symptoms are present. They may be linked to conditions such as familial adenomatous polyposis, pregnancy, and trauma, and may even grow to large sizes. On imaging, they may present with well-defined borders and a relative decrease in enhancement and may appear heterogeneously T2 hyperintense with relative T1 hypointensity when compared to muscle.[52] In addition, ADC measurements may assist in differentiating CSSE lesions from desmoid tumours as desmoids present comparatively higher ADC values ranging from 1.2 to 1.9 $\times$ 10^{-3} mm^2/s.[26] Still, basing the differential approach solely on ADC measurements is not advised, as not all CSSEs will demonstrate diffusion restriction. Thus, histopathology will often be necessary for differentiating CSSE from a desmoid tumour as their imaging features may be similar.[53]

Metastasis should be considered in the presence of a known prior or concurrent primary tumour or if another suspicious lesion is simultaneously discovered for the first time in the present imaging examinations. Differentiating imaging findings are non-specific or may resemble the primary tumour.

Finally, keloid scars may be differentiated clinically as the fibroproliferative growth will extend beyond the edges of the original incision and into neighbouring tissue, but imaging findings are non-specific. Suture granulomas may be diagnosed on imaging by the detection of suture material within the reactively formed tissue (US with a high-frequency probe will be of most assistance), but clinical suspicion of retained suture material is helpful.[52]

Nevertheless, CSSE lesions may be distinguished from other conditions by the history of CS surgery, their proximity to the CS scar, the presence of subacute bleeds in endometrial cysts, observed as foci of T1 signal hyperintensity on MRI examination, and the cyclically reoccurring perimenstrual symptoms, if present.[26,27,29,37] If a diagnostic conundrum still remains, histopathology will provide the ultimate diagnosis.[27]

Malignant potential

Lastly, comparable to endometriosis lesions in other parts of the body, CSSE lesions may also present malignant transformation to endometrioid adenocarcinoma or clear cell carcinoma; however, this scenario is extremely rare (0.3–1%) and even less common than the malignant transformation of ovarian endometriomas[54] and develops many years (4–41 years) following CS surgery.[55] As a result, there is a paucity of specific imaging findings in the literature that will aid in the diagnosis of malignant vs. benign CSSE, and currently there is no recommendation for follow-up imaging.[29] So far, imaging findings pointing towards the diagnosis of malignant transformation of extraovarian endometriosis have been described as those of an intermediate T1 and T2 signal intensity, solid, contrast-enhancing lesion with diffusion restriction.[56] In addition, similar to ovarian endometriomas, if a CSSE lesion displays rapid size increase or endometrial cysts with contrast-enhancing nodules in their walls, this should also raise suspicion towards malignant CSSE.[37,54,57] Furthermore, 2-[^{18}F]-fluoro-2-deoxy-D-glucose positron-emission tomography (^{18}F-FDG PET) combined with CT (^{18}F-FDG PET/CT) has also been documented as a useful diagnostic tool by demonstrating increased radiotracer uptake in the solid parts of a CSSE lesion with suspicious malignant characteristics[58] and have also been employed in the diagnosis of post-surgical recurrence of malignant CSSE.[59] Similarly, ^{18}F-FDG PET/MRI studies have also been implemented and proven useful by depicting increased radiotracer uptake in malignant CSSE lesions and may be advantageous to PET/CT studies due to their enhanced soft-tissue contrast and lack of ionising radiation in comparison.[60] Moreover, PET studies may be helpful in the evaluation of disease extent and possible lymph node involvement, therefore enhancing confidence in treatment planning[61]; however, it must be kept in mind that a broad range of several unrelated soft-tissue mass-causing conditions of the ventral abdominal wall may also display increased activity,[59] therefore rendering this imaging method inadequate as a standalone diagnostic tool as well. In addition, PET studies are costly examinations that are not readily available in all institutions.

Preoperative diagnosis of CSSE malignant transformation is challenging and often inaccurate; therefore, routine imaging is not considered useful.[55] As a result, just like for benign CSSE, histopathology remains the reference standard for a reliable diagnosis of CSSE with malignant transformation,[54] in which case the treatment will consist primarily of major surgery (total clear margin resection of the primary lesion) and adjuvant chemotherapy or radiation therapy.[55]

Helpful clinical and/or imaging tips regarding the differential diagnosis of CSSE lesions from other benign or malignant conditions mentioned are summarised in Table 2.

The role of the various imaging studies in the diagnosis of CSSE lesions is reviewed in Table 3.

Table 2
Helpful conclusive clinical and imaging tips for the differential diagnosis of caesarean-section scar endometriosis (CSSE) lesions from other benign or malignant conditions.

Hernias	C: Physical examination - Valsalva manoeuvres I: Demonstration of abdominal wall defect and a bowel or fat-containing herniated sac
Lipomas	C: Painless, not symptomatic I: Demonstration of fatty tissue lesion characteristics
Abscess	C: Febrile patient, leucocytosis, inflammatory markers, typically within the first month following CS I: Fluid collection, peripheral contrast enhancement, air–fluid level
Hematoma	C: Recent CS surgery, anticoagulant therapy, or a recent trauma within or near the scar. Usually within the immediate perioperative period; resolves by the median time of CSSE detection. Decrease in haemoglobin levels if significant in size I: Well-delineated, hyperdense collection on CT (acutely), possibly with concomitant active contrast medium extravasation. MRI signals vary according to chronicity
Injection site granulomas	C: History of injection therapy within the vicinity of the CS scar I: Fluid-like collections, calcifications
Desmoid tumours	C: Associated with familial adenomatous polyposis, pregnancy, and trauma. May grow to large sizes I: May present with well-defined borders and relatively decreased enhancement. Heterogeneously T2 hyperintense with relative T1 hypointensity; higher ADC values compared to CSSE lesions Histopathology is often necessary for differentiating CSSE from a desmoid tumour
Metastasis	C: Consider in the presence of a known prior or synchronous primary tumour I: Non-specific or similar to the primary lesion
Keloid scars	C: Will extend beyond the edges of the original incision and into neighbouring tissue I: Non-specific
Suture granulomas	C: Suspicion of retained suture I: Detection of suture material within the reactively formed tissue (US most helpful)
CSSE with malignant transformation	C: Painful lesion at CS scar, many years following CS surgery. CA-125 may be increased. Very rare I: Intermediate T1/T2 signal intensity, solid, contrast-enhancing lesion with diffusion restriction on MRI. May display rapid size increase or endometrial cysts with contrast-enhancing nodules in their walls. PET studies may show increased radiotracer uptake
CSSE	C: History of CS surgery, proximity of lesion to CS scar, cyclically reoccurring perimenstrual symptoms I: Subacute bleeds in endometrial cysts (observed as hyperintense T1 foci on MRI)

C, clinical characteristics; I, imaging characteristics; CS, caesarean-section; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; PET, positron-emission tomography.

Table 3
The role of the different imaging studies in the diagnosis of caesarean -section scar endometriosis (CSSE) lesions.

US	• Frequently the first imaging technique used (cheap and readily available) • Findings are non-specific • More useful for ruling out other differentials and for image-guided biopsy
CT	• Not advised for CSSE (limited contrast resolution, radiation exposure) • Often performed for other reasons (CSSE mimicking an acute abdomen) • More useful for eliminating other aetiologies and for preoperative evaluation
MRI	• Reference standard of non-invasive imaging modalities for identifying and classifying endometriosis and for disease mapping and preoperative planning • Superior characterisation of tissue properties • Provides improved sensitivity and specificity • More repeatable and with a wider field of view (compared to US) • Lacks ionising radiation (compared to CT) • Costly examination, reduced availability (compared to US and CT) • Inferior to laparoscopy for intraperitoneally located CSSE lesions
PET (CT/MRI)	• Useful in differentiating malignant from benign CSSE (demonstrates increased radiotracer uptake) • Useful in diagnosing post-surgical recurrence of malignant CSSE • Helpful in evaluating disease extent - enhances confidence in treatment planning • Not very specific - inadequate as a standalone diagnostic tool • Costly examinations - reduced availability (compared to US, CT, and MRI)

US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; PET, positron-emission tomography.

Treatment options

Medical treatment

Medical treatment with oral contraceptives, progestogens, and hormone suppression therapy with gonadotropin-releasing hormone (GnRH) analogues may provide a temporary alleviation of the CSSE-associated symptoms; however, a relapse will occur following drug withdrawal.[12]

Surgical treatment

Surgical removal of CSSE lesions is the preferred definitive treatment option, which should be performed with a wide local excision to avoid recurrences.[62] Although generally the postoperative recurrence rates are low or non-existent,[12,62] some studies have described post-resection recurrence rates as high as 4.3%.[15] Thus, besides wide excision with clear margins, caution is also advised against the reinoculation of endometrial cells during the attempt at curative surgery, as this scenario could also lead to

recurrences. Furthermore, for the avoidance of endometrial cell implantation along the CS scar, a peritoneal saline wash, isolation of the surgical incision, change of needle, and replacement of instruments during closure of superficial layers have all been suggested.[62] Moreover, if a FNAC or biopsy has been performed preoperatively, it is also suggested to include the needle tract during surgical excision.[63]

Minimally invasive treatment

Percutaneous treatment options, such as sclerotherapy with ultrasound-guided injection of alcohol,[64] radiofrequency ablation,[65] and cryoablation,[66] have also been described as successful surgical alternatives for the treatment of intramuscular or subcutaneous CSSE lesions and seem to present promising results, thus necessitating further research. In addition, in a comparative study by Zhu *et al.*, it was demonstrated that both high-intensity focused ultrasound ablation and surgery are safe and efficient for the management of abdominal wall endometriosis, but the former has the advantages of being less intrusive and requiring a less lengthy hospitalisation than the latter.[67]

Conclusion

Given the rising prevalence of CS, CSSE may be underrepresented in the literature and occur more frequently than previously thought. Familiarising clinicians and radiologists with this condition is imperative to avoid a delayed diagnosis. Locating a painful soft tissue mass-like lesion along the path of a previous CS scar is the most indicative clue that should initially alert radiologists towards suggesting CSSE, especially if typical clinical manifestations, such as cyclical symptoms associated with menstruation, are also present. The concomitant detection of hyperintense (haemorrhagic) foci, identified on T1 fat-saturated sequences, will strongly support the diagnosis on MRI, which is the most sensitive imaging technique for CSSE assessment. A non-specific, contrast-enhancing, hypodense nodule with spiculate edges may be suggestive if the lesion was originally detected on CT. Although ultrasound is frequently the first imaging method used, the findings are non-specific; therefore, making it more useful for ruling out other differentials and for image-guided biopsy. In any case, histopathology will ultimately provide the definitive diagnosis. Surgical excision is the mainstay of treatment; however, minimally invasive, percutaneous techniques have also been implemented successfully.

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Declaration of competing interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

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References

1. Zondervan KT, Becker CM, Missmer SA. *Endometriosis N Engl J Med* 2020 Mar;**382**(13):1244–56.
2. Macer ML, Taylor HS. Endometriosis and infertility: a review of the pathogenesis and treatment of endometriosis-associated infertility. *Obstet Gynecol Clin North Am* 2012 Dec;**39**(4):535–49.
3. Chapron C, Marcellin L, Borghese B, *et al.* Rethinking mechanisms, diagnosis and management of endometriosis. *Nat Rev Endocrinol* 2019 Nov;**15**(11):666–82.
4. Taylor HS, Kotlyar AM, Flores VA. Endometriosis is a chronic systemic disease: clinical challenges and novel innovations. *Lancet (London, England)* 2021 Feb;**397**(10276):839–52.
5. Alimi Y, Iwanaga J, Loukas M, *et al.* The clinical anatomy of endometriosis: a review. *Cureus* 2018 Sep 25 https://www.cureus.com/articles/14685-the-clinical-anatomy-of-endometriosis-a-review.
6. Hsu AL, Khachikyan I, Stratton P. Invasive and noninvasive methods for the diagnosis of endometriosis. *Clin Obstet Gynecol* 2010 Jun;**53**(2):413–9.
7. Gaunt A, Heard G, McKain ES, *et al.* Caesarean scar endometrioma. *Lancet* 2004 Jul;**364**(9431):368.
8. Zhang P, Sun Y, Zhang C, *et al.* Caesareanscar endometriosis: presentation of 198 cases and literature review. *BMC Womens Health* 2019 Jan;**19**(1):14.
9. Granese R, Cucinella G, Barresi V, *et al.* Isolated endometriosis on the rectus abdominis muscle in women without a history of abdominal surgery: a rare and intriguing finding. *J Minim Invasive Gynecol* 2009 Nov;**16**(6):798–801.
10. Singh KK, Lessells AM, Adam DJ, *et al.* Presentation of endometriosis to general surgeons: a 10-year experience. *Br J Surg* 1995 Oct;**82**(10):1349–51.
11. Hensen J-HJ, Van Breda Vriesman AC, Puylaert JBCM. Abdominal wall endometriosis: clinical presentation and imaging features with emphasis on sonography. *AJR Am J Roentgenol* 2006 Mar;**186**(3):616–20.
12. Adriaanse BME, Natté R, Hellebrekers BWJ. Scar endometriosis after a caesarean section: a perhaps underestimated complication. *Gynecol Surg* 2013 Nov 18;**10**(4):279–84.
13. Sasson IE, Taylor HS. Stem cells and the pathogenesis of endometriosis. *Ann N Y Acad Sci* 2008 Apr;**1127**(1):106–15.
14. Pados G, Tympanidis J, Zafrakas M, *et al.* Ultrasound and MR-imaging in preoperative evaluation of two rare cases of scar endometriosis. *Cases J* 2008 Aug;**1**(1):97.
15. Horton JD, DeZee KJ, Ahnfeldt EP, *et al.* Abdominal wall endometriosis: a surgeon's perspective and review of 445 cases. *Am J Surg* 2008 Aug;**196**(2):207–12.
16. Choudhary S, Fasih N, Papadatos D, *et al.* Unusual imaging appearances of endometriosis. *AJR Am J Roentgenol* 2009 Jun;**192**(6):1632–44.
17. Pathan ZAAK, Dinesh U, Rao R. Scar endometriosis. *J Cytol* 2010;**27**:106–8.
18. Bektaş H, Bilsel Y, Sarı YS, *et al.* Abdominal wall endometrioma; a 10-year experience and brief review of the literature. *J Surg Res* 2010 Nov;**164**(1):e77–81.
19. Ozel L, Sagiroglu J, Unal A, *et al.* Abdominal wall endometriosis in the caesarean section surgical scar: a potential diagnostic pitfall. *J Obstet Gynaecol Res* 2012 Mar;**38**(3):526–30.
20. Loh S-H, Lew B-L, Sim W-Y. Primary cutaneous endometriosis of umbilicus. *Ann Dermatol* 2017;**29**(5):621.

21. Alnafisah F, Dawa SK, Alalfy S. Skin endometriosis at the caesarean section scar: a case report and review of the literature. *Cureus* 2018 Jan 13 https://www.cureus.com/articles/10358-skin-endometriosis-at-the-caesarean-section-scar-a-case-report-and-review-of-the-literature.
22. Zhang J, Liu X. Clinicopathological features of endometriosis in abdominal wall—clinical analysis of 151 cases. *Clin Exp Obstet Gynecol* 2016;**43**(3):379–83.
23. Ballard DH, Mazaheri P, Oppenheimer DC, *et al.* Imaging of abdominal wall masses, masslike lesions, and diffuse processes. *RadioGraphics* 2020 May;**40**(3):684–706.
24. Wolf Y, Haddad R, Werbin N, *et al.* Endometriosis in abdominal scars: a diagnostic pitfall. *Am Surg* 1996 Dec;**62**(12):1042–4.
25. Coley BD, Casola G. Incisional endometrioma involving the rectus abdominis muscle and subcutaneous tissues: CT appearance. *AJR Am J Roentgenol* 1993 Mar;**160**(3):549–50.
26. Busard MPH, Mijatovic V, van Kuijk C, *et al.* Appearance of abdominal wall endometriosis on MR imaging. *Eur Radiol* 2010 May 21;**20**(5):1267–76.
27. Gidwaney R, Badler RL, Yam BL, *et al.* Endometriosis of abdominal and pelvic wall scars: multimodality imaging findings, pathologic correlation, and radiologic mimics. *RadioGraphics* 2012 Nov;**32**(7):2031–43.
28. Francica G. Reliable clinical and sonographic findings in the diagnosis of abdominal wall endometriosis near caesarean section scar. *World J Radiol* 2012;**4**(4):135.
29. Rodgers SK, Kirby CL, Smith RJ, *et al.* Imaging after caesarean delivery: acute and chronic complications. *RadioGraphics* 2012 Oct;**32**(6):1693–712.
30. Gajjar KB, Mahendru AA, Khaled MA. Caesarean scar endometriosis presenting as an acute abdomen: a case report and review of literature. *Arch Gynecol Obstet* 2008 Feb 14;**277**(2):167–9.
31. Rezvani M, Shaaban AM, Kennedy AM. The role of multimodality imaging after caesarean delivery. *Ultrasound Q* 2015 Mar;**31**(1):5–18.
32. Dwivedi AJ, Agrawal SN, Silva YJ. Abdominal wall endometriomas. *Dig Dis Sci* 2002 Feb;**47**(2):456–61.
33. Balleyguier C, Chapron C, Chopin N, *et al.* Abdominal wall and surgical scar endometriosis: results of magnetic resonance imaging. *Gynecol Obstet Invest* 2003;**55**(4):220–4.
34. Jha P, Sakala M, Chamie LP, *et al.* Endometriosis MRI lexicon: consensus statement from the society of abdominal radiology endometriosis disease-focused panel. *Abdom Radiol* 2020 Jun 14;**45**(6):1552–68.
35. Saba L, Sulcis R, Melis GB, *et al.* Endometriosis: the role of magnetic resonance imaging. *Acta Radiol* 2015 Mar 1;**56**(3):355–67.
36. Yu C-Y, Perez-Reyes M, Brown JJ, *et al.* MR Appearance of umbilical endometriosis. *J Comput Assist Tomogr* 1994 Mar;**18**(2):269–71.
37. Siegelman ES, Oliver ER. MR imaging of endometriosis: ten imaging pearls. *RadioGraphics* 2012 Oct;**32**(6):1675–91.
38. Coutinho A, Bittencourt LK, Pires CE, *et al.* MR imaging in deep pelvic endometriosis: a pictorial essay. *RadioGraphics* 2011 Mar;**31**(2):549–67.
39. Foti PV, Farina R, Palmucci S, *et al.* Endometriosis: clinical features, MR imaging findings and pathologic correlation. *Insights Imaging* 2018 Apr 15;**9**(2):149–72.
40. Zawin M, McCarthy S, Scoutt L, *et al.* Endometriosis: appearance and detection at MR imaging. *Radiology* 1989 Jun;**171**(3):693–6.
41. Wolf GC, Kopecky KK. MR Imaging of endometriosis arising in caesarean section scar. *J Comput Assist Tomogr* 1989 Jan;**13**(1):150–2.
42. Onbas O, Kantarci M, Alper F, *et al.* Nodular endometriosis: dynamic MR imaging. *Abdom Imaging* 2007 Sep 7;**32**(4):451–6.
43. Fujii S, Kakite S, Nishihara K, *et al.* Diagnostic accuracy of diffusion-weighted imaging in differentiating benign from malignant ovarian lesions. *J Magn Reson Imaging* 2008 Nov;**28**(5):1149–56.
44. Lall C, Bura V, Lee TK, *et al.* Diffusion-weighted imaging in haemorrhagic abdominal and pelvic lesions: restricted diffusion can mimic malignancy. *Abdom Radiol* 2018 Jul 6;**43**(7):1772–84.
45. Balaban M, Idilman IS, Toprak H, *et al.* The utility of diffusion-weighted magnetic resonance imaging in differentiation of endometriomas from haemorrhagic ovarian cysts. *Clin Imaging* 2015 Sep;**39**(5):830–3.
46. Raafat M, Talaat SH, Abdelghaffar SM, *et al.* Can diffusion and T2 star-weighted magnetic resonance imaging aid in the diagnosis of ectopic endometrium? *Egypt J Radiol Nucl Med* 2021 Dec 26;**52**(1):137.
47. Bekiesinska-Figatowska M. Magnetic resonance imaging of the female pelvis after caesarean section: a pictorial review. *Insights Imaging* 2020 Dec 27;**11**(1):75.
48. Woodward PJ, Sohaey R, Mezzetti TP. Endometriosis: radiologic–pathologic correlation. *RadioGraphics* 2001 Jan;**21**(1):193–216.
49. Murphy KP, O'Connor OJ, Maher MM. Adult abdominal hernias. *AJR Am J Roentgenol* 2014 Jun;**202**(6):W506–11.
50. Hayeri MR, Ziai P, Shehata ML, *et al.* Soft-tissue infections and their imaging mimics: from cellulitis to necrotizing fasciitis. *RadioGraphics* 2016 Oct;**36**(6):1888–910.
51. Boukrid M, Dubuisson J. Conservative management of a scar abscess formed in a caesarean-induced isthmocele. *Front Surg* 2016;**3**:7.
52. Kocher MR, Hardie A, Schaefer A, *et al.* Caesarean-section scar endometrioma: a case report and review of the literature. *J Radiol Case Rep* 2017 Dec 17;**11**(12):16–26.
53. Anand M, Deshmukh S. Massive abdominal wall endometriosis masquerading as desmoid tumour. *J Cutan Aesthet Surg* 2011;**4**(2):141.
54. Robinson KA, Menias CO, Chen L, *et al.* Understanding malignant transformation of endometriosis: imaging features with pathologic correlation. *Abdom Radiol* 2020;**45**(6):1762–75.
55. Mihailovici A, Rottenstreich M, Kovel S, *et al.* Endometriosis-associated malignant transformation in abdominal surgical scar. *Medicine (Baltimore)* 2017 Dec;**96**(49):e9136.
56. McDermott S, Oei TN, Iyer VR, *et al.* MR imaging of malignancies arising in endometriomas and extraovarian endometriosis. *RadioGraphics* 2012 May;**32**(3):845–63.
57. Vellido-Cotelo R, Muñoz-González JL, Oliver-Pérez MR, *et al.* Endometriosis node in gynaecologic scars: a study of 17 patients and the diagnostic considerations in clinical experience in tertiary care center. *BMC Womens Health* 2015 Dec 18;**15**(1):13.
58. Ferrandina G, Palluzzi E, Fanfani F, *et al.* Endometriosis-associated clear cell carcinoma arising in caesarean section scar: a case report and review of the literature. *World J Surg Oncol* 2016 Dec 3;**14**(1):300.
59. Jiang M, Chen P, Sun L, *et al.* ^{18}F-FDG PET/CT findings of a recurrent adenocarcinoma arising from malignant transformation of abdominal wall endometriosis. *Clin Nucl Med* 2015 Feb;**40**(2):184–5.
60. Wang H, Xue Q, Shou Y, *et al.* ^{18}F-FDG simultaneous PET/MR findings of a malignant transformation and metastases of abdominal wall endometriosis. *Eur J Nucl Med Mol Imaging* 2020 Dec 25;**47**(13):3190–1.
61. Vinchant M, Poncelet C, Ziol M, *et al.* Malignant transformation of abdominal wall endometriosis: case report and literature review. *Tumori J* 2013 Mar 29;**99**(2):e49–54.
62. Sumathy S, Mangalakanthi J, Purushothaman K, *et al.* Symptomatology and surgical perspective of scar endometriosis: a case series of 16 women. *J Obstet Gynecol India* 2017 Jun 26;**67**(3):218–23.
63. Kaunitz A, Di Sant'Agnese PA. Needle tract endometriosis: an unusual complication of amniocentesis. *Obstet Gynecol* 1979 Dec;**54**(6):753–5.
64. Bozkurt M, Çil AS, Bozkurt DK. Intramuscular abdominal wall endometriosis treated by ultrasound-guided ethanol injection. *Clin Med Res* 2014 Dec;**12**(3–4):160–5.
65. Carrafiello G, Fontana F, Pellegrino C, *et al.* Radiofrequency ablation of abdominal wall endometrioma. *Cardiovasc Intervent Radiol* 2009 Nov 30;**32**(6):1300–3.
66. Dibble EH, D'Amico KC, Bandera CA, *et al.* Cryoablation of abdominal wall endometriosis: a minimally invasive treatment. *AJR Am J Roentgenol* 2017 Sep;**209**(3):690–6.
67. Zhu X, Chen L, Deng X, *et al.* A comparison between high-intensity focused ultrasound and surgical treatment for the management of abdominal wall endometriosis. *BJOG Int J Obstet Gynaecol* 2017 Aug;**124**:53–8.