ORIGINAL ARTICLE

Comparison between Ultrasonography and Magnetic Resonance Imaging in Endometriosis: A Prospective Study in a Tertiary Hospital

Sulabh Puri[1], Ashima Gupta[2], Gurpreet S Sandhu[3], Jaswinder K Mohi[4]

Abstract

Introduction: Endometriosis is an important cause for abdominal and pelvic pain in young women. It occurs due to the presence of functional endometrial tissue outside the uterine cavity. Ultrasonography and magnetic resonance imaging (MRI) are noninvasive and accurate diagnostic modalities for evaluation of ovarian and deep endometriosis.

Aim: To compare and assess the diagnostic accuracy of ultrasonography and MRI for evaluation of endometriosis.

Materials and methods: A prospective study was done on 40 patients sent to the radiology department in our tertiary-care hospital over a period of 2 years with clinical suspicion of endometriosis. These patients were evaluated on ultrasonography, followed by MRI scan for the location and extent of disease. The sensitivity and specificity of diagnostic modalities were calculated.

Results: The sensitivity and specificity of ultrasound for diagnosing ovarian endometriosis (endometriomas) were 90.62 and 75.00%, respectively, and that of MRI were 93.94 and 85.71%, respectively. The sensitivity and specificity of ultrasound for diagnosing deep endometriosis (involving uterosacral ligament) were 25 and 97.30%, respectively, and that of MRI were 75.0 and 100%, respectively. The sensitivity and specificity of ultrasound for diagnosing scar endometriosis were 66.67 and 97.30%, respectively, and that of MRI were each 100%, respectively. The sensitivity and specificity of ultrasound for diagnosing tubal endometriosis were 50.00 and 97.37%, respectively, and that of MRI were each 100%, respectively. The findings of ultrasonography and MRI for evaluation of endometriosis were also correlated with histopathology.

Conclusion: Both ultrasonography and MRI are comparable modalities for evaluation of ovarian, scar site, and tubal endometriosis; however, MRI is the most useful and better imaging modality for evaluation of indeterminate cases and deep endometriosis.

Keywords: Deep endometriosis, Endometriosis, Magnetic resonance imaging, Ovarian endometriosis, Tubal endometriosis, Ultrasonography, Uterosacral ligament.

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Introduction

The presence of endometrial tissue in the ectopic region outside the endometrial cavity is known as endometriosis.[1] Endometriosis is common in premenopausal women age-group.[2,3] The common risk factors for developing endometriosis include early age at the onset of menstruation, prolonged menstrual cycle, infertility, and a positive family history of endometriosis.[4] The hypothesis of retrograde menstruation which states that the spillage of endometrial tissue through the fallopian tubes and its insertion into the peritoneal or pelvic organs is a widely accepted point of view regarding the causation of endometriosis.[5] Endometriosis is of three types—superficial peritoneal, ovarian, and deep infiltrating endometriosis.[6] Superficial endometriosis involves the superficial peritoneal implant on the surface of the pelvic organs or peritoneum. The most commonly affected sites are the cul-de-sacs and the adnexa. Due to their small size, they are not fully detected by ultrasound or MRI and can only be detected by laparoscopy. Implants within the ovaries undergo repetitive bleeding resulting in formation of chocolate cysts, another name given to ovarian endometriomas. Since ultrasound is cheap, safe, and easy to use, it has become the first-line investigation for evaluation of ovarian endometriosis, whereas MRI is reserved for evaluation of indeterminate cases and cases with higher stages of ovarian endometriosis.[7] Deep penetration of endometrial glands along with stroma beyond 5 mm in the peritoneal surfaces of various regions is defined as deep endometriosis.[7,8] One of the commonest sites of involvement is uterosacral ligaments followed by pouch of Douglas and broad ligaments for deep endometriosis. Fallopian tubes, urinary bladder, ureters, gut, and the previous scar site are less common sites that are affected.[6] The gold standard for diagnosing deep endometriosis is the laparoscopy, but MRI is an essential tool to diagnose and evaluate extent of involvement.[9]

[1–4]Department of Radiodiagnosis, Government Medical College, Patiala, Punjab, India

Corresponding Author: Gurpreet S Sandhu, Department of Radiodiagnosis, Government Medical College, Patiala, Punjab, India, e-mail: gurpreetsandhu1529@gmail.com

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Materials and Methods

This was a prospective study done on 40 clinically suspected patients of endometriosis which were referred to the radiodiagnosis department between November 2018 and November 2020 from the Department of obstetrics and gynecology of our institute. Informed consent was taken from the selected patients before imaging was done. Transabdominal ultrasound examination was first done using

3.5 MHz curvilinear probe with full bladder and patient lying in supine position after good contact gel. Subsequently, transvaginal sonography (TVS) using 8 MHz probe was done in these patients after complete evacuation of bladder to confirm our findings and search for additional lesions. Patients with contraindication for MRI, for example, with noncompatible metallic implants were excluded from the study. This was followed by MRI scan which was done on 1.5 T Siemens (1.5 MAGNETOM AERA MACHINE). Imaging sequences included T1-weighted image (T1WI), T2-weighted image (T2WI), and fat-saturated T1-weighted image (T1FATSATWI). These patients were evaluated on ultrasonography, followed by MRI scan for the location and extent of disease. Follow-up of the patients was also done, and results of ultrasound and MRI were compared with histopathology after laparoscopic surgery was done in these patients. The sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated for ultrasonography and MRI in comparison to histopathology. Cohen's Kappa value (*k*) was used to determine the level of agreement between the index tests (ultrasonography and MRI) and reference standard (histopathology) regarding the presence or absence of endometriotic lesions. Agreement was interpreted as: $k < 0.20$, poor agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, good agreement; 0.81–1.00, and very good agreement.

Results

In our study, age distribution ranged from 21 to 40 years. Maximum number of individuals were in the age-group of 31–35 years (52.5%). The mean age of the patients in our study was 31.45 ± 4.44 years.

Results on Ultrasound

In our study, out of 40 cases, endometriosis was detected in 36 cases on ultrasonography. Ovaries were the most common site, involved in 31 cases followed by scar site in 3 cases. Uterosacral ligament was involved in two cases, and fallopian tube was involved in one case. There was simultaneous involvement of ovaries and fallopian tube in one case.

Results on MRI

In our study, out of 40 cases, endometriosis was detected in 38 cases on MRI. Ovaries were the most common site, involved in 31 cases, followed by uterosacral ligaments and scar site in three cases each. Fallopian tube was involved in two cases. There was simultaneous involvement of ovaries and fallopian tube in one case and simultaneous involvement of ovaries and uterosacral ligament in one case.

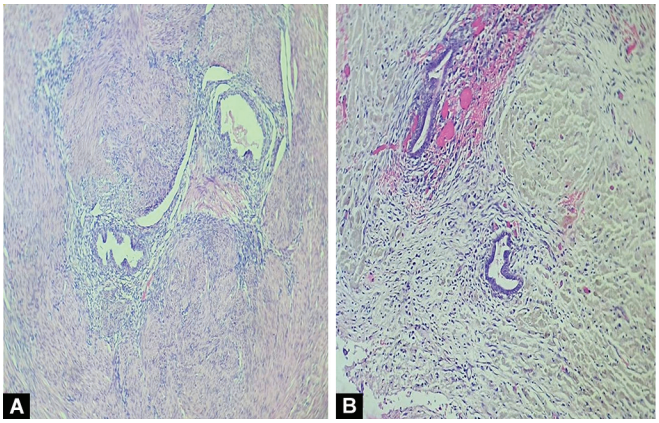
Results on Histopathology

In our study, endometriosis was detected in 39 cases on histopathological follow-up. Ovaries were the most common site, involved in 32 cases on histopathological follow-up (Fig. 1). The uterosacral ligaments were involved in four cases. Extraperitoneal (scar) endometriosis was present in three cases. Fallopian tube was involved in two cases. There was simultaneous involvement of ovaries and fallopian tube in one case and simultaneous involvement of ovaries and uterosacral ligament in one case (Table 1).

Comparison of Ultrasound and MRI with Histopathology

The sensitivity and specificity of ultrasound for diagnosing ovarian endometriosis were 90.62 and 75.00%, respectively, with good agreement with histopathology. The sensitivity and specificity of ultrasound for diagnosing deep endometriosis (uterosacral ligament) were 25 and 97.30%, respectively, with fair agreement. The sensitivity and specificity of ultrasound for diagnosing scar endometriosis were 66.67 and 97.30%, respectively, with good agreement with histopathology. The sensitivity and specificity of ultrasound for diagnosing scar endometriosis were 50.00 and 97.37%, respectively, with moderate agreement with histopathology (Table 2).

The sensitivity and specificity of MRI for diagnosing ovarian endometriosis were 93.94 and 85.71%, respectively, with good agreement with histopathology. The sensitivity and specificity of MRI for diagnosing deep endometriosis (uterosacral ligament) were 75.0 and 100%, respectively, with very good agreement with histopathology. The sensitivity and specificity of MRI for diagnosing scar endometriosis and fallopian tube endometriosis were 100% each, respectively, with a perfect agreement with histopathology (Table 3).



Figs 1A and B: (A) Photomicrography from ovarian cyst wall showing endometrial glands and stroma with areas of hemorrhage and hemosiderins-laden macrophages. (Hematoxylin and eosin stain, 100×); (B) Photomicrograph showing presence of endometrial glands and stroma embedded deep within the myometrium (Hematoxylin and eosin stain, 100×)

Table 1: Site-wise distribution of endometriosis detected on histopathology ($N = 40$)

Site	*Cases*	*Percentage*
Ovaries	32	80.0%
Uterosacral ligaments	4	10%
Extraperitoneal (scar)	3	7.5%
Fallopian tube	2	5.0%

Discussion

In our study, age distribution ranged from 21 to 40 years. The majority of individuals were in the age-group of 31–35 years (52.5%). The patients' mean age in our study was 31.45 ± 4.44 years. The results of the present study can be compared with the study conducted by Kruger et al. which reported that the average age was 33.5 ± 6.1 years.[10]

Distribution of Endometriosis on Ultrasound and MRI

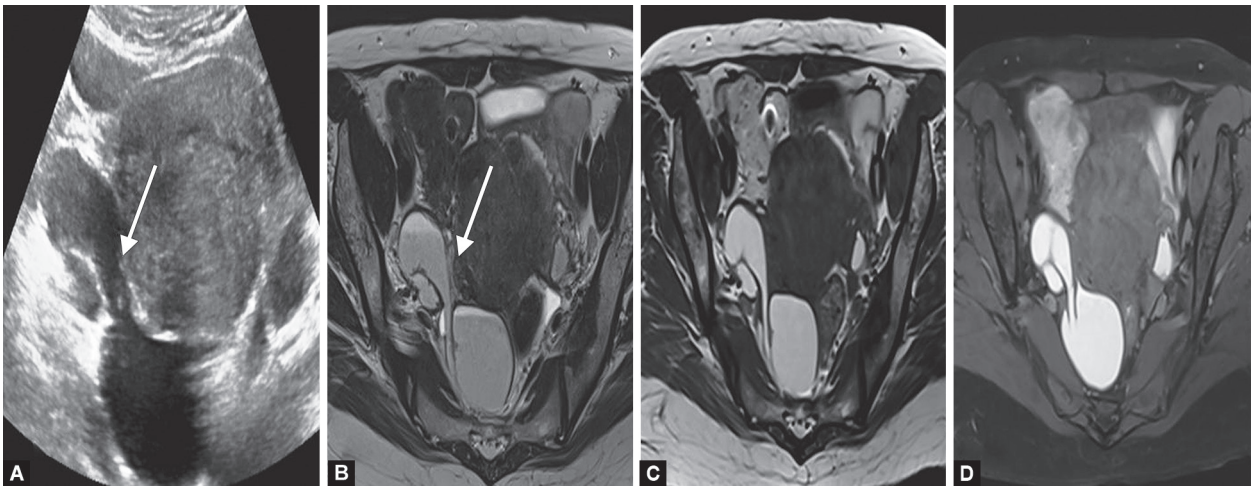
In our study, endometriosis was detected in 36 cases on ultrasound and 38 cases on MRI. On ultrasound, 31 ovarian endometriotic cysts were detected by the presence of unilocular or multilocular

Table 2: Sensitivity/specificity of ultrasound for evaluation of endometriosis

Site	*Sensitivity*	*Specificity*	*PPV (+predictive value)*	*NPV (−predictive value)*	*Diagnostic accuracy*	*Kappa value*
Ovaries	90.62%	75.00%	93.55%	66.67%	87.50%	0.626
Uterosacral ligaments	25.00%	97.30%	50.00%	92.31%	90.24%	0.285
Scar	66.67%	97.30%	66.67%	97.30%	95.00%	0.639
Fallopian tube	50.00%	97.37%	50.0%	97.37%	95.00%	0.473

Table 3: Sensitivity/specificity of MRI for evaluation of endometriosis

Site	*Sensitivity*	*Specificity*	*PPV (+predictive value)*	*NPV (−predictive value)*	*Diagnostic accuracy*	*Kappa value*
Ovaries	93.94%	85.71%	96.88%	75.00%	92.50%	0.754
Uterosacral ligaments	75%	100%	100%	97.20%	97.50%	0.844
Scar	100%	100%	100%	100%	100%	1.000
Fallopian tube	100%	100%	100%	100%	100%	1.000



Figs 2A to D: (A) Patient with tubal endometriosis with bilateral ovarian endometriomas seen as tubular structure with internal echoes in right adnexa (arrow) with unilocular cystic lesions in bilateral ovaries filled with homogeneous low-level internal echoes as seen on ultrasound; (B) On MRI tubal endometriosis seen as elongated tubular structure in right adnexa (arrow) with ovarian cysts seen bilaterally showing shading on axial T2WI; (C) Hyperintensity on axial T1WI and (D) With no suppression of signal on axial T1FATSAT image

cystic lesions filled with homogeneous low-level internal echoes and no internal vascularity on color Doppler flow imaging (Fig. 2A) which was in agreement with Glastonbury.[11] Two lesions of deep endometriosis (uterosacral ligament involvement) were detected on ultrasound. One lesion appeared as a hypoechoic nodule in the retrocervical region and the other appeared as an asymmetrical thickening of right uterosacral ligament, as described by Guerriero et al.[12] Three scar site endometriotic lesions were detected as solid hypoechoic lesion with no color flow at scar site which was in agreement with Teh et al.[13] Two tubal endometriotic lesions were diagnosed by the presence of anechoic tubular lesion filled with homogeneous echoes which was in agreement with Tadros et al.[14]

MR diagnosis of 31 ovarian endometriomas and two fallopian tube endometriosis was made by the presence of a hyperintense signal on T1WI and T1FATSATWI images and by the presence of T2 shading (Figs 2B to D). This was in agreement with Takeuchi et al. which stated that hyperintense signal on T1WI and shading on T2WI were diagnostic MRI signs of endometriomas[15] and Jha et al.[9]

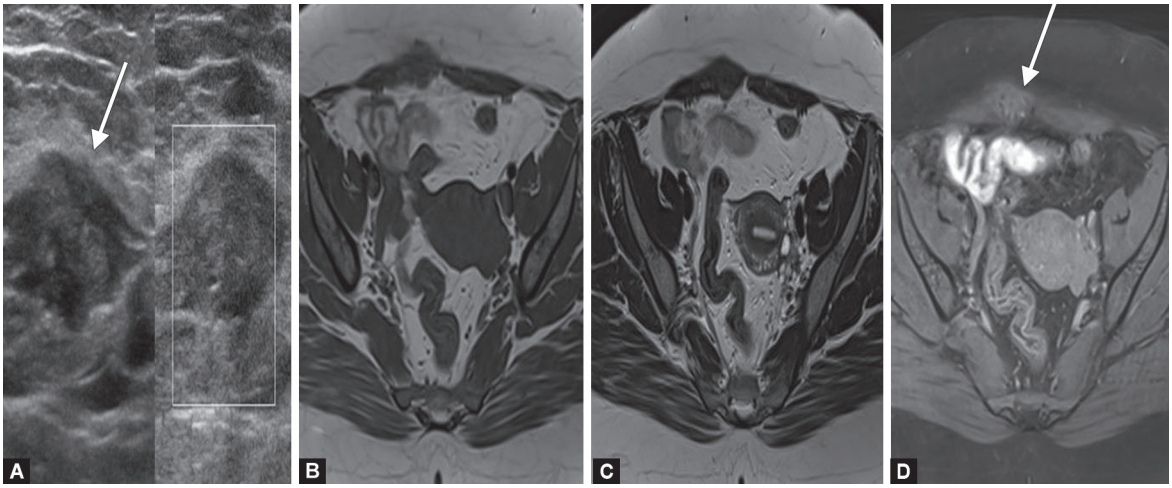
Out of a total three uterosacral ligament endometriotic lesions detected on MRI, two lesions presented as asymmetrical thickening which were of low signal intensity on T1/T1FATSATWI images and T2WI and hyperintense foci on T1FATSATWI images were noted in one of them. One lesion presented as retrocervical nodule which was of low signal intensity on T1/T1FATSATWI images and T2WI with hyperintense foci in it on both T1FATSATWI described by Chamie et al.[16] Three scar site endometriotic lesions were detected which were of low signal intensity on T1/T1FATSAT images with hyperintense foci within them and low signal intensity on T2WI (Fig. 3) which was in agreement with Teh et al.[3]

Comparison of Ultrasonography and MRI with Histopathology (Site-wise)

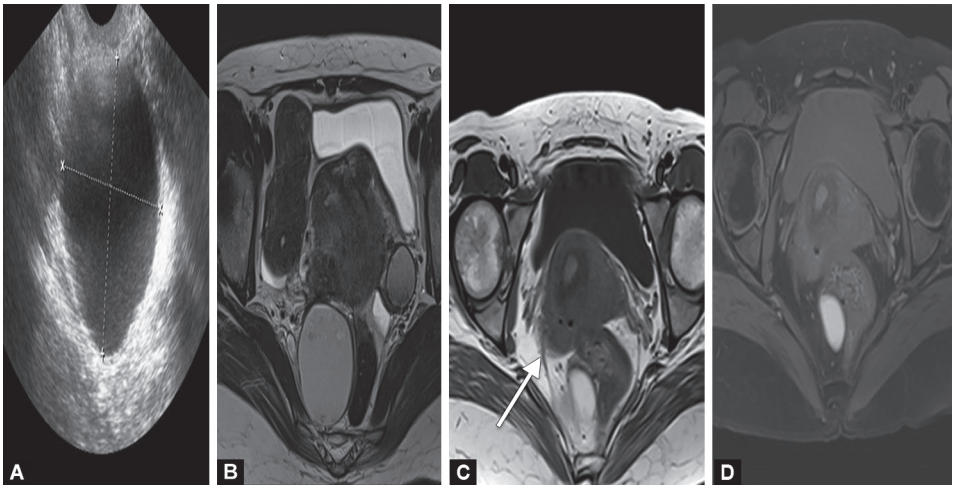
Ovaries

Out of the total 32 histopathologically proven cases of ovarian endometriosis, ultrasound was able to correctly detect ovarian endometriosis in 29 cases and MRI was able to correctly detect ovarian endometriosis in 30 cases.

Two cases were labeled as hemorrhagic cyst on ultrasound due to its heterogeneous internal echopattern and fine internal septations but was correctly diagnosed as ovarian endometriosis on MRI based on T2 shading and confirmed on histopathology. Our findings are consistent with Asch et al. which reported that endometriomas infrequently appeared as a complex heterogeneous cyst mimicking hemorrhagic cyst.[17]



Figs 3A to D: (A) A patient with scar endometriosis seen as irregular hypoechoic lesion at the site of previous C-section scar on ultrasound (arrow) with no internal vascularity; (B) On MRI, the scar endometriosis is seen as a nodule with irregular margins abutting the anterior surface of right rectus abdominis muscle showing low signal intensity, similar to muscle on axial T1WI; (C) Axial T2WI; (D) With few hemorrhagic hyperintense foci seen on axial T1FATSAT image (arrow)



Figs 4A to D: (A) A young female with ovarian endometriomas and deep pelvic endometriosis is seen as a large unilocular cystic lesion measuring ~9.1 × 6.2 × 5.8 cm in right ovary filled with homogeneous low-level internal echoes and similar smaller lesion in left ovary; (B) On MRI, ovarian endometriomas are showing shading on axial T2WI; (C) With no suppression on axial T1FATSAT images. Thickening of right uterosacral ligament seen as low signal intensity (arrow), similar to muscle on T1WI and (D) Axial T1FATSAT image

One case presented as cyst with fluid–fluid level on ultrasound and MRI displayed high signal intensity on both T1 and T2 weighted images, making the case indeterminate on both ultrasound and MRI but was proven to be endometrioma on histopathology. Our ultrasound findings are consistent with Collins et al. which reported the presence of fluid–fluid level as an atypical feature of endometrioma.[18] Our MRI results were consistent with Imaoka et al. concluded that ovarian endometriomas could present as adnexal cysts with high signal intensity on T1FATSATWI images and T2WI.[19]

One case presented with diffuse low-level internal echoes on ultrasound and T2 shading on MRI but was later found to be a hemorrhagic cyst on histopathology. Our false-positive result on ultrasound was consistent with Nardo et al. which reported that hemorrhagic cysts may display low-level internal echoes especially in acute cases mimicking endometriomas.[20] The false-positive result of MRI was consistent with the study done by Corwin et al. which reported that T2 shading could be present in hemorrhagic cysts and was not exclusive for endometriomas.[21]

One case presented as a cystic mass with an area of low-level echoes on ultrasound which was mistaken for an endometrioma but was diagnosed as dermoid cyst by the presence of fat on MRI and histopathology, making the case falsely positive on ultrasound. The sensitivity and specificity of ultrasound for diagnosing ovarian endometriosis (endometriomas) were 90.62 and 75.00%, respectively, and that of MRI were 93.94 and 85.71%, respectively.

Nisenblat et al. explored the diagnostic accuracy of TVUS and MRI for ovarian endometriosis. Sensitivity and specificity of ultrasound for ovarian endometriosis were 93 and 96%, respectively, and MRI were 95 and 91%, respectively.[22]

Uterosacral Ligament

Out of the total four proven cases of deep endometriosis involving the uterosacral ligament on histopathology, one case was correctly detected on ultrasound and three cases on MRI (Fig. 4). Three cases were missed on ultrasound, and one case was missed on MRI. One case was falsely labeled as uterosacral ligament thickening

on ultrasonography but was found to be normal on MRI and histopathology. The sensitivity and specificity of ultrasound for diagnosing uterosacral ligament involvement were 25 and 97.30%, respectively, and of MRI were 75.0 and 100%, respectively.

Indrielle-Kelly et al. reported that ultrasonography had low sensitivity and specificity for detecting deep endometrosis (uterosacral ligament involvement) as compared to MRI. Significant differences in diagnostic accuracy between TVS and MRI were observed for uterosacral ligament (USL) assessment ($p = 0.04$) where MRI was significantly better.[23]

Scar

In our study, two cases of scar endometriosis were diagnosed on ultrasound on the basis of high clinical suspicion of cyclical pain at scar site of previous cesarean section. Both the cases were evaluated on MRI and found to be positive. Both cases were confirmed on histopathology.

One case was misdiagnosed as intramuscular hematoma on ultrasonography but was correctly diagnosed as scar endometriosis on MRI and histopathology. One case was falsely labeled as an endometriotic lesion on ultrasonography but was found to be a desmoid tumor on MRI and histopathology.

Our results are consistent with Hansen et al. which conducted a retrospective study of 12 surgically proven cases of abdominal wall endometriosis. Sonography detected 11 lesions in the abdominal wall. The study concluded that sonographic findings of a solid mass near a cesarean section scar strongly suggested its diagnosis.[24] Similar case of scar endometriosis was diagnosed on ultrasound and cross-sectional imaging in a report by Kotdawala et al.[25]

Our MRI results are consistent with Balleyguier et al. which evaluated four patients operated for scar endometriosis for whom MRI had suggested the diagnosis in all the cases.[26] Another study of 17 cases of extrapelvic endometriosis by Babulal et al. reported usefulness of cross-sectional imaging for detection of scar endometriosis.[27]

Fallopian Tube

One case of tubal endometriosis in the form of hematosalpinx was found on ultrasound which was confirmed on MRI and histopathology. One case was misdiagnosed as hydrosalpinx on ultrasonography but was correctly diagnosed as tubal endometriosis on MRI and histopathology. One case was falsely labeled as tubal endometriotis on ultrasonography due to the presence of tubular lesion with homogeneous echoes but was found to be a pyosalpinx on MRI and histopathology.

The results can be compared to a study done by Tadros et al. which found 100% sensitivity and specificity for transvaginal ultrasound and MRI in cases of hematosalpinx.[14]

Conclusion

Both ultrasound and MRI are noninvasive and safe modalities which are useful for the diagnosis of endometriosis. In our study, ultrasound and MRI had comparable sensitivity for evaluation and detection of ovarian, tubal, and scar site endometriosis; however, the sensitivity and specificity of MRI were significantly more for detecting and diagnosing indeterminate cases and deep pelvic endometriosis.

Clinical Significance

Ultrasound can be used as a first-line investigation in endometriosis, followed by MRI to see the extent of disease and make accurate diagnosis for indeterminate cases and deep endometriosis.

Limitations of The Study

The limitation of this study was a small sample size. A larger population cohort is desirable to achieve more accurate results.

Orcid

Gurpreet S Sandhu https://orcid.org/0000-0002-0576-7273

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