Application of MRI-Ultrasound Fusion to Gynaecological Disorders

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Introduction

Pelvic ultrasound in gynaecology is essentially an extension of the clinical examination: it is safe, easily reproduced and inexpensive. However, it is often under-utilised, meaning that costlier and less accessible imaging techniques, such as pelvic MRI, are performed when complex disorders such as endometriosis are suspected.

Fusion imaging combining ultrasound with CT or MRI has already been discussed in several publications with reference to liver disease and particularly prostate biopsy, for which it is currently used in some hospitals. This technique also seems entirely appropriate to pelvic exploration: the organs are fixed, MRI is freed from investigational conditions, and precise diagnosis is possible for diseases that are difficult to prove with ultrasound. However, ultrasound has a higher spatial resolution and is a dynamic technique, of particular benefit when diagnosing pelvic adhesions.

Moreover, use of Doppler provides the assessment of the vascularization and hemodynamics.

In the latest version of the Aplio Series, ultrasound fusion imaging is available for transvaginal pelvic exploration. It can be combined with Superb Micro-vascular Imaging (SMI), a special Doppler technique offering high sensitivity and resolution at low-velocity flows with very few motion artefacts.

The procedure is simple and consists of the following steps (Fig. 1):

1. Load the DICOM volume for pelvic MRI into the ultrasound machine.
2. Place the patient in the lithotomy position.
3. Insert the transvaginal probe (the probe is equipped with a sensor that is tracked by a magnetic field generator placed next to the patient).
4. A sagittal section of the uterus is used to synchronize both US and MRI images.
5. Place markers to further improve image alignment.
6. Real-time MRI and ultrasound images are displayed together (Fig. 2).

Below, we will provide several examples of how this technique can be applied to different pelvic diseases.

Endometriosis

Deep endometriosis can be found on the utero-sacral ligaments, rectosigmoid, rectovaginal septum or bladder in the form of hypoechogenic nodules, which are often irregular and frequently involve the adjacent organs. However, these lesions are difficult to identify in current practice using transvaginal ultrasound and are therefore often subject to additional investigation using MRI.

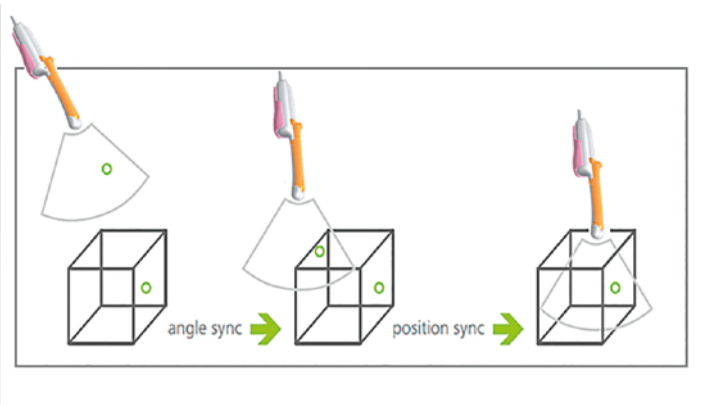

Fig. 1: Process of synchronising MRI and ultrasound images.

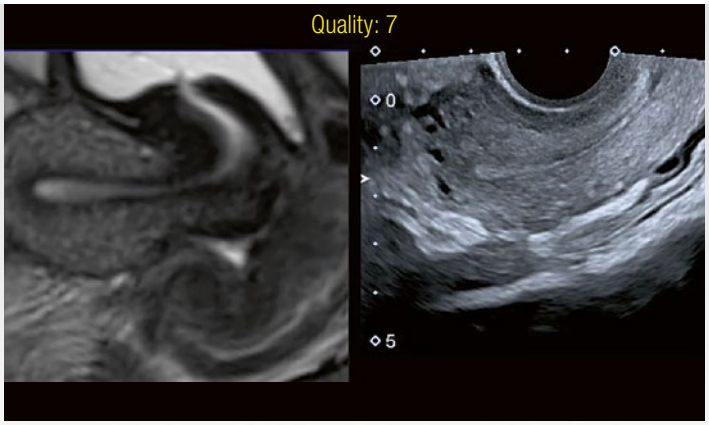

Fig. 2: MRI and ultrasound sagittal section showing the quality score for detection by the probe (quality 7).

Fusion imaging makes it easier to locate MRI-detected lesions using ultrasound and therefore allows their monitoring from the initial scan onwards. In addition, the use of Doppler sonography and dynamic manoeuvres to look for adhesions completes the real-time examination.

Lastly, fusion improves our knowledge of the ultrasound signs of these lesions and can be used to teach operators with a lesser degree of training how to detect them.

Example 1

Below is an example of posterior deep endometriosis in a 27-year-old patient with late presentation of longstanding dysmenorrhoea. A nodule infiltrating the anterior rectal wall can be seen (Fig. 3).

Example 2

The patient with a history of right salpingo-oophorectomy presented with menorrhagia and ultrasound found a hypoechogenic mass on the right uterine horn. An endometriosis nodule was suspected. This was confirmed by MRI and is clearly visible on fusion imaging (Fig. 4).

Example 3

A 26-year-old patient with a long history of chronic dysmenorrhoea and the recent onset of rectal bleeding. A nodule was palpated at the posterior vaginal fornix. MRI combined with ultrasound found a large nodule protruding into the rectal light (Fig. 5).

Example 4

A 33-year-old woman, asymptomatic nulliparous, who had tried to become pregnant for 8 months. A routine ultrasound was made highlighting a hypo-echogenic cyst which was an evident endometrioma with a posterior endometriosis nodule involved. There was no intestinal involvement. Although the uterus was retroverted, fusion confirmed a free Douglas pouch, an endometrioma which was actually larger than visible on MRI (Fig. 6a) and a posterior lesion appearing as a hypo-echogenic area behind the uterosacral ligaments near the cyst (Fig. 6b).

Real-time fusion imaging is also proving useful in patients with adenomyosis.

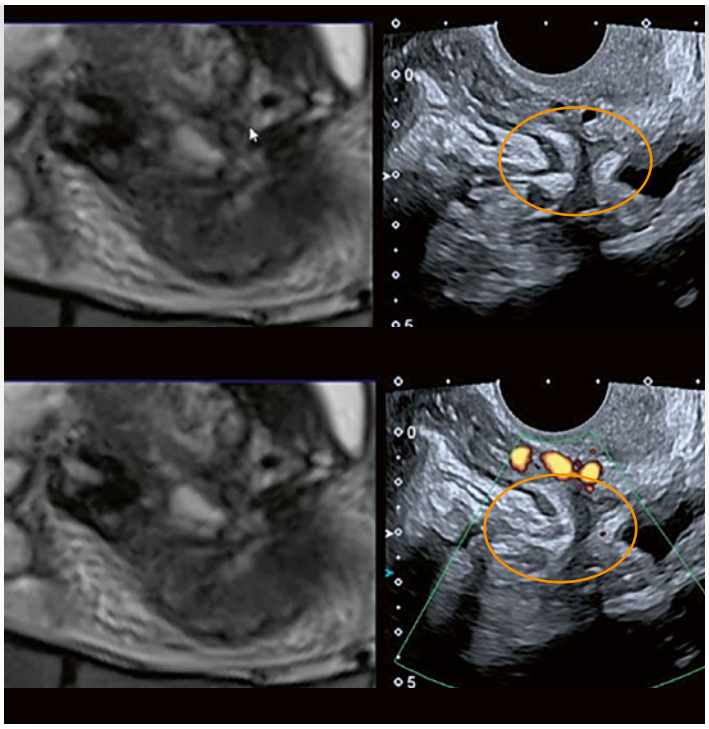

Fig. 3: MRI/ultrasound sagittal section at the recto-uterine pouch. A posterior nodule infiltrates the anterior rectal wall.

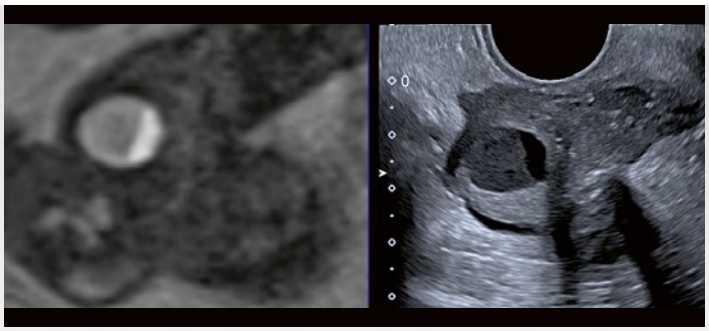

Fig. 4: Endometriosis nodule on the right uterine horn on MRI and ultrasound.

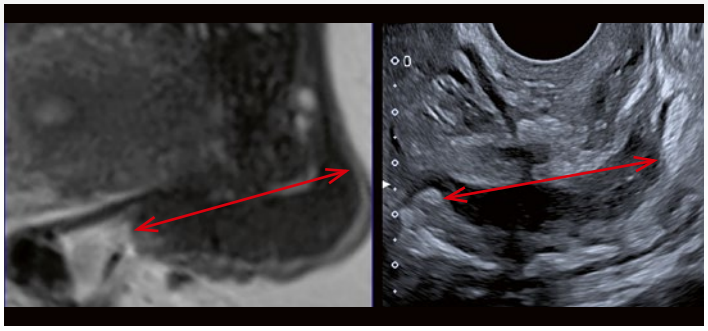

Fig. 5: Rectal endometriosis nodule on MRI and ultrasound.

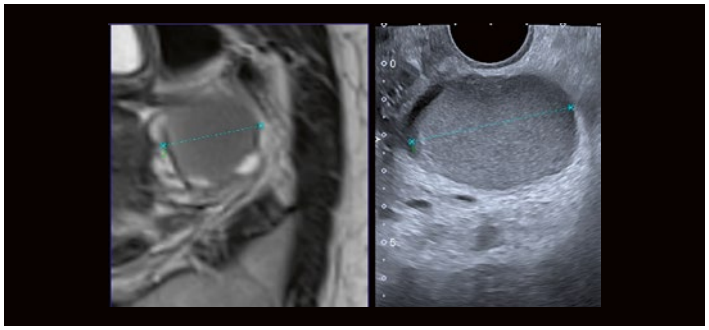

Fig. 6a: MRI and ultrasound parasagittal planes: endometrioma increased between MRI and Fusion.

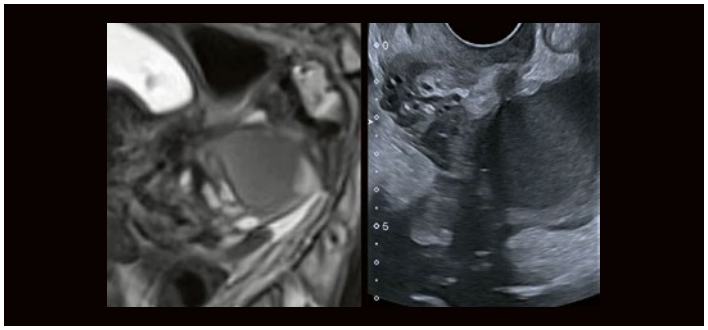

Fig. 6b: MRI and ultrasound parasagittal planes: posterior nodule.

Example 5

In a 66-year-old patient with a history of breast cancer, endometrial hypertrophy (16.8 mm) was found during a routine examination (Fig. 7a), leading to further investigation with MRI. This shows the opposite: endometrial atrophy with associated adenomyosis.

Comparing the fusion ultrasound and MRI sections allows the ultrasound image to be understood and means that the endometrium can be defined more accurately for further monitoring (Fig. 7b).

Polyps

Polyps are also easily identified by fusion imaging together with Doppler sonography. The higher spatial resolution of ultrasound means they can be defined more easily (Fig. 8).

Endometrial cancer

Treatment for endometrial cancer depends on the initial FIGO (2009) stage. Pelvic MRI is the standard investigation; it can evaluate invasion of the myometrium and the presence of adenopathy, allowing the FIGO stage to be established. Fusion imaging is also applicable to this disease, since it can combine ultrasound data and MRI images together with Doppler sonography.

Example 6

Endometrial cancer was diagnosed in a 55-year-old woman with postmenopausal bleeding (Fig. 9). The tumour invades more than 50 % of the myometrial thickness without lymph node involvement (FIGO IB). SMI imaging in Monochrome mode (M-SMI) shows the peripheral vessels and real-time MRI-ultrasound fusion allows a good analysis of its contours (Fig. 9).

Conclusion

Real-time MRI-ultrasound fusion is a new technique that is perfectly suited to gynaecological disorders, especially endometriosis. The Aplio technology makes it easy to implement, and it combines the advantages of both types of imaging during a single examination. Fusion allows the operator to improve the diagnostic performance.

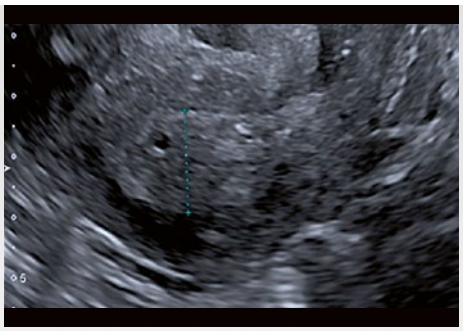

Fig. 7a: Endometrial thickness measurement using transvaginal ultrasound.

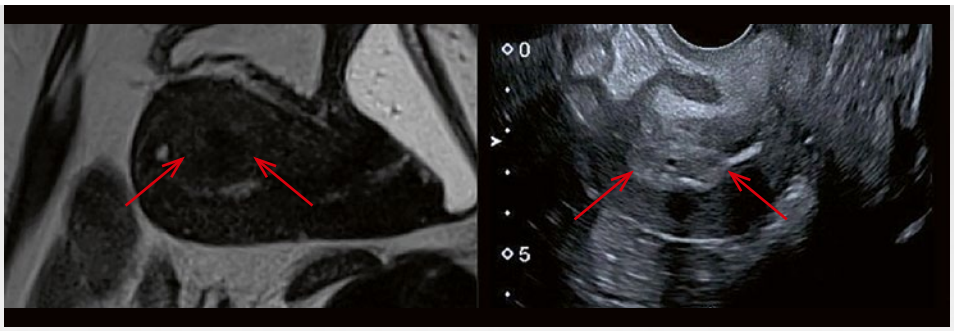

Fig. 7b: MRI/ultrasound sagittal section: adenomyosis had led to an incorrect endometrium measurement.

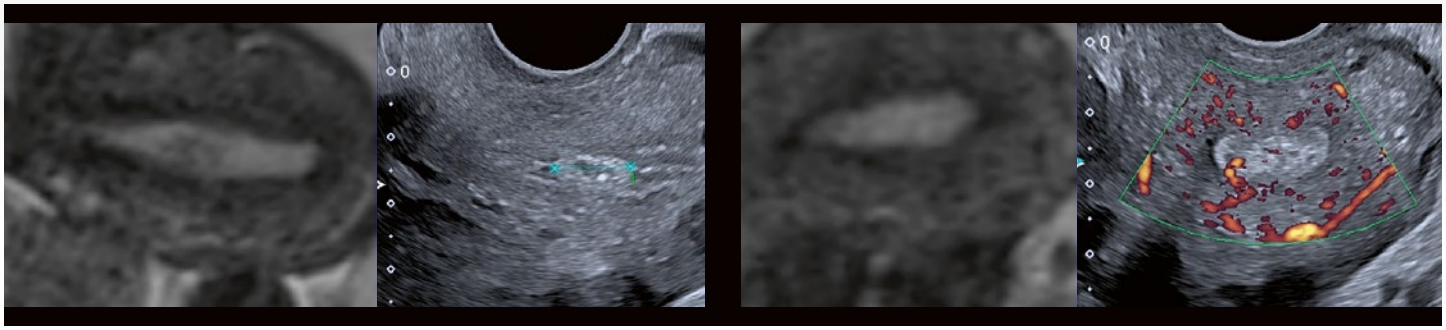

Fig. 8: MRI/ultrasound sagittal and transverse sections: polyp with vascular pedicle.

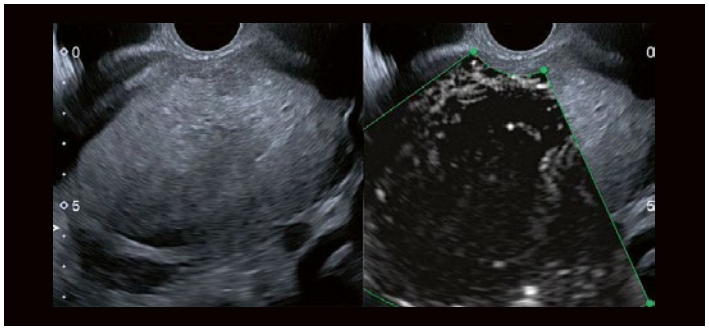

Fig. 9a: Sagittal section of the uterus with M-SMI: large vascularised endometrial tumour.

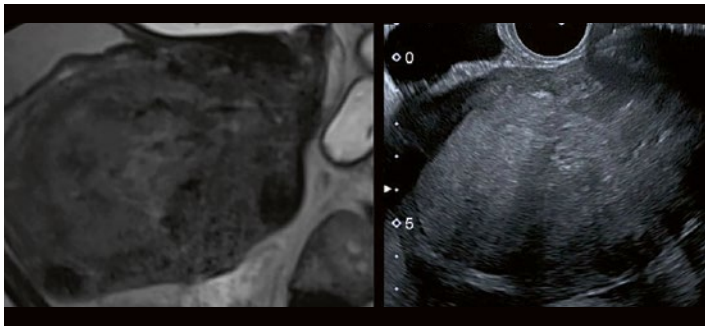

Fig. 9b: MRI and ultrasound sections of the tumour.

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