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Diagnostic role of magnetic resonance hysterosalpingography in the evaluation of female infertility

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Abstract

Background: In the evaluation of female infertility, hysterosalpingography (HSG) with fluoroscopy provides limited evaluation of congenital uterine malformation and extrauterine disease. Transvaginal ultrasonography (TVS) is though commonly used, has its limitations in assessment of tubes. Addition of sonosalpingography can help assess tubal patency but may be inconclusive in cases of unilateral or bilateral obstruction and is grossly operator dependent. Recent past has seen evolution of magnetic resonance imaging (MRI) to evaluate problems associated with female infertility, with unparalleled advantages of having no radiation and being less operator-dependent. The need to assess tubal patency has been addressed by increasing literature on utilization of gadolinium (Gd) in MRI and comparing it with HSG alone or a mixture of HSG and laparoscopy. We aimed to evaluate the sensitivity and specificity of using magnetic resonance imaging (MRI) and magnetic resonance hysterosalpingography (MRHSG) as a screening test for female infertility and to compare accuracy, positive predictive value and efficacy of MRI and MRHSG with laparoscopy.

Results: Fifty-four out of 63 patients had bilateral tubal patency (85.7%). Nine patients had tubal pathology (14.3%) out of which one had unilateral and eight had bilateral tubal obstruction. Endometrial cavity abnormality was found in four patients and ovarian abnormalities were detected in 28.5% patients. MRHSG has shown high sensitivity and specificity for tubal patency evaluation when compared to the true gold standard for tubal patency assessment, laparoscopic chromotubation. With laparoscopy as standard, there was 100% sensitivity and specificity for structural abnormality, myometrial abnormalities and endometrial cavity assessment in MRHSG.

Conclusions: In comparison with diagnostic laparoscopy, MRHSG was found to have good sensitivity and specificity for assessment of tubal patency, excellent sensitivity and specificity for the assessment of structural malformation and endometrial cavity lesions. Furthermore MRHSG was good in picking up extra-uterine diseases.

Keywords: Imaging, Hysterosalpingography, Infertility, Laparoscopy, Tubal patency, Diagnostic, Tubal obstruction

Background

For women, problems with fertilization arise mainly from either structural problems in the Fallopian tubes or uterus or problem in releasing eggs (ovarian dysfunction) [1] The European Society for Human Reproduction And Embryology Capri Workshop states that the initial diagnostic tests for infertility should include a mid-luteal phase progesterone assay, a semen analysis of male partner and a test for tubal patency such as a hysterosalpingogram [2]. Tubal assessment remains vital during evaluation of infertility in a female. Hysterosalpingography (HSG) with fluoroscopy provides limited evaluation of congenital uterine malformation and extrauterine disease [3]. Transvaginal ultrasonography (TVS) is fast,

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reliable and commonly used, but has its limitations in assessment of tubes. Addition of sonosalpingography can help assess tubal patency but may be inconclusive in cases of unilateral or bilateral obstruction and is grossly operator dependent. In the era of evidence-based medicine, MRI has an indispensable role in the diagnosis and management of female infertility. MRI increases the diagnostic performance of transvaginal sonography in the accurate detection of extensive pelvic inflammation, complex tubo ovarian pathologies, leiomyomas, exact delineation of endometriosis and adenomyosis [4] The need to assess tubal patency has been addressed by increasing literature for utilization of gadolinium (Gd) in MRI and comparing it with HSG alone or a mixture of HSG and laparoscopy [5–11].

We aimed to determine whether MRHSG, using a clinically available MR angiographic sequence (3D time-resolved imaging of contrast kinetics [TRICKS]), could be used to reliably ascertain tubal patency and to compare its accuracy, positive predictive value and efficacy with laparoscopy.

Methods

After obtaining institutional ethical clearance, this study was conducted in the departments of Radio-diagnosis, obstetrics/gynecology and Urology at our institute from January 2018 to December 2021. It was a cohort study. In all cases informed consent of the patient and her attendant was taken. The procedure was performed in the late follicular phase of the menstrual cycle to ensure that the patient was not pregnant and to prevent false-positive intrauterine filling defects and proximal tubal occlusion due to endometrial thickening. Female patients with primary or secondary infertility aged between 18 and 40 years for MR evaluation of infertility were included in our study, while those women having active pelvic infection, recent uterine or tubal surgery, history of contrast hypersensitivity and patients in whom MRI was otherwise contraindicated (e.g., metallic prosthesis, non-MR compatible pacemakers or claustrophobia), were excluded from our study.

All MR studies were performed using 1.5-Tesla MR System (Magnetom Avanto, Siemens Medical Systems, Erlangen, Germany). As a first step, uterine cannulation was performed in the procedure room using an 8F Foley's balloon catheter and speculum, placed into the uterine cavity and blocked at its position by balloon inflation, under all aseptic precautions. Then the patient was shifted to the MR scanner room where the procedure was started by acquisition of the preliminary localizing sequence, following which the imaging protocol was used.

For imaging of the true pelvis standard axial and sagittal T1-w and T2-w sequences were taken as follows.

- T1-weighted axial (TR/TE 500/min; section thickness 8 mm; FoV 20 cm).
- T2-weighted axial (TR/TE 6000/130; FoV 22 cm; section thickness 5 mm).
- T2-weighted sagittal (TR/TE 2700/102; section thickness 4 mm; FoV 22 cm).

Following these sequences, 20 mL of a 1:100 mixture of gadodiamide (Omniscan, GE Healthcare) to normal saline (0.9%) was gently hand-injected during a multiphase acquisition using dynamic time-resolved T1-weighted angiographic sequence (3D TRICKS). An oblique axial plane through the pelvis to include the uterus, ovaries and cul-de-sac was used with the following parameters: TR/TE 4.5/minimum; number of excitations, 0.7; matrix, 256×128; field of view of 26–28 cm, slice thickness of 4.4 mm and a temporal resolution of 2.2 s.

A final axial T1-weighted, fat-suppressed 3D-spoiled gradient echo series was obtained for assessment of free peritoneal spill. A set of dynamic subtracted images were reconstructed with a slice thickness of 2.2–2.7 mm and evaluated similar to an MR angiographic examination. Both the subtracted series and the anatomic images were reviewed on a PACS system (Siemens MR Workstation). After the study was complete, 20–40 ml of normal saline was used to flush the uterus and the catheter was removed. All the patients were discharged with written instructions and contact numbers in case of complications. They were asked to mark the degree of pain/discomfort felt during the study in a visual analog pain scale. The entire MRI examination was completed in 35–45 min, including the time required to place the HSG catheter. Three days after the examination, patients were telephonically contacted to inquiry about potential complications and the acceptability of the examination.

Comparison was made between findings on MRHSG and diagnostic laparoscopy (with chromotubation). MRHSG images were reported by a senior professor of radiology with twenty-five-year experience at our institute. Laparoscopy was done within a five-month period after MRHSG, by a trained gynecologist at our institute. For laparoscopy, after placing the patient under general anesthesia and following insertion of the trocars and laparoscopic camera, the disposable uterine manipulator was placed and 10–20 ml of methylene blue was injected through the device into the uterine cavity to confirm spillage of the dye in the pelvic cavity and, therefore, check for tubal patency. In cases where diagnostic laparoscopy was indeterminate, the diagnosis was made by

characteristic imaging findings or clinical follow-up for a period of about one year.

The recorded data were compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as Mean ± SD, and categorical variables were summarized as frequencies and percentages. Frequency distribution tables bar and pie charts were used for data presentation. Sensitivity, specificity, PPV and NPV values were obtained to assess the accuracy of MR-HSG in evaluation of female infertility taking laparoscopy as gold standard.

Results

Out of sixty-six recruited patients, the catheter got dislodged in three patients, who were excluded from the study. Mean age was 31.8 years (range 20- 39 years) with the majority, 71.5% more than 30 years of age. Forty-six (73%) of patients were found having primary infertility, and 17 (27%) patients were having secondary infertility. The duration of infertility was 2–8 years, and the mean duration of infertility was 5.5 ± 2.14 years. Twenty-seven (42.86%) of patients were found to have infertility for a duration of less than 5 years, and 36 (57.14%) were found to have duration of infertility for a period of more than 5 years. Forty-seven (74.60%) of patients had history of regular cycles, and 16 (25.39%) had history of irregular cycles. Laparoscopic chromotubation was performed after MRHSG in all patients. Average time between MRHSG and diagnostic laparoscopy was 70 days.

Visualization of the ovaries and the uterine myometrium was possible on the basis of axial and coronal T1 and T2 spin echo and fast spin echo images in all patients. Even though there was free spill of contrast on MRHSG, it was difficult to visualize the actual fallopian tubes in their entirety in most patients. The uterine abnormalities that were identified on MRI are given in Table 1. Ovarian abnormalities were detected in 18 patients, in whom 14 had polycystic ovarian morphology, three had endometriotic cyst, and one had atrophic ovaries.

Table 1 Uterine abnormality on MRI findings

Uterine abnormality		Frequency ($n=63$)	Percentage
Myometrial lesions	Fibroid	5	7.9
	Adenomyosis	2	3.2
	Fibroid + Adenomyosis	1	1.6
Structural abnormality	Septate uterus	1	1.6
Normal		54	85.7

Tables 2 and 3 depict the distribution of fallopian tubal patency and dilatation on MRHSG and laparoscopy, respectively. Five patients had hydrosalpinx with absent spillage bilaterally, and one had absent spillage on right on MRHSG. At laparoscopy, 56 (88.8%) patients showed no tubal block, 2(3.2%) showed one-sided tubal occlusion, and 5 (7.9%) showed two-sided tubal occlusion. Figure 1 depicts the sensitivity, specificity, positive predictive value and negative predictive value of MRHSG. The sensitivity of MRHSG was 100% (95% CI 75.3–100%) and specificity 71.4% (95% CI 47.8–88.7%) when disease was defined as any form of tubal occlusion detected at laparoscopy, be it one-sided or two-sided. The positive predictive value was 68.4% and negative predictive value was 100%. The accuracy was 82.4%. Sensitivity and specificity of MRHSG were 62.5% (95% CI 24.5–91.5%) and 72.0% (95% CI 50.6–87.9%), respectively, when the definition of disease was limited to double-sided tubal occlusion detected at laparoscopy, with positive and negative predictive value being 41.7% and 85.7%, respectively. The diagnostic accuracy was 69.7%. Table 4 shows the diagnostic accuracy of MRHSG compared to laparoscopy which reveals 100% sensitivity and specificity for structural abnormalities, myometrial abnormalities and endometrial cavity assessment. Subsequently, one out of

Table 2 Fallopian tube dilatation and patency on MR HSG

MR HSG findings			Frequency	Percentage
Right Fallopian Tube	Hydrosalpinx	Present	5	7.9
		Absent	58	92.1
	Patency	Patent	54	85.7
		Not Patent	9	14.3
Left Fallopian Tube	Hydrosalpinx	Present	5	12.7
		Absent	58	87.3
	Patency	Patent	55	87.3
		Not Patent	8	12.7

Table 3 Fallopian tube dilatation and patency on Laparoscopy

Laparoscopic findings			Frequency	Percentage
Right Fallopian Tube	Hydrosalpinx	Present	5	7.9
		Absent	58	92.1
	Patency	Patent	56	88.9
		Not Patent	7	11.1
Left Fallopian Tube	Hydrosalpinx	Present	5	12.7
		Absent	58	87.3
	Patency	Patent	56	88.9
		Not Patent	7	11.1

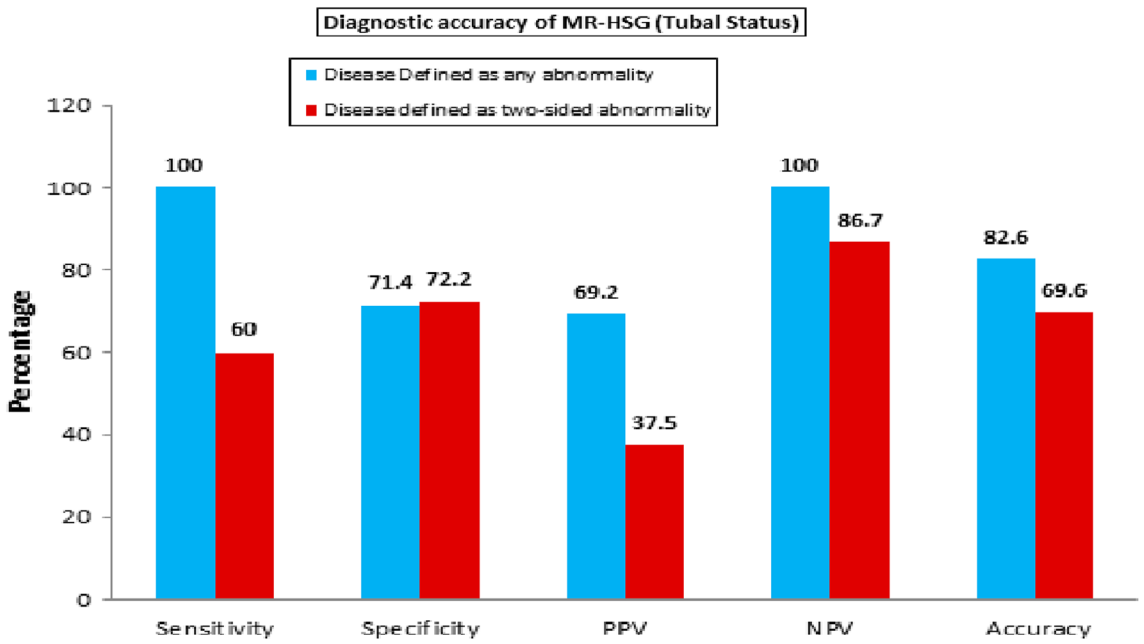


Fig. 1 Bar graph depicting the sensitivity, specificity, positive predictive value and negative predictive value of MR HSG for assessment of tubal status

Table 4 Diagnostic accuracy of MR HSG as compared to laparoscopy for non-tubal findings

Parameter	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
Uterine structural abnormality	100 (12.5–100)	100 (84.6–100)	100 (12.5–100)	100 (84.6–100)
Myometrial abnormality	100 (12.5–100)	100 (84.6–100)	100 (12.5–100)	100 (84.6–100)
Endometrial cavity	100 (29.8–100)	100 (87.6–100)	100 (29.8–100)	100 (87.6–100)
Right ovary morphology	54 (10.2–98.7)	79.5 (58.5–93.9)	21.7 (10.3–72.1)	96.1 (75.2–99.8)
Left ovary morphology	69.2 (18.3–99.6)	81 (54.3–4.8)	32.4 (15.4–75.9)	95.2 (75.6–99.8)

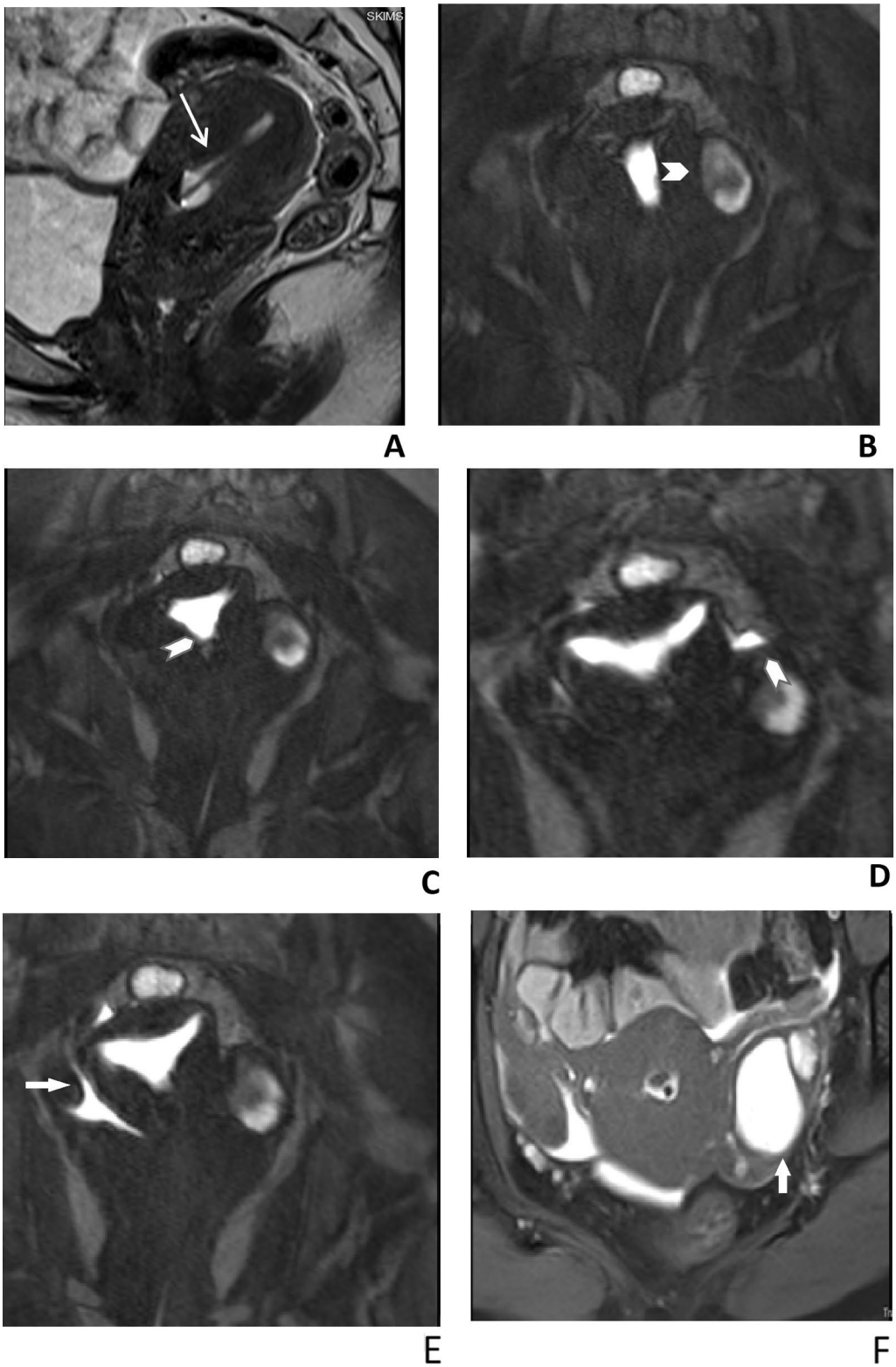
fifty-four patients achieved pregnancy during one-year follow-up.

Discussion

Magnetic resonance imaging (MRI) is steadily gaining importance in the investigation of female reproductive tract [10]. With excellent soft tissue contrast and no ionizing radiation, the introduction of gadolinium-based contrast agents into the uterine cavity, allows evaluation of the fallopian tubes [6, 7]. Fallopian tube pathologies are a common factor to female infertility. Either conventional HSG or laparoscopy combined with chromotubation is considered as the gold standard in the assessment of the patency of the fallopian tubes [12]. A disadvantage of conventional HSG is that this technique leads to a radiation dose to the reproductive organs of young potentially fertile women that may cumulate up to 440 ± 140 cGy/m^2 [7]. Compounded with a limited evaluation of other causes of infertility, such as congenital uterine malformation, myometrial abnormalities (adenomyosis, leiomyomas) and

(See figure on next page.)

Fig. 2 Twenty-eight-year-old female with primary infertility. Sagittal T2-weighted image showing retroverted uterus with correct position of the inflated balloon (arrow) above the internal cervical os. **A** Early MR angiography image from series of dynamic MR angiographic sequence (time-resolved imaging of contrast kinetics{TRICKS}) shows small amount of dilute gadodiamide beginning to accumulate in endometrial canal (arrowhead) (**B**). Subsequent MR angiography images reveal more accumulation of contrast material in endometrial canal (**C**), filling of fallopian tubes (**D**, **E**) (arrow). T1-weighted fat sat image reveals bilateral free spill (arrow) with left endometrial cyst (arrow) (**F**)



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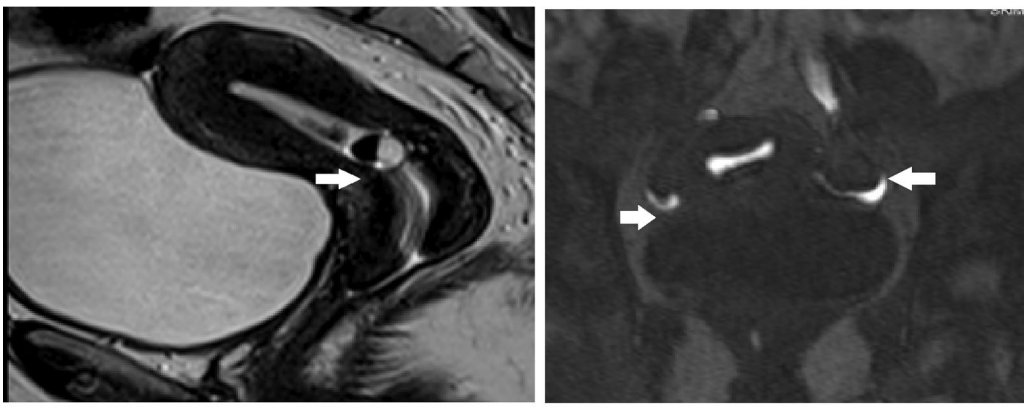

Fig. 3 Thirty-two-year-old female with secondary infertility. Sagittal T2W image showing anteverted uterus with balloon in correct position (arrow) (**A**). MR angiographic image showing contrast in endometrial cavity and bilateral tubes (arrows) (**B**)

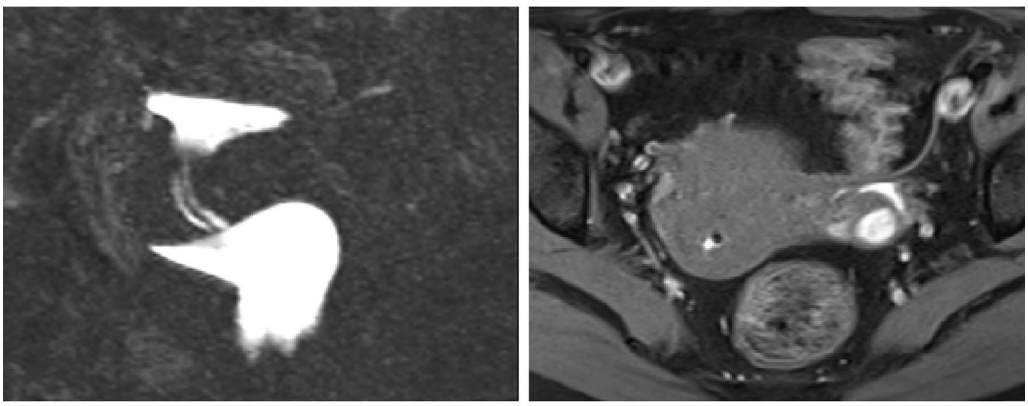

Fig. 4 Thirty-year-old female with primary infertility.MR angiographic image showing dilute gadodiamide in endometrial canal and thin rim of contrast in left fallopian tube. Reflux of contrast material in vaginal lumen due to tubal occlusion (**A**). Minimal amount of left tubal spill seen. No spill on right side (**B**)

extrauterine diseases (endometriosis, adhesions, pelvic infection, adnexal disease), convHSG leaves so much to be assessed [11]. This is where MR comes in. It can efficiently define uterine disease and anomalies with evaluation of endometrium as well as myometrium, with the advantage of identifying extrauterine causes of infertility. Moreover, tubal patency assessment is possible using a clinically available MR angiographic sequence (3D TRICKS). Several attempts have been made by different investigators to assess tubal patency in women using T1-weighted and T2-weighted sequences with a maximum temporal resolution of 20 s per phase, which resulted in adequately depicting tubal patency in most but not all patients [13]. In the current study, we used the 3D TRICKS MR angiographic sequence with dilute 1:100 gadodiamide and normal saline and successfully visualized contrast spill from fallopian tubes with laparoscopic chromotubation as the reference method (Figs. 2, 3, 4, 5, 6, 7).

Three-fourths of the patients in our study had primary infertility. The results were consistent with the study done by Sakar et al. [14] on conventional HSG, wherein the women with primary infertility outnumbered those with secondary infertility. Another study done by Winter et al. [12] also had primary infertility as the main indication for MRHSG.

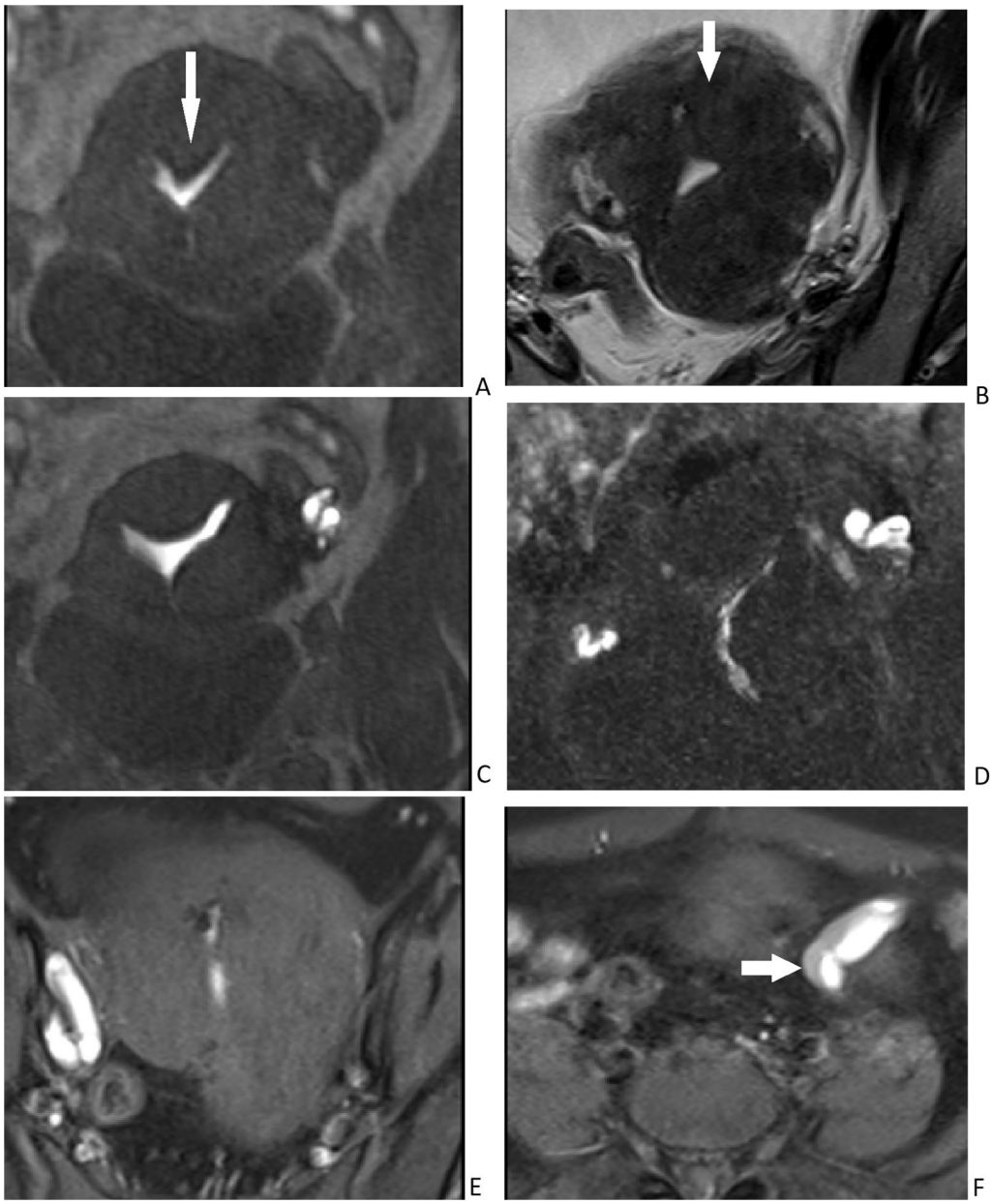

Fig. 5 Thirty-five-year-old female evaluated for primary infertility, A-F subtracted dynamic 3D T1 weighted angiographic (TRICKS) MR HSG image of first injection of dilute gadodiamide showing deformity of endometrial cavity in fundal region (**A**) (arrow), T2W axial image showing multiple fibroids, with one causing (arrow) the deformity in endometrial canal as seen on MR HSG (**B**). Subtracted dynamic 3D T1 weighted angiographic image showing left (**C**) and bilateral hydrosalpinx (**D**). Postcontrast fat sat T1 weighted axial image showing contrast in right (**E**) and left (**F**) fallopian tubes showing fluid level consistent with hematosalpinx (arrow).No spill seen on bilateral sides

The main focus of our study was evaluation of tubes with MRHSG. Fifty-four (85.7%) patients had bilateral Fallopian tubes patent. A total of 9 patients had tubal pathology (14.3%) out of which one had unilateral and eight had bilateral tubal obstruction. Sadowski et al. [11] found bilateral tubal patency in 75% patients and tubal pathology in 25% on MRHSG. The study done by Winter et al. [12] found bilateral tubal patency in 82% patients and tubal pathology in 18% on MRHSG. In our cohort, at MRHSG, 54 (85.71%) patients showed no tubal block, 1 (1.6%) showed one-sided tubal occlusion, and 8 (12.7%) showed two-sided tubal occlusion. In comparison, at laparoscopy 56 (88.8%)

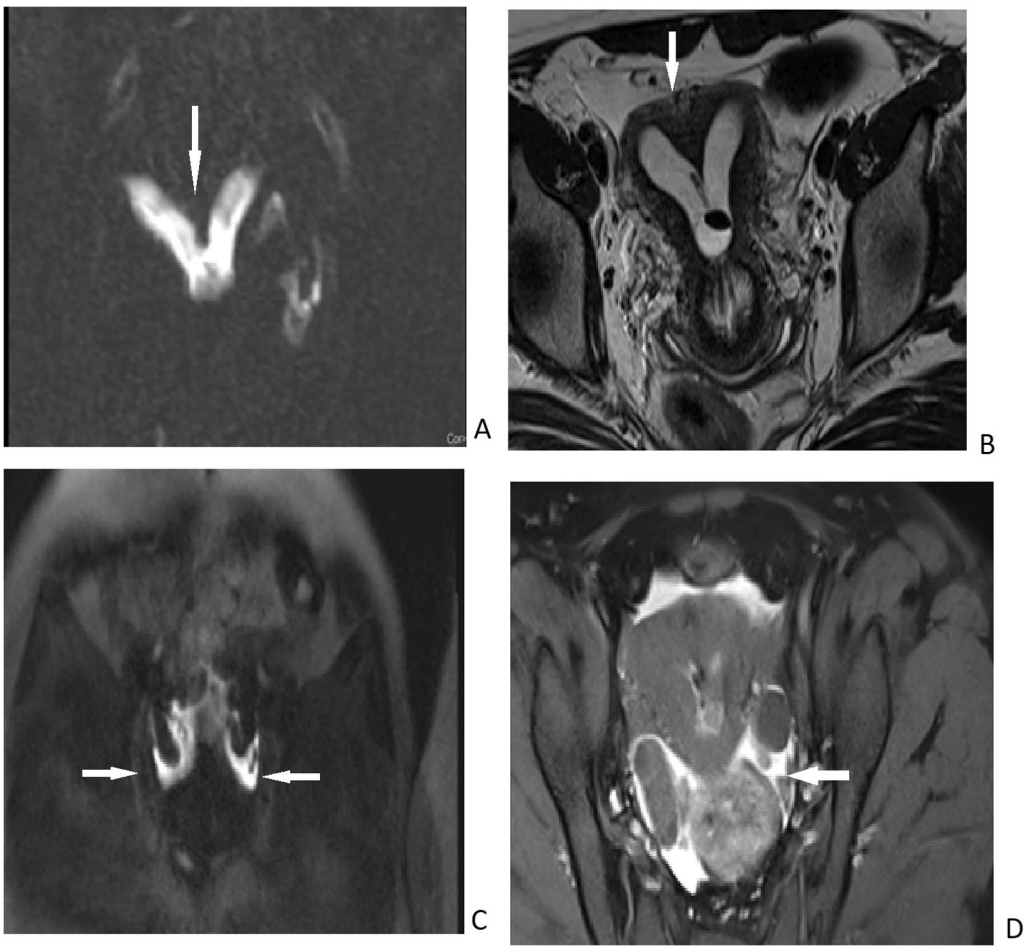

Fig. 6 In 31-year-old woman, subtracted dynamic 3D T1-weighted angiographic (TRICKS) MR HSG image shows indention of fundus (arrow) (**A**). Coronal T2-weighted image through uterus shows indentation of serosal contour of fundus, myometrium and endometrium into uterine canal, indicating septate uterus (arrow) (**B**). Image from subtracted dynamic 3D T1-weighted angiographic series (time-resolved imaging of contrast kinetics [TRICKS]) in 45-year-old woman shows bilateral spill of contrast material (arrows) (**C**). Postcontrast fat sat T1W axial image showing fluid in peritoneal cavity (arrow) (**D**)

patients showed no tubal block, 2 (3.2%) showed one-sided tubal occlusion, and five (%) showed two-sided tubal occlusion. The sensitivity of MRHSG was 100% and specificity 71.4% when disease was defined as any form of tubal occlusion detected at laparoscopy, be it one-sided or two-sided, with positive and negative predictive values being 68.4 and 100%, respectively. Our study was consistent with the study done by A Kohan et al. [15] in terms of sensitivity which also showed 100% sensitivity of MRHSG for tubal patency evaluation. Sensitivity and specificity of MRHSG in our study were 62.5% and 72.0%, respectively, when the definition of disease was limited to double-sided tubal occlusion detected at laparoscopy, with positive and negative predictive value being 41.7% and 85.7%, respectively. Volondat et al. [16] found the diagnostic accuracy of MRHSG for 'global' analysis of tubal abnormalities (without distinguishing laterality or characteristic of abnormality) was 88.5% and that with laterality matching was 76.9%.

Our study on the diagnostic performance of MRHSG has shown high sensitivity and good specificity for tubal patency evaluation when compared to the true gold standard for tubal patency assessment, laparoscopic chromotubation. More patent tubes ($n=2$) were diagnosed with laparoscopy than MRHSG which may be attributed to either higher tissue contrast or to a secondary outcome of the initial procedure, as also reported and hypothesized by Sadowski et al. [11].

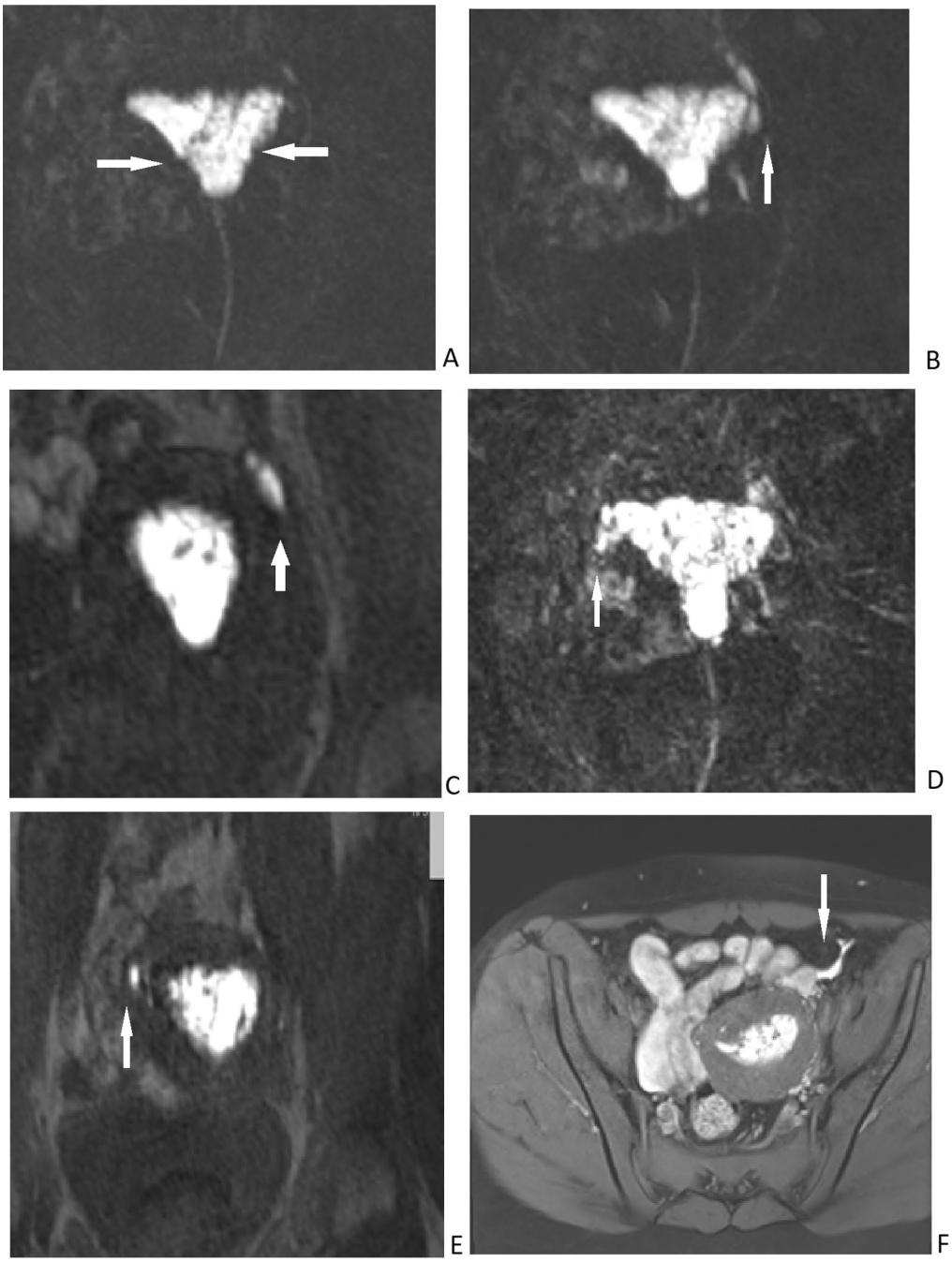

Fig. 7 Thirty-year-old female evaluated for primary infertility. Subtracted dynamic 3D T1 W angiographic series showing irregular endometrial contour (arrows) (**A**). Subsequent images reveal contrast in left (arrow) (**B**, **C**) and right (arrow) (**D**, **E**) fallopian tubes. On postcontrast fat sat T1 weighted axial image, bilateral tubal spill (white arrowheads) noted with thickened endometrium (arrow) (**F**). Case of adenomyosis

Diagnostic accuracy of MRHSG compared to laparoscopy revealed 100% sensitivity and specificity for structural abnormality and endometrial cavity. The study done by A Kohan et al. [15] also showed 100% agreement between MRHSG and laparoscopy over uterine morphology and type of morphology.

The complications encountered were mild pelvic pain (3), dizziness (2) and bleeding per vagina (2). The bleeding was referred as spotting during the first 24 h that would spontaneously disappear after that lapse of time. Volondot et al. [16] in their study had 4 patients complaining of pain, two developed vagal symptoms, and one

case of salpingitis after the procedure. We did not experience any case with vagal symptoms or infective complications in our study.

Besides having high sensitivity and specificity for uterine morphology and abnormalities, MRHSG also helped to detect and characterize myometrial and adnexal abnormalities. In our patient group, five had leiomyomas, two had adenomyosis, one had both leiomyoma and adenomyosis and one had septate uterus. A study done by Sadowski et al. [11] found the uterine contour abnormalities on MRI to be due to myometrial abnormality (leiomyoma) and congenital uterine malformation (arcuate and partial sepate). Another study done by Winter et al. [12] found comparable results and detected uterine abnormalities to be either due to myometrial lesions (leiomyomas) in three patients or congenital uterine malformation (arcuate uterus and partial septate uterus) in two patients. Ovarian abnormalities were detected in 18 patients, in whom 14 had polycystic ovarian morphology, three had endometriotic cyst and one had atrophic ovaries. Sadowski et al. [11] in a study found adnexal abnormalities including a hydrosalpinx, endometrioma and an atrophic ovary. Winter et al. [12] found adnexal abnormalities in 6 patients which include polycystic ovaries in 5 patients and hydrosalpinx in one patient.

Furthermore, most of the findings reported in MR-HSG correlated with those reported on diagnostic laparoscopy. Poor correlation between MR-HSG and surgery was only found in the case of peritoneal adherences, as flimsy adherences could not be detected by MR sequences, resulting in an underestimation of pelvic endometriosis.

The downsides in our study were small sample size and utilization 1.5 T MRI for evaluation in all the women selected. 3 T MRI is being installed nowadays although less frequently in government sector in resource-poor countries like India, thereby limiting the generalizability of the study results. Although expensive than combination of USG and conventional HSG, MRHSG may prove to be one-stop shop for the evaluation of female infertility especially in patients where both conventional HSG and standard MRI are necessary for the evaluation. Advances in MR sequences may eventually allow us to study the motility and mucosal surfaces of tubes in lieu of celioscopy.

Conclusions

In comparison with diagnostic laparoscopy, MRHSG was found to have excellent sensitivity and specificity for assessment of tubal patency, structural malformation and endometrial cavity lesions. Furthermore MRHSG was good in picking up extra-uterine diseases. MRHSG is a safe and feasible investigation in patients where both conventional HSG and standard MRI are necessary for the evaluation of female infertility.

Abbreviations

HSG: Hysterosalpingography; MR: Magnetic resonance; MRHSG: Magnetic resonance hysterosalpingography; MRI: Magnetic resonance imaging; TRICKS: Time-resolved imaging of contrast kinetics; TVS: Transvaginal sonography; USG: Ultrasonography.

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Author contributions

SS participated in paper writing, research performance, data collection and analysis, interpreting imaging studies. NAC interpreted imaging studies and supervised paper writing. MN participated in paper writing and data analysis, MAM participated in research design, patient work up, data collection and analysis, SN, RK and SA performed diagnostic laparoscopy after imaging examination in study population. Allauthors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publically available because it could compromise individual privacy as it contains information regarding some socially sensitive variables but can be made available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Institutional ethical committee clearance was obtained before starting the study. Informed written consent was obtained from all participants before recruitment. A copy of ethical committee approval is available with the corresponding author.

Consent for publication

All the participants have consented for publication of their data. All co-authors have consented and authorized the corresponding author to publish this work.

Competing interests

The authors declare that they have no competing interests.

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References

1. Mustafa M, Sharifa AM, Hadi J, Izam EM, Aliya S (2019) Male and female infertility: causes, and management. IOSR J Dent Med Sci (IOSR-JDMS) 18(9):27–32
2. Crosignani PG, Rubin BL (2000) Optimal use of infertility diagnostic tests and treatments: The ESHRE Capri Workshop Group. Hum Reprod 15(3):723–732

3. Kiridi E, Ibrahim I, Lawani L (2015) Hysterosalpingography: still relevant in the evaluation of infertility in the Niger Delta. Int J Med Biomed Res 4(1):50–54
4. Grover SB, Antil N, Katyan A, Rajani H, Grover H, Mittal P, Prasad S (2020) Niche role of MRI in the evaluation of female infertility. Indian J Radiol Imaging 30(1):32–45
5. Rastogi R (2010) Role of imaging in female infertility. Indian J Radiol Imaging 20(3):168–173
6. Unterweger M, De Geyter C, Frölaparoscopyich JM, Bongartz G, Wiesner W (2002) Three-dimensional dynamic MR-hysterosalpingography; a new, low invasive, radiation-free and less painful radiological approach to female infertility. Hum Reprod 17:3138–3141
7. Wiesner W, Ruehm SG, Bongartz G, Kaim A, Reese E, De Geyter C (2001) Three-dimensional dynamic MR hysterosalpingography: a preliminary report. Eur Radiol 11:1439–1444
8. Cipolla V, Guerrieri D, Pietrangeli D, Santucci D, Argirò R, de Felice C (2016) Role of 3.0 Tesla magnetic resonance hysterosalpingography in the diagnostic work-up of female infertility. Acta Radiol 57:1132–1139
9. PelegríMartínez L, Kohan AA, VercherConejero JL (2017) Optimization of the protocols for the use of contrast agents in PET/CT studies. Radiologia 59:64–74
10. Freeman-Walsh CB, Fahrig R, Ganguly A, Rieke V, Daniel BL (2008) A hybrid radiography/MRI system for combining hysterosalpingography and MRI in infertility patients: initial experience. AJR Am J Roentgenol 190(2):157–160
11. Sadowski EA, Ochsner JE, Riherd JM, Korosec FR, Agrawal G, Pritts EA, Kliewer MA (2008) MR hysterosalpingography with an angiographic time-resolved 3D pulse sequence: assessment of tubal patency. AJR Am J Roentgenol 191:1381–1385
12. Winter L, Glücker T, Steimann S, Frölaparoscopyich JM, Steinbrich W, De Geyter C, Pegios W (2010) Feasibility of dynamic MR-hysterosalpingography for the diagnostic work-up of infertile women. Acta Radiol 51:693–701
13. Holst N, Abyholm T, Borgersen A (1983) Hysterosalpingography in the evaluation of infertility. Acta Radiol Diagn (Stockh) 24(3):253–257
14. Sakar MN, Gul T, Atay AE, Celik Y (2008) Comparison of hysterosalpingography and laparoscopy in the evaluation of infertile women. Saudi Med J 29(9):1315–1318
15 Kohan AA, Kucharczyk MC, Posadas NT, Napoli MN, Gile S, Fuentes NA, GarciaMonaco RD, Chacon RC (2017) Diagnostic performance of magnetic resonance hysterosalpyngography: initial results. Rev Argent Radiol 81(1):3–11
16. Volondat M, Fontas E, Delotte J, Fatfouta I, Chevallier P, Chassang M (2019) Magnetic resonance hysterosalpingography in diagnostic work-up of female infertility: comparison with conventional hysterosalpingography: a randomised study. Eur Radiol 29:501–508

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