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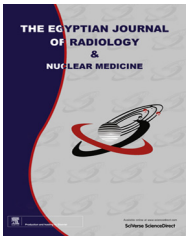

ORIGINAL ARTICLE

Septate or bicornuate uterus: Accuracy of three-dimensional trans-vaginal ultrasonography and pelvic magnetic resonance imaging

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KEYWORDS

Mullerian duct anomalies;
Septate uterus;
Bicornuate uterus;
Three dimensional ultrasound;
Pelvic magnetic resonance imaging

Abstract *Objective:* To estimate the accuracy of 3-dimensional transvaginal ultrasonography (3D-TVUS), hysterosalpingography (HSG) and pelvic magnetic resonance imaging (MRI) in the differentiation between septate and bicornuate uterus.

Patients and methods: Thirty-six patients with suspected septate or bicornuate uterus on 2D ultrasound or hysterosalpingography (HSG) underwent 3D-TVUS examination, MR imaging, diagnostic laparoscopy and hysteroscopy. HSG was performed only for those patients who did not undergo the procedure before (21 patients), we retrospectively revised the hysterosalpingography of 15 patients performed outside our hospital with acceptable quality.

Results: HSG showed sensitivity of 77.4%, specificity of 60% and overall accuracy of 75% in the differentiation between the septate and bicornuate uterus. MRI showed sensitivity of 93.5%, specificity of 80%, PPV of 96.6% and negative predicative value of 66.6%, with overall accuracy of 91.6%. The 3D ultrasound showed the highest diagnostic parameters, with sensitivity of 96.7%, specificity of 100%, PPV of 100% and negative predicative value of 83.3%, with overall accuracy of 97.2%.

Conclusions: Transvaginal 3-D ultrasonography is accurate for diagnosis and differentiation between septate uterus and bicornuate uterus. We recommend 3-D transvaginal ultrasonography as the first and only mandatory step in the assessment of the uterine cavity in patients with a

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suspected septate or bicornuate uterus, especially before planning surgery. MRI should be preserved for patients in whom 3D TVS is not possible like virgins.

1. Introduction

Congenital uterine anomalies, which can arise from malformations at any step of the Mullerian developmental process, are present in 5.5% of the unselected population, in 8% of infertile women, and in 13.3% of women with histories of miscarriages (1). Septate uterus is more common than bicornuate uterus with a ratio 4–7:1 (1). Both anomalies are reported to increase the rate of miscarriage and adverse pregnancy outcome (2,3).

There are several classifications of uterine malformation, but the most widely accepted is that established in 1988 by the American Fertility Society (AFS) (4) (Fig. 1).

Septate uterus is associated with poorest reproductive outcomes, and high incidence of abortion and miscarriage and now surgical interference is the preferred method for intervention (1,5). On the other hand, surgical intervention is not indicated for bicornuate uterus (6), which makes the differentiation between the two entities highly significant.

Hysterosalpingography has been used as a screening method for uterine anomalies, however, its accuracy in differentiation between septate and bicornuate uterus is doubtful, because it cannot explore the external contour of the uterus (7,8).

Pelvic magnetic resonance imaging (MRI) has also proven special Excellency in the diagnosis of Mullerian duct anomalies (9–11). But it is expensive, less available, and needs special training for radiologists interpreting pelvic MRI.

Recently, 3-dimensional (3-D) ultrasonography has been reported to have a high accuracy in diagnosing congenital anomalies (12–14)). It is a noninvasive and reproducible procedure (15).

The aim of this study is to estimate the accuracy of 3-dimensional transvaginal ultrasonography (3D-TVUS), hysterosalpingography (HSG) and pelvic magnetic resonance imaging (MRI) in the differentiation between septate and bicornuate uterus.

2. Patients and methods

2.1. Patient characteristics

This study included thirty-six patients between October 2012 and September 2013 with a suspected diagnosis of septate or bicornuate uterus based on 2-dimensional (2-D) ultrasonography or hysterosalpingography (HSG). All women underwent 3D transvaginal ultrasonography of the uterine cavity and pelvic MRI. HSG was performed only for those patients who did not undergo the procedure before (21 patients), we retrospectively revised the hysterosalpingography of 15 patients performed outside our hospital with acceptable quality. All patients underwent hysteroscopy and/or laparoscopy. Written consent was taken from all patients, with full explanation of the procedures. We excluded from the study patients with uterine myomas or other masses, and patients with previous uterine surgery.

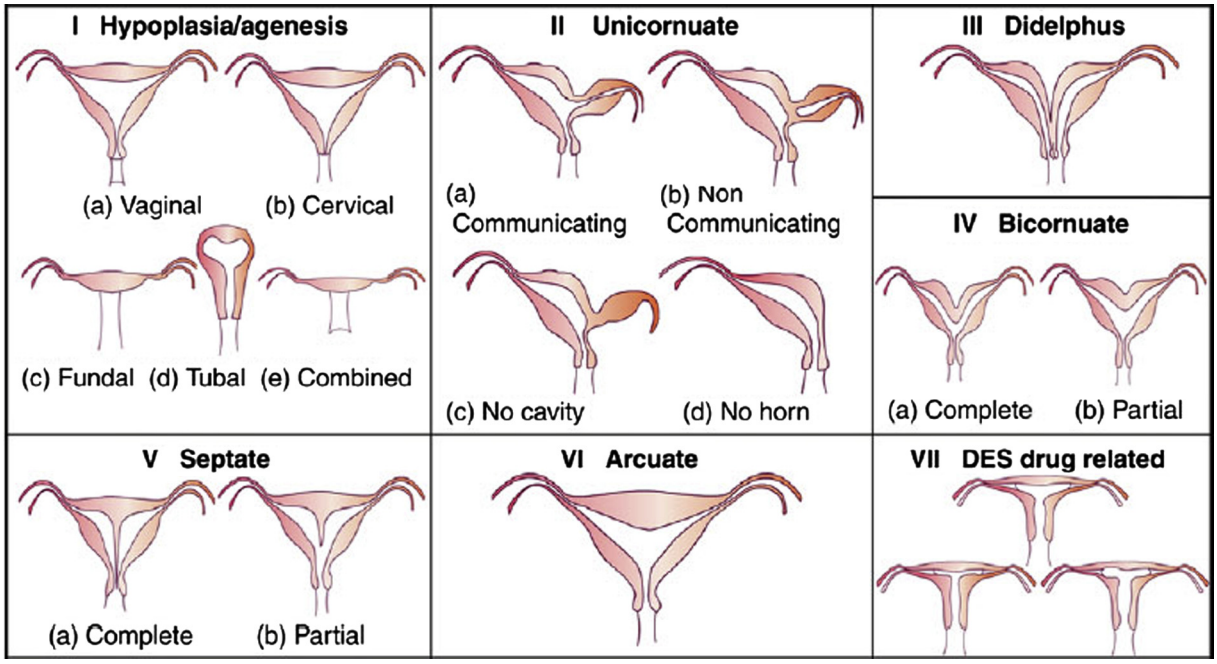

Fig. 1 American fertility society classification of uterine malformations (4).

2.2. 3D ultrasound examination of uterine cavity and cervical canal

Examinations were performed using a Voluson E8 (GE Medical Systems, Zipf, Austria) ultrasound machine, equipped with endocavitary probe RIC5-9H 5–9 MHz 4D. In all cases we obtained one to three static volumes of the uterus, with a quality ranging from medium to maximum. Initially we visualized the uterus on 2D ultrasound in a strict mid-sagittal view, adjusting the capture window to obtain the optimal 3D volume. The volume was then obtained using a sweep angle of 90° from one side of the uterus to the other, bisecting the capture plane. In 17 cases volume was obtained from a transverse plane so that both uterine horns could be visualized, and in 6 cases we obtained two volumes, one to study the fundus and cavity and another to study the cervix and cervical canal. The volumes were manipulated until a satisfactory surface rendered image was obtained of the fundus and uterine cavity as well as the cervical canal. When the volume was obtained in a transverse plane, we included both uterine horns in the rendering box and adjusted the green line so that a good quality image showing both cavity and fundus was obtained in the rendered view. Luminosity and contrast curves were adjusted for both multiplanar and rendered images, as well as for threshold and transparency.

The ultrasound diagnosis of uterine anomalies was based on the criteria of the modified American Fertility Society Classification according to 3-D ultrasonography landmarks (4,16) (Table 1). For the diagnosis of bicornuate uterus, the process is as follows: (1) distance between the interostial line and the uterine fundus was >15 mm; and (2) outer surface: distance between the intercornual line and the apex of the fundal external contour was >-10 mm (Fig. 2). For the diagnosis of septate uterus, the process is as follows: (1) distance between interostial line and the uterine fundus was >15 mm; and (2) outer surface and present cleft between the horns: the distance between the intercornual line and the apex of the fundal external contour was <10 mm (17).

2.3. Magnetic resonance imaging

All patients underwent MRI after 3D ultrasound patients, using a Siemens Avanza 1.5 Tesla machine (Siemens Medical solutions, Mountain View, CA, USA). All studies included coronal high-resolution T2-weighted turbo spinecho imaging with the following parameters: TR/effective TE, 3410/114;

Table 1 Classification of congenital uterine anomalies according to 3D transvaginal ultrasonography.

Uterine structure	Fundal contour	External contour
Normal	Straight or convex	Uniformly convex or with indentation <10 mm
Arcuate	Concave fundal indentation with central point of indentation at obtuse angle	Uniformly convex or with indentation <10 mm
Subseptate/septate	Presence of septum that does (septate) or not (subseptate) extend to the cervix	Uniformly convex or with indentation <10 mm
Bicornuate	Two well-formed uterine cornua, with convex fundal contour in each	Fundal indentation >10 mm dividing the 2 cornua

After Woelfer et al. (16), based on criteria suggested by The American Fertility Society (4).

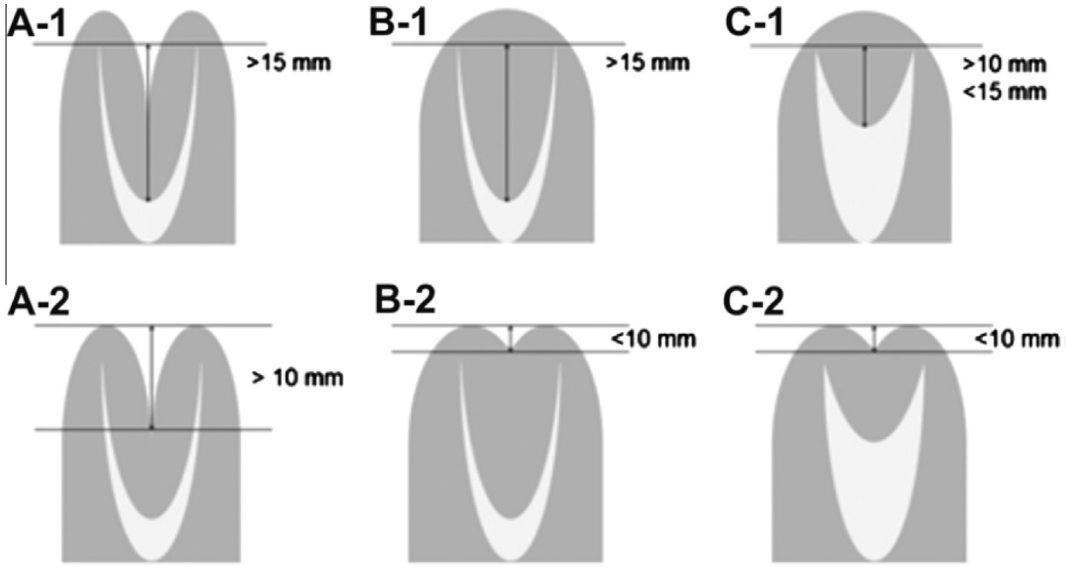

Fig. 2 Diagnosis of bicornuate (A), septate (B), and arcuate (C) uteri by 3D-TVS and 3D-SIS on the coronal planes; (1) distance between the interostial line and the uterine fundus; (2) outer surface: distance between intercornual line and present cleft between the horns/the apex of fundal external contour (adopted from Ludwin et al. (17)).

Table 2 Number of bicornuate and septate uterus diagnosed with hysterosalpingography, 3D UG and MRI, and concordance with operative hysteroscopy/laparoscopy.

Final diagnosis hystroscopy/laparoscopy	HSG	3D-US	MRI
Bicornuate uterus $N = 5$	Bicornuate = 3 Septate = 2	Bicornuate = 5 Septate = 0	Bicornuate = 4 Septate = 1
Septate $N = 31$	Bicornuate = 7 Septate = 24	Bicornuate = 1 Septate = 30	Bicornuate = 2 Septate = 29

HSG, hysterosalpingography; 3D-US, three dimensional ultrasound; MRI, magnetic resonance imaging.

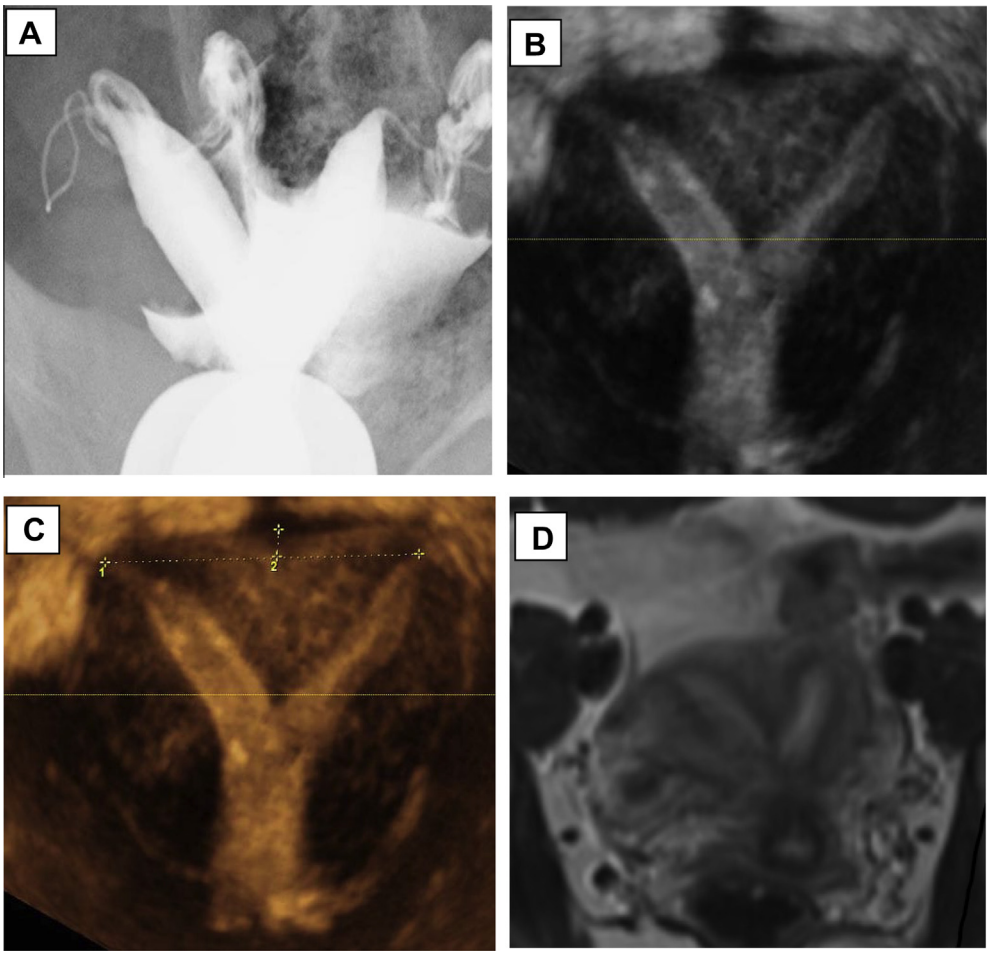

Fig. 3 A case of incomplete septum: (A) Diagnosis of bicornuate uterus was suggested by hysterosalpingography. (B and C): 3D-transvaginal ultrasound: straight external contour. (D) T2WI MRI: no cleft with straight fundus.

refocusing flip angle, 180°; rectangular field of view, 250 × 100 mm; matrix, 320 × 320; slice thickness, 4 mm; 195 Hz/pixel; 19 slices; 1–3 signal averages; average time of acquisition, 2 min 49 s.

When differentiating bicornuate from septate uteri using MRI, all cases with an incision > 1 cm deep in the fundus were considered to be bicornuate uterus.

2.4. Operative hysteroscopy and laparoscopy

Operative hysteroscopic assessment and treatment (transcervical resection of the septum) was performed in case of sonographically diagnosed septate uterus (31 patients), 15 of them had combined hysteroscopy and laparoscopy due to suspected other anomalies (tubal obstruction in 3 cases, pelvic adhesions in 6 cases and ovarian pathology in 6 cases. Bicornuate uteri were confirmed by laparoscopic assessment (5 cases).

3. Results

The 3-D ultrasonography imaging was obtained in all 36 cases.

Results are summarized in Table 2. The final diagnosis was 5 cases with bicornuate uterus and 31 cases with septate uterus.

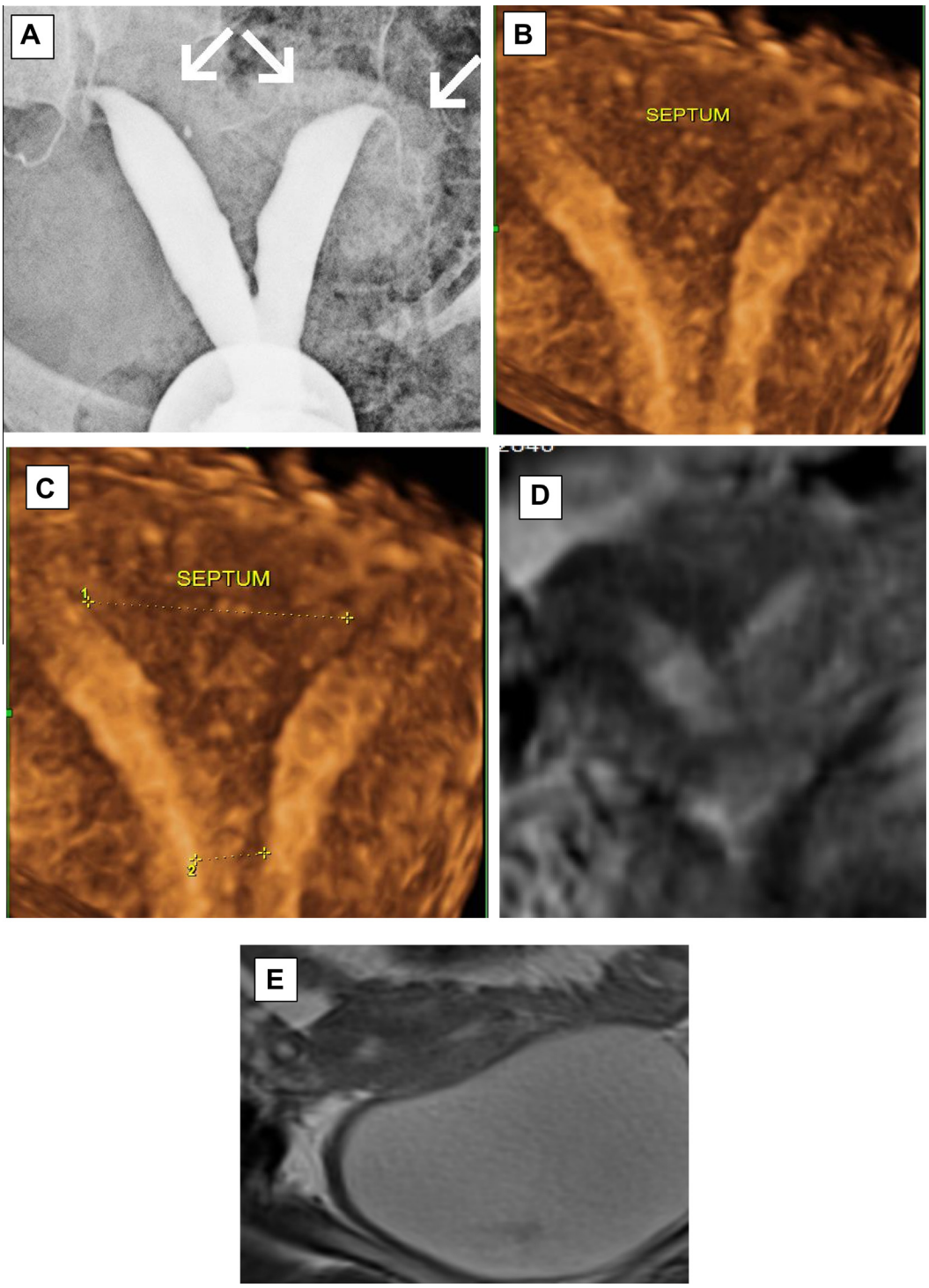

Fig. 4 A case of complete septum: (A) Diagnosis of septate uterus was suggested by hysterosalpingography. (B and C) 3D-transvaginal ultrasound: straight external contour. (D and E) T2WI MRI: muscular septum seen dividing the uterine cavity.

Septate uterus was sonographically diagnosed in 30 patients (6 complete septa and 24 incomplete septa) and bicornuate uterus in 6 patients, with one false diagnosis of bicornuate uterus.

Thirty-one septate uteri and 5 bicornuate uteri were diagnosed by MRI. Two cases of septate uterus were falsely diagnosis as bicornuate uteri, and one case of bicornute uterus was falsely diagnosed as septate uterus . MRI showed sensitivity of 93.5%, specificity of 80%, PPV of 96.6% and negative predicative value of 66.6%, with overall accuracy of 91.6% (Figs. 3D, 4D and E, 5C).

We performed hysterosalpingography for 21 patients. 15 patients had hysterosalpingography outside our hospital with acceptable quality. Seven patients reported as bicornuate

uterus on HSG, and proved to be septate uterus on hysteroscopy/laparoscopy (Table 2). In general, HSG showed sensitivity of 77.4%, specificity of 60% and overall accuracy of 75% in the diagnosis of septate uterus (Table 3) (Figs. 3–5A).

The 3D ultrasound showed the highest diagnostic parameters, with sensitivity of 96.7%, specificity of 100%, PPV of 100% and negative predicative value of 83.3%, with overall accuracy of 97.2% (Figs. 3B and C, 4B and C, Fig. 5B).

4. Discussion

Septate uterus is the most common Mullerian duct anomaly, with an incidence of 50–80% in various reports (18–20). The differentiation between septate and bicornuate uterus is very important. Septate uterus, the anomaly carrying the worst prognosis and associated with high incidence of miscarriage and habitual abortion can easily be treated by hysteroscopy. Hysteroscopic metroplasty of the septate cavity decreases the rate of miscarriage from 85% to 15% and improves the term birth rate from less than 10% to more than 20% (21–23). On the other hand, bicornuate uterus, which has a less adverse impact on pregnancy, there is no strong evidence that surgical intervention is beneficial (6) (see Fig. 6).

In the current study 13.3% of the study patients had bicornuate uterus, all others had septate uterus. The septal endometrium may have significant structural alterations compared

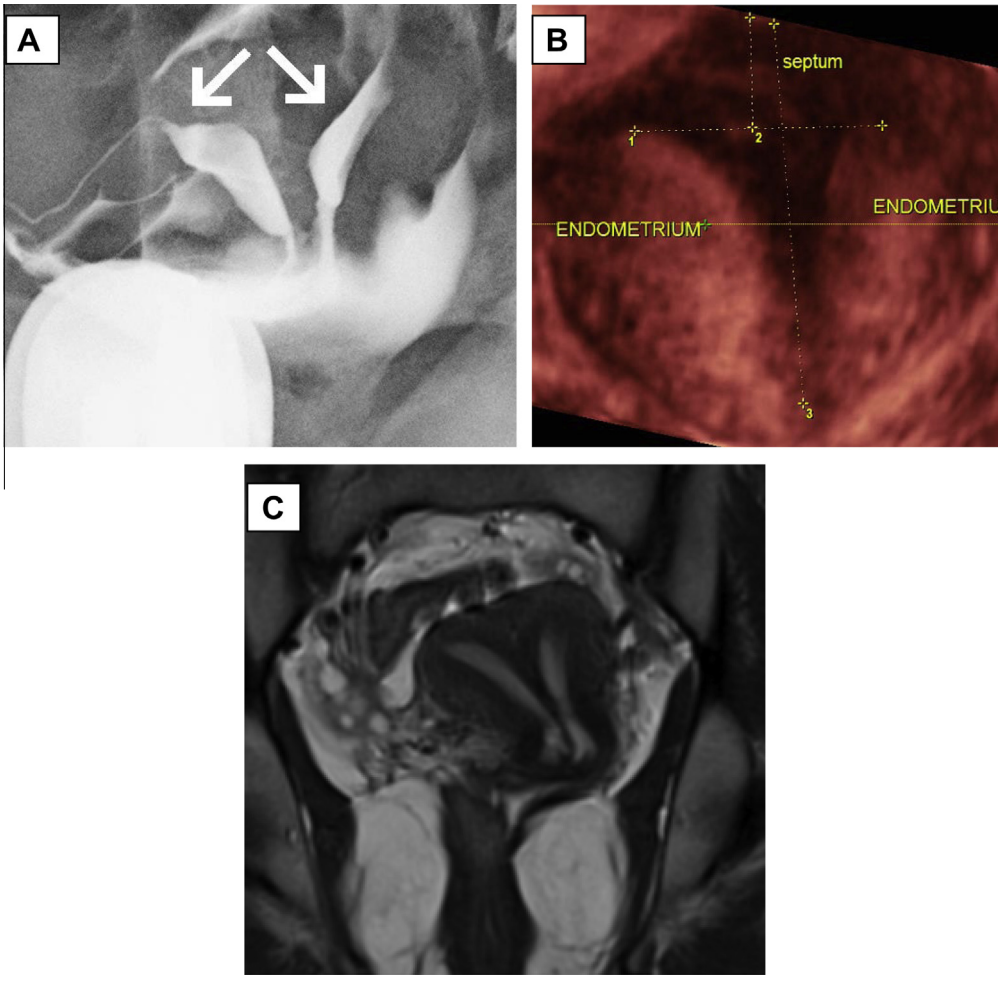

Fig. 5 A case of complete septum, reaching to the cervical canal: (A) Diagnosis of bicornuate uterus was suggested by hysterosalpingography. (B) 3D-transvaginal ultrasound: convex external contour. (C) T2WI MRI: no cleft with straight fundus, the septum seen dividing the uterine cavity and cervical canal.

Table 3 Sensitivity, specificity, PPV, and NPV of various imaging modalities for the differentiation between septate and bicornuate uterus.

	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy
HSG	77.4	60	92.3	30	75
3D-US	96.7	100	100	83.3	97.2
MRI	93.5	80	96.6	66.6	91.6

HSG, hysterosalpingography; 3D-US, three dimensional ultrasound; MRI, magnetic resonance imaging.

with endometrium from the lateral uterine wall, with relatively scanty vascularity, factors may lead to primary infertility (3,24).

In the current study hysterosalpingography showed a relatively low sensitivity of 75%, specificity of 60% and accuracy of 75% in differentiation between the septate and bicornuate uterus. Though traditionally, hysterosalpingography has been used to screen for anatomic anomalies, hysterosalpingography does not evaluate the external contour of the uterus, and can therefore not reliably differentiate between septate and bicornuate uterus (7,8). Ludwin et al. (25) found overall accuracy 80.7% for hysterosalpingography in differentiation between septate and bicornuate uteri. Soares et al. (26) reported a rate of false-positive results of 38%, and sensitivity 44% for hysterosalpingography in the diagnosis of uterine anomalies. In a recent study that included 119 patients, congenital anomalies were correctly identified in 100% of the cases by 3D-sonography but in only 35–100% of the cases by hysterosalpingography. An incomplete septum or an arcuate uterus may not be differentiated from a bicornuate uterus on HSG (27).

Three-dimensional ultrasonography permits the obtaining of planar reformatted sections through the uterus which allow precise evaluation of the fundal indentation (12). Our results confirm that volume transvaginal 3-D ultrasonography is very accurate for the diagnosis and classification of septate and bicornuate uterus. In the current study, 3D-TVUS had sensitivity of 96.7%, specificity of 100%, PPV of 100% and negative predicative value of 83.3%, with overall accuracy of 97.2%. Raga et al. (28) found 3D ultrasound to have a 91.6% accuracy in the study of the fundus and 100% in that of the cavity. Wu et al. (29) found 3D ultrasound to have a 92% accuracy in the diagnosis of septate uterus and 100% of bicornuate uterus. Also comparing it with laparoscopy and hysteroscopy, Mohamed et al. (30) recorded a sensitivity of 97%, specificity of 96%, positive predictive value of 92% and negative predictive value of 99% in the diagnosis of Mullerian anomalies while Ghi et al. recorded both a sensitivity and a specificity of 100% in the diagnosis of uterine malformations and 96% concordance between ultrasound and endoscopy with respect to the type of anomaly diagnosed (14). In a recent report by Ludwin et al. (17) , 3D-TVUS had an accuracy of 97.4% in differentiation between septate, bicornuate and arcuate uteri.

MRI offers a noninvasive approach of assessing the internal and the external contour of the uterus. Pellerito et al. (11) reported 100% accuracy compared with combined hysteroscopy and laparoscopy. Fedele et al. (3) reported 100% sensitivity and 79% specificity, Bermejo et al. (31) reported a high degree of concordance between 3-D ultrasonography and MRI in the diagnosis of uterine malformation. In our study, 33/36 diagnoses were correct with MRI, with 93.5% sensitivity and 80% specificity. Our results are in agreement with Faivre et al. (32) who found MRI inferior to 3D-TVS in differentiation between septate and bicornuate uteri.

Misdiagnosis by MRI can be explained by several factors. First, uterus may be acutely retroverted or anteverted, so direct coronal view of the uterus may not be possible. Second, technically inadequate images may make diagnosis difficult.

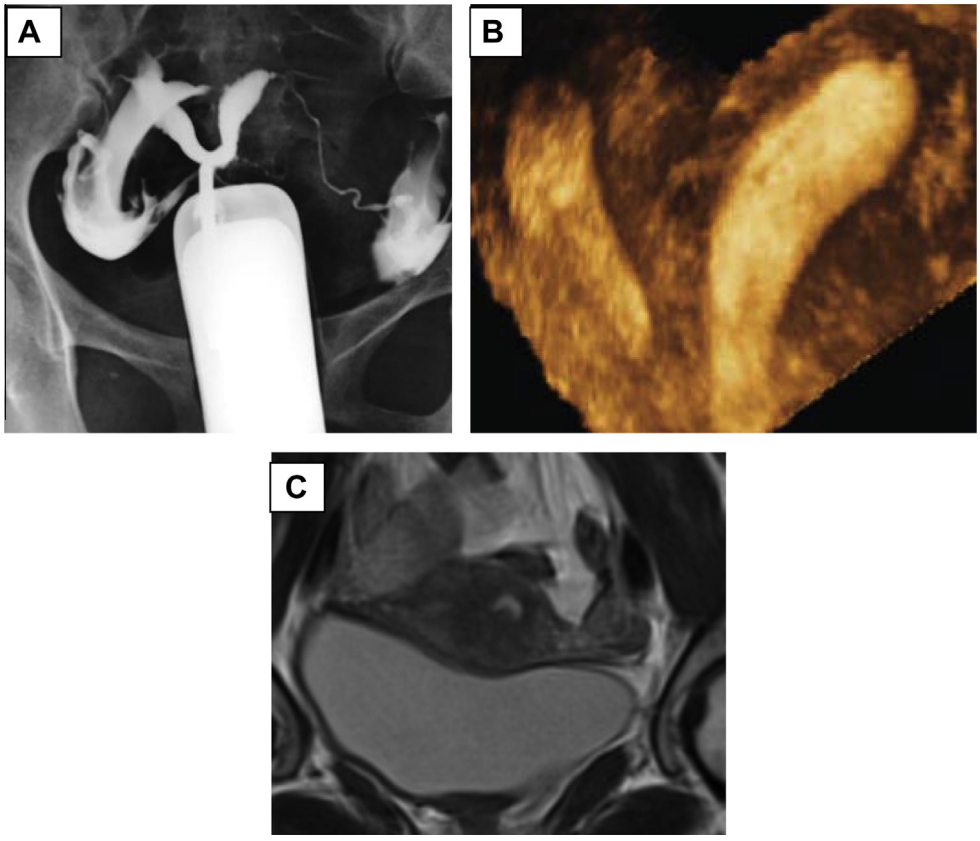

Fig. 6 A case of bicornuate uterus: (A) Diagnosis of bicornuate uterus was suggested by hysterosalpingography. (B) 3D-transvaginal ultrasound: cleft seen in the upper border. (C) T2WI MRI: myometrium seen between the two cornua.

Third, differences in the MRI machines and their software used to obtain and evaluate the images (33,34).

This study has some limitations. First the radiologist who carried out the MRI examination was not blinded to the 3D ultrasound diagnosis. Second, patients with other Mullerian anomalies were not included in the study. Third, virgin female patients were not included in the study, thus we do not know if three dimensional trans-abdominal ultrasound has the same accuracy as trans-vaginal ultrasound.

5. Conclusion

Transvaginal 3-D ultrasonography is accurate for diagnosis and differentiation between septate uterus and bicornuate uterus. We recommend 3-D transvaginal ultrasonography as the first and mandatory step in the assessment of the uterine cavity in patients with a suspected septate or bicornuate uterus, especially before planning surgery. MRI should be preserved for patients in whom 3D TVS not possible like virgins.

Conflict of interest

We have no conflict of interest to declare.

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