IMAGING KEY TO DIAGNOSE ADNEXAL MASSES- MRI WITH HISTOPATHOLOGICAL CORRELATION
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ABSTRACT

BACKGROUND
The aim of our study is to evaluate the accuracy of MR imaging in characterisation of adnexal masses.

MATERIALS AND METHODS
This study was done for a span of 7 months from July 2016 to January 2017. Preoperative MR imaging of the pelvis was performed in 77 women with clinically and sonographically detected adnexal masses. The accuracy of MR imaging in the differentiation between benign and malignant ovarian masses was evaluated using histopathological results as the standard of reference.

RESULTS
The sensitivity, specificity and accuracy of MR imaging in characterisation of ovarian masses were 95.2%, 98.4% and 97.6%, respectively.

CONCLUSION
In conclusion, MR imaging is a better diagnostic modality for differentiating and characterising benign and malignant adnexal masses.

KEYWORDS
Magnetic Resonance Imaging, Adnexal Masses, Ovarian Tumours.

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BACKGROUND
Adnexal masses account for most common indication for gynaecological surgery, but definitive diagnosis is not possible until the surgery and histopathological examination have been performed. However, the preoperative characterisation of the lesion is crucial to decide the type of surgery and feasibility of conservative management and probability of malignancy, which is based mostly on imaging appearance.

MR imaging may provide useful information for the characterisation of ovarian masses as non-neoplastic/neoplastic, and in latter case, as benign or malignant.¹ Moreover, it enables a specific diagnosis to be made as it is well known to differentiate between haemorrhage, fat and collagen by T1 and T2-weighted images.

Gadolinium-enhanced MR studies provide best assessment of complex adnexal masses.²-³ Contrast T1-weighted MR depicts features of malignancy such as enhancing nodules/solid areas with/without necrosis.

In this study, we propose MR imaging guided approach to diagnose adnexal masses based on the MR signal intensity features (haemorrhage, elevated protein, fat and collagen) and enhancement behaviour of each lesion using pathologically-proven examples from our institution.

MATERIALS AND METHODS
This study includes 77 women referred from Gynaecology Department of our institution for the evaluation of clinically/sonographically detected adnexal masses within a study period of July 2016 to January 2017.

Informed consent was taken from all patients and MR imaging was performed in all. Out of 77 women, 4 patients has no histopathological confirmation as 2 of them were lost in followup and other 2 underwent surgery in another hospital. Therefore, they were excluded from our study. Other 4 patients had to be excluded from this study because they had benign diseases (2 with nonneoplastic ovarian cyst other 2 with endometrioma). So, they were followed up clinically and sonographically.
Out of 77 women, 69 underwent surgery in the age group of (21-75 yrs.) with the mean age of 48 yrs. Time period between imaging and surgery was less than 4 weeks.

**MR Imaging Technique**

Patients were instructed to fast for at least 4 hrs. prior to the examination immediately before MR imaging. All patients were given 1 mg of intramuscular glucagon.

The same 1.5-T MR unit (Philips) was used for conducting all MR examinations using a body coil in our department.

The MR protocol included the following sequences:

1. Axial spin echo T1-weighted images before and after the application of a fat saturation prepulse covering the area from the iliac crests to the symphysis pubis or the ovarian mass, if larger;
2. Axial, sagittal and coronal turbo spin echo T2-weighted images; and
3. Fat-suppressed, contrast-enhanced (after the intravenous administration of 0.2 mmol/kg of gadolinium chelate compounds) spin echo T1-weighted images.

**Statistical Analysis**

Statistical values including sensitivity, specificity, accuracy, positive and negative predictive values for MR imaging in characterisation of ovarian mass malignancy using the histopathological diagnosis as the standard of reference were evaluated.

**RESULTS**

**Data Interpretation**- MR images were evaluated by two radiologists with 4 and 3 yrs. of experience in female imaging respectively at different times without the knowledge of either surgical finding or histological diagnosis using a imaging-guided approach. We evaluated signal intensity features and enhancement behaviour for each lesion.

The following primary imaging features were considered suggestive of ovarian mass malignancy, presence of masses bilaterally, size larger than 4 cm, mass partly cystic solid with solid components enhancing after contrast material administration, presence of necrosis within a solid tumour, cystic or solid cystic lesions with thick and irregular walls or septa of thickness more than 3 mm and/or with papillary projections demonstrating enhancement on contrast administration.3-17

The presence of secondary findings such as pelvic organ or wall invasion, ascites, peritoneal metastases and lymphadenopathy increased the confidence in the diagnosis of malignancy. A lesion was characterised as malignant when at least two primary criteria or one primary and one secondary finding were present.

Features suggestive of benignity were the following:

- Mass diameter less than 4 cm, entirely cystic lesion with wall thickness of less than 3 mm and no evidence of internal structures or invasive disease.3-17 A lesion that met 3 of the 4 mentioned criteria was assessed as benign.

- Functional cysts are the most commonly encountered cystic masses in women of reproductive age as a normal part of the menstrual cycle including follicles (diameter <20 mm), dominant follicles (diameter 20-25 mm), follicular cysts (resulting from persistence of an unruptured follicle) and corpus luteum cysts (resulting from a failure of the corpus luteum to regress). The latter one may enlarge because of an internal bleeding showing high signal on T1-weighted images.

- Paraovarian cysts arise from mesothelial, paramesonephric or mesonephric remnants. It is important to identify the ipsilateral ovary as a separate structure in order to avoid misinterpretation; however, sometimes a beak sign can be found.17

- Hydrosalpinx (high signal intensity on T2-weighted images); pyosalpinx (high signal intensity on diffusion-weighted images) and hematosalpinx (high signal intensity on T1-weighted images) on some scans may assume a cystic appearance mimicking an ovarian cystic lesion, but their tubular structure can be visualised in multiplanar images. Fallopian tubes can also be distended by pus or blood, respectively.

- A lesion that manifest as cystic to complex adnexal masses with high signal intensity on T1-weighted and intermediate to low signal intensity on T2-weighted images associated with T2 shading sign was considered as endometrioma.

- An unilocular cyst with a thin regular wall (less than 3 mm) serous fluid shows low signal intensity on T1-weighted and high signal intensity on T2-weighted images, which are small and more often bilateral was considered as serous cystadenoma.

- An ovarian mass with multiple cystic loculi may have variable signal intensity on both T1-weighted and T2-weighted images, namely stained-glass appearance was considered as mucinous cystadenoma as seen in Figure 1.

- A complex adnexal mass with high signal intensity both on T1-weighted and T2-weighted images and signal loss on fat suppression sequences was considered as teratoma as seen in Figure 2.

- A homogenous mass with low signal intensity on both T1 and T2 was considered as leiomyoma as seen in Figure 3.

- In fibromas, the prominent fibrosis with abundant collagen content is responsible for the low signal intensity, while in thecoma, the mainly lipidic content of theca cells maybe depicted at chemical shift imaging. After contrast administration, only a minimal enhancement can be demonstrated as seen in Figure 4.

- An enlarged ovary with peripherally arranged follicles with low signal intensity on T1 and high signal intensity on T2 showing a pedicle sign was considered as ovarian torsion as seen in Figure 5.

- Serous cystadenocarcinoma and mucinous are complex multilocular masses, thick and irregular walls, septations, solid components and papillary projections frequently...
bilateral. Of low signal intensity on T2-weighted images with contrast enhancement after gadolinium administration.

Granulosa cell tumours are usually benign; however, they maybe malignant as well granulosa cell tumours appear mostly as both cystic and solid masses.\textsuperscript{18,19}

A rapidly growing endometrioma along with multilocularity, presence of mural nodules with enhancement after gadolinium administration and association with endometrial hyperplasia should raise the suspicion of malignancy probably endometriod or clear cell carcinoma.\textsuperscript{11,13}

Stomach, colon, breast, lung and contralateral ovary are the most frequent neoplasms to metastasise to the ovaries. Ovarian metastasis are more often bilateral with a cystic and solid or a predominant solid morphological appearance.

The MR imaging findings were compared with surgical and histopathological examination results.

### Imaging Features Suggestive of Benign and Malignant Ovarian Lesion

<table>
<thead>
<tr>
<th>Imaging Features</th>
<th>Benign</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal diameter</td>
<td>&lt;4 cm</td>
<td>&gt;4 cm</td>
</tr>
<tr>
<td>Presence of mass unilaterally or bilaterally</td>
<td>Unilateral mass</td>
<td>Bilateral masses</td>
</tr>
<tr>
<td>Content - solid/cystic</td>
<td>Entirely cystic</td>
<td>Cystic solid or soft tissue mass with necrosis</td>
</tr>
<tr>
<td>Papillary projections</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Wall characteristics</td>
<td>Smooth, thin (of thickness &lt;3 mm)</td>
<td>Irregular, thick (&gt;3 mm)</td>
</tr>
<tr>
<td>Ascites</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Peritoneal metastases</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
<td>Absent</td>
<td>Present</td>
</tr>
</tbody>
</table>

### Histologic Diagnosis of the 91 Adnexal Masses

<table>
<thead>
<tr>
<th>Histologic Diagnosis</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benign</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonneoplastic ovarian cyst</td>
<td>10</td>
<td>14.9</td>
</tr>
<tr>
<td>Endometrioma</td>
<td>9</td>
<td>13.4</td>
</tr>
<tr>
<td>Serous cystadenoma</td>
<td>7</td>
<td>10.4</td>
</tr>
<tr>
<td>Mucinous cystadenoma</td>
<td>3</td>
<td>4.5</td>
</tr>
<tr>
<td>Benign mixed ovarian tumour (serous, mucinous)</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Teratoma</td>
<td>8</td>
<td>11.9</td>
</tr>
<tr>
<td>Fibroma or fibrothecoma</td>
<td>3</td>
<td>4.5</td>
</tr>
<tr>
<td>Leiomyoma-adenomyosis</td>
<td>21</td>
<td>31.3</td>
</tr>
<tr>
<td>Pyosalpinx</td>
<td>3</td>
<td>4.5</td>
</tr>
<tr>
<td>Ovarian torsion</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Malignant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serous cystadenocarcinoma</td>
<td>9</td>
<td>37.5</td>
</tr>
<tr>
<td>Granulosa cell tumour</td>
<td>2</td>
<td>8.3</td>
</tr>
<tr>
<td>Endometrioid carcinoma</td>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>Mixed malignant ovarian tumour (endometriod, clear cell carcinoma)</td>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>Borderline tumour</td>
<td>4</td>
<td>16.6</td>
</tr>
<tr>
<td>Metastatic adenocarcinoma ovarian in origin</td>
<td>5</td>
<td>20.8</td>
</tr>
<tr>
<td>Leiomyosarcoma</td>
<td>2</td>
<td>8.3</td>
</tr>
</tbody>
</table>
Figure 1. A 53-Year-Old Woman with Right Ovarian Mucinous Cystadenoma - a) Coronal T1, b) Coronal T2, c) Coronal STIR, d) Postcontrast Axial T1-Weighted Images Depict a Multilocular Cystic Right Ovarian Tumour with Fluid Signal Intensity of Low T1 and High T2. No Other Solid-Enhancing Components are noted.

Figure 2. A 28-Year-Old Woman with Right Ovarian Complex Cystic Mass (Mature Cystic Teratoma). a) Axial T2 and b) Axial STIR Images Depict in Homogenous Ovarian Tumour with Fat Components, which Appears Bright on T2 and Suppressed on STIR Images, Fluid, Nonenhancing Soft Tissue, Septa and a Dense Focus of Calcification.
Figure 3. A 45-Year-Old Woman with Multiple Subserosal Leiomyomas Presented as Adnexal Mass- a) Coronal T1, and b) Axial T2-Weighted Images show Multiple Homogenous Solid Lesions with T1 and T2 Low Signal Intensities Noted in the Uterine Myometrium

Figure 4. A 48-Year-Old Woman with Left Ovarian Fibroma. a) T1 Weighted, b) T2 Weighted, c) STIR, d) Postcontrast T1 Weighted Images Depict a Large Well-Circumscribed, Irregular Shape Left Adnexal Mass that Returns Isosignal on T1, Low Signal on T2 and STIR with Avid Enhancement on Postcontrast Scan. There is Multiple Cystic Changes within Lesion.
At surgery and histopathological examination, 91 adnexal masses were identified in 69 women; of them, 67 were benign and 24 were malignant. MR examination detected 87 (95%) of 91 masses with 65 of 67 (97%) benign lesions and 22 of 24 (91%) malignant lesions being identified.

In benign lesions, an endometrioma of a diameter measuring 0.6 cm and a case of a functional ovarian cyst and paraovarian cyst are misinterpreted as a single mass on imaging and in malignant lesions- a case of serous cystadenocarcinoma with microscopic involvement of contralateral ovary, which were misinterpreted as single ovarian mass. On MR imaging, they were not detected.

The diagnostic performance of MR imaging in characterising ovarian malignancy are shown in table.

<table>
<thead>
<tr>
<th>Sensitivity Percentage</th>
<th>Specificity Percentage</th>
<th>Accuracy Percentage</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td>95.3</td>
<td>98.2</td>
<td>97.5</td>
<td>95.3</td>
</tr>
</tbody>
</table>

The sensitivity, specificity and accuracy of MRI were 95.3, 98.2 and 97.5%, respectively. MRI proved to be better imaging modality than CT and US in characterising the ovarian masses.

We had one false-positive case with MRI, histologically proved to represent a subserosal degenerated uterus leiomyoma, which although detected as a homogeneous adnexal mass was accompanied by a small amount of ascites in a postmenopausal woman, a finding implying malignancy. A false negative case, a borderline tumour, which was incorrectly characterised as a multilocular cystic mass lesion. We got very small percentage of false negatives and false positives when we compared the MR diagnosis with histopathological reports. This variance occurred because of borderline tumours are difficult to characterise on imaging and less specificity of secondary findings like ascites for malignancy because these findings can also occur in benign lesions.

MRI correctly identified three complex ovarian masses as benign, which were misdiagnosed as malignant by US and CT due to presence of mildly-enhancing component. The masses show low signal intensity on T2-weighted images, a finding indicative of the presence of fibrous tissue or smooth muscle, which were confirmed by histology as subserosal degenerated leiomyoma in one case and an ovarian fibrothecoma in the other two cases.

**DISCUSSION**

Usually adnexal masses detected by means of clinical examination or sonography if an ovarian mass is detected, determination of a degree of suspicion for malignancy is important and is based largely on imaging appearance. Ultrasoundography (US) is routinely used as the standard method for the detection and the assessment of adnexal masses. Although, the reported sensitivities of the technique are high (85-100%), the specificities are variable (50-100%).10,23 Both US and MRI are equally sensitive in the evaluation of the intratumoral structure of ovarian masses, but MRI was proved more specific and accurate.18,25-27

Ultrasound is the first imaging study performed in the evaluation of suspected ovarian lesion. A combination of grey scale and Doppler features obtained with transabdominal and/or transvaginal scanning used for the investigation of ovarian lesions.1 Doppler ultrasound has a sensitivity of 84% and specificity of 82% in diagnosing cancer.28 However, unless morphological and vascularity features clearly indicate a benign lesion, further assessment is mandatory. Levin et al in a consensus statement for the society of radiologists made recommendations about management of adnexal masses- “adnexal masses in the physiological range in terms of size and appearance in a woman of menstrual age or a simple adnexal cyst less than or equal to 1 cm in a postmenopausal woman are likely
MR imaging is known to provide increased resolution for imaging of gynaecologic diseases.\(^{19,30,31,32}\) One of the main advantages of the technique is its efficacy in tissue characterisation allowing a confident diagnosis of dermoid cysts, most endometriomas, uterine leiomyomas and ovarian fibromas in the majority of cases.\(^{30,32}\) Several series reported a high detection rate (95%) and a high accuracy (91-93%) in the characterisation of complex adnexal masses with MR imaging.\(^{4,5}\) Contrast-enhanced MR studies also have a major role in differentiation of benign vs. malignant adnexal masses by their contrast characteristics.\(^{4,5}\)

In this series, our findings demonstrated that MR imaging had a high detection rate (95%) for ovarian masses. Microscopic disease, small lesion size and difficulty in defining whether a large ovarian mass is unilateral or bilateral are the major limitations for lesion detection. Our results also showed that MRI demonstrated satisfactory diagnostic performances in characterising and differentiating ovarian masses. The sensitivity, specificity and accuracy of MRI were 95.3, 98.2 and 97.5%, respectively. We had only one false positive case and one false negative case.

Borderline tumours are often difficult to characterise on imaging because of their close resemblance to benign lesions.\(^{20-22}\) Bazot et al in his study reported that specificity of MR imaging in recognising the borderline nature of ovarian tumours preoperatively is about only 45.4%.\(^{16}\)

Outwater et al reported the presence of abundant papillary projections in tumours of low malignant potential\(^{21}\) and Burkholz et al proved that in characterisation of low malignant potential should be considered in the presence of an ovarian mass with an abundance of papillary projections in a young patient.\(^{22}\)

We had three cases, which were falsely diagnosed by MDCT as malignant masses because of mildly-enhancing solid components. These cases were correctly characterised with MRI due to the presence of tissue of low signal intensity on T2-weighted images and histologically represented as subserosal degenerated leiomyomas in two patients and ovarian fibromas in the other patient. Fibrosis and smooth muscle have characteristically low signal intensity on T2-weighted images due to the T2 shortening effects of intramuscular actin, myosin and collagen as well as the decreased extracellular fluid compared to the surrounding tissues.\(^{30}\) These findings proved that in characterisation of lesions especially fibrous lesions MRI is superior to CT. We had also a second false negative case with CT, which detected a hyperdense adnexal mass. But, on MRI, the mass revealed a small enhancing component within the tumour leading to the correct preoperative characterisation.

Our study showed high sensitivity, specificity and accuracy of MRI in characterisation of adnexal masses confirm the high diagnostic performances of MR imaging. The high resolution of MR images permitted a comprehensive evaluation of the internal features of ovarian masses as well as the detection of ancillary findings such as those of pelvic organ invasion, lymphadenopathy, ascites and peritoneal metastases increasing substantially the confidence in the diagnosis of malignancy.\(^{14}\) Another important advantage of MRI is that simultaneously staging of ovarian malignancies is possible with the same study.

**CONCLUSION**

In conclusion, MRI demonstrated satisfactory results in characterisation of adnexal masses. A large number of patients in which sonographic findings are unreliable or indicating any malignant features are needed to validate the role of MRI in the characterisation and differentiation of adnexal masses. Morphological appearance, signal intensity characteristics and adequate use of intravenous contrast material are critical elements for arriving at correct diagnosis. Because of its accuracy and satisfactory results in lesion characterisation, MRI will evolve into the most widely used diagnostic modality in characterisation and staging of ovarian malignancies.

**REFERENCES**


