



## Role of Diffusion Weighted MR Imaging in Adnexal lesions in Female Pelvis A Prospective study

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### Abstract

**Aims & objectives:** 1) MRI criteria for accurate diagnosis of adnexal lesions 2) Differentiating MR features for benign from suspicious malignant lesions. 3) Defining the potentiality of DWI in the characterization of complex adenexalmasses.

**Summary:** The final diagnosis of the 56 patients included in the study was based on biopsy and histopathological verification in 37 patients (58.7%). The other patients were diagnosed by the characteristic MRI features, and follow up by monitoring clinical response to medical treatment (41.2%) The 6 patients diagnosed to have torsion of pedicle were later proven surgically. All the patients diagnosed with benign and malignant ovarian neoplasms were histopathologically proven. All the patients having tuberculoustubo-ovarian abscesses were pathologically proven. All the patients diagnosed as borderline ovarian neoplasms were pathologically proven. All the patients with endometriomas showed characteristic MRI features. All the patients with extraovarian pathologies were improving on medical treatment. Followup in majority of cases did not reveal any recurrence/complications.

**Conclusions:** Sonographically indeterminate adenexal masses of solid or complex cystic content benefit from further evaluation with MRI, which is highly accurate for identifying the origin of a mass and characterising its tissue content, obviating surgery in many cases. The role of DWI in distinguishing between benign and malignant cystic tumors is limited and the ADC values calculated from the DWI will add useful information to the differential diagnosis especially ovarian cystic masses. An adenexal mass with no restricted diffusion usually is a benign lesion, however information derived from images obtained with other sequences will be helpful. Pitfalls were noted in some Ovarian cystic lesions with water diffusion restriction in cases of Abscess, mature cystic teratomas, endometriotic cysts. All malignant ovarian lesions are always restricted in the DWI with ADC values less than 0.5. DWI provides supplemental information in patients with gynecological disorders and could easily be incorporated into standard clinical protocols utilizing MRI, corroborating with histopathological findings.

**Keywords:** Adnexal masses, Indeterminate lesions, Diffusion weighted Imaging, Magnetic Resonance Imaging.

## Introduction

Adenexal masses present a special diagnostic challenge when imaging findings cannot be categorised into benign or malignant pathology. High resolution transvaginal ultrasound became the initial imaging modality of choice for evaluating women with suspected adenexal masses since it is easily available, provides good diagnostic accuracy and is inexpensive, however some shortcomings with this modality include limited by decreased specificity for diagnosis of benignity, limited field of view, obscuration of pelvic organs due to bowel gas, obesity factors etc. CT has a limited value in the diagnosis of adenexal masses. Now Evaluation of adnexal lesions by MRI is considered as an imaging modality of choice because of its excellent tissue characterization, multi planar reconstruction and non ionizing ability<sup>(1)</sup> supplementing USG findings especially when they are inconclusive or sub optimal creating possible faulty interpretations. Recent developments in MR Imaging techniques like Diffusion weighted MR imaging increases the contrast between the lesion and the surrounding tissues, have magnified the role and potential of MRI in female pelvis. Diffusion-Weighted magnetic resonance (DW MR) imaging is sensitive to molecular diffusion, which is the random thermal motion of molecules, known as Brownian motion, in the field gradients produces incoherent phase shifts that result in signal attenuation. MR imaging is the only method by which the molecular diffusion process is evaluated in vivo. As diffusion directly reflects molecular mobility, measurement of diffusion with MR imaging holds promise for clinical application<sup>(3,4)</sup>. DWI also enables the quantitative evaluation of apparent diffusion coefficient of intravoxel incoherent motion. the ADC value describes microscopic water diffusibility and has been reported to be valuable for distinguishing malignancy from benign lesions<sup>(5,6)</sup>. In the last decade ,in the characterisation of undeterminate complex adenexal masses, conventional techniques were complemented with still conflicting

results by diffusion weighted imaging (DWI)<sup>(7,8)</sup>. In our study, we have analysed the MRI findings in neoplastic and non neoplastic adenexal masses.

## Materials & Methods

MRI examinations of 112 female patients with initial undetermined complex adenexal masses referred for MRI based on ultrasound findings for further characterization and staging. Pelvic MR with DWI was done for all patients, contrast MR was done for 42 patients

**Period of Study:** extending from September 2012 to December 2015.

### Inclusion criteria

1. All patients with indeterminate adenexal masses on USG
2. Staging of known malignant conditions
3. Patients of all age groups ranging from 16-75 yrs.

### Exclusion criteria

Present study was limited to ovaries and adenexa, rest of the female reproductive organ pathologies have been excluded as general criteria for precise conclusions.

Pure simple cysts were excluded from the analysis.

Patients having history of claustrophobia

Patients who did not consent to be a part of study

Patients those who had metallic implants if any.

All patients were subjected to the following: Ultrasound examination was done on a Philips HD15pure wave ultrasound system (Erlangen, Germany) including a convex probe for the abdomino pelvic approach and an endovaginal probe for the trans vaginal approach. Pelvic MRI with DWI was performed in all patients. Contrast administration in 42 cases only.

### Data Analysis

All the images were analysed on conventional sequences for: Morph structural features differentiating predominantly cystic, mixed and predominantly solid masses, Involvement of one or both ovaries, Size of the lesion, Signal intensity of the tumour, enhancement of the solid

component if present, wall thickness and regularity of tumour and its enhancement, presence of vegetation and septations, their pattern and their size. MR images were analyzed for the presence of ascites, presence of infiltrated pelvic/ paraaortic nodes, involvement of other pelvic organs and presence of peritoneal and omental deposit Suggestive MR signal for benign masses: Simple cystic tumours show low signal on T1W images and high signal on T2W images with no solid component. Complex benign looking masses: High signal intensity on T1W is considered either fat or blood. On fat suppressed images low signal is noted with fat while high signal is still noted in blood. Malignant MR criteria according to Timmerman et al.: presence

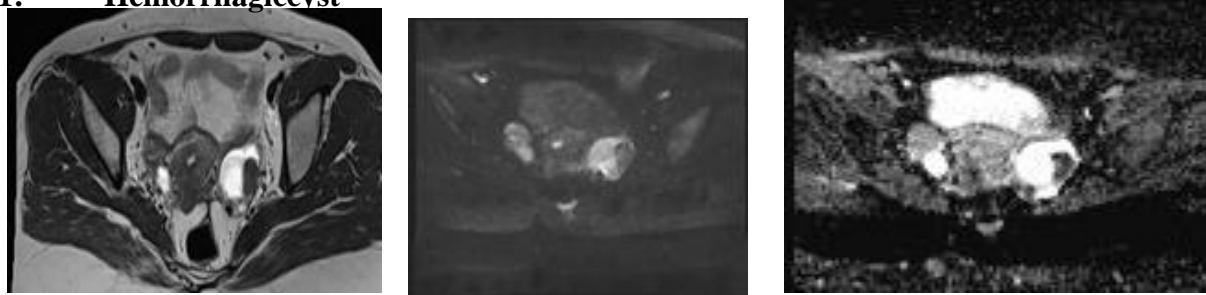
of wall thickening >3mm ,solidvegetations more than 1cm.thick septa>3mm and areas of necrosis and breaking down. Signs of tumour spread for staging: enlarged lymph nodes, ascites, peritoneal and omental deposit. Post contrast images were used for the recognition of enhancement of the solid component, the tumour wall, septations and vegetations.

**DW MR Analysis**

Qualitative analysis: If the lesion shows high signal intensity on diffusion images with low signal in the corresponding ADC maps its restricted diffusion or shows low signal intensity On diffusion images with high signal in the corresponding ADC maps its facilitated diffusion.

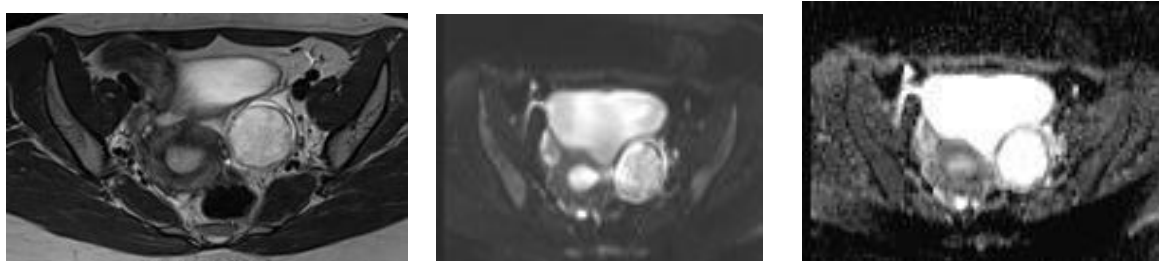
Category	T2WI	B O	B 800	ADC
T2shine through effect	Hyperintense	Hyperintense	Hypointense	Hyperintense
Restricted diffusion	Mild to moderate Hyperintense	Hyperintense	Hyperintense	Hypointense
T2 black out	Hypointense	Hypointense	Hypointense	Hypointense

**CASE1: Hemorrhagiccyst**

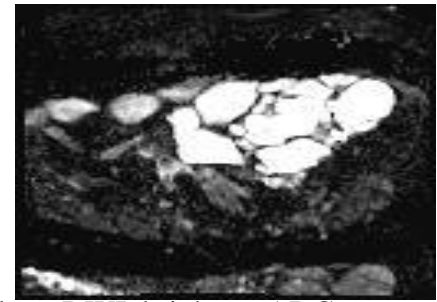
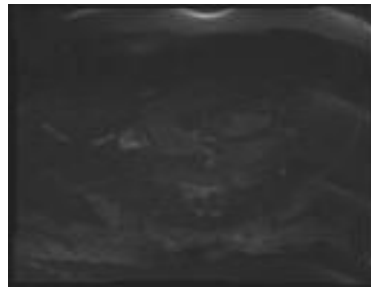
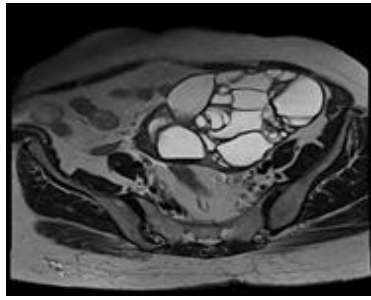


Hyper intense SOL noted in the left adenaxaon T2WI SOL is bright on DWI, ADC

**Case2: Endometrioma**

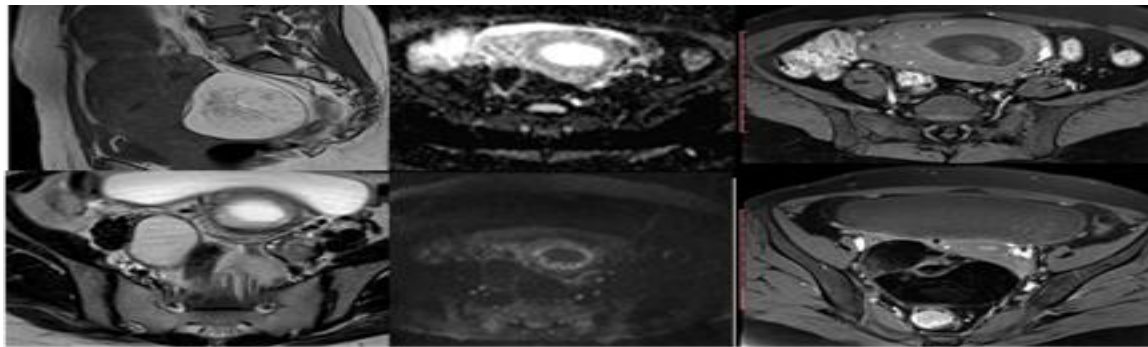


Hypointense SOL noted in the left adenexa on T2WI Dark on DWI, ADC

**CASE 3: Benign mucinous cystadenoma**

Complex multiloculated SOL Hyperintense on T2WI

SOL is dark on DWI, bright on ADC

**CASE 4: Ovarian torsion**

On T2WI images the pedicle looks engorged and hyperintense and showing restriction of diffusion

**Quantitative analysis**

Regarding the quantitative analysis of DWI, we generated the ADC map, then we selected the ROI (region of interest) manually on the solid and the cystic component of the tumors, which was then automatically calculated on the work station to get the ADC values. Regions of interest were manually traced and placed on both solid and cystic components covering a region of 1cm<sup>2</sup>. values were registered in x10<sup>-3</sup>mm<sup>2</sup>/sec.

**Observation & Results**

The present study included 112 female patients with indeterminate adnexal lesions on ultrasound examination. The patient's age ranged from 17-75 years. (mean age was 35 years). The age in cases with benign etiology ranged between 17-75 years (mean age 35). While the age in cases with malignant tumours ranged between 26 to 56 years (mean age 43 years). The patients included in the study had a final imaging diagnosis of ovarian lesions in 100 patients (89.28%) and 12 patients (10.71 %) had tuboovarian involvement

34 patients were diagnosed as ovarian endometriomas, 8 had bilateral disease; 12 patients had ovarian dermoids; 6 patients had hemorrhagic ovarian cysts ; ) 12 Patients had ovarian torsion associated with ovarian masses. 12 patients had PID; 14 patients were diagnosed as benign cystic ovarian neoplasms, 2 had bilateral disease 14 patients were diagnosed as Solid malignant ovarian neoplasms

**Discussion**

Accurate characterisation of an adnexal mass helps to inform the patient about the surgical route and the feasibility of conservative treatment<sup>(9)</sup> MR imaging has shown to be more specific and accurate than US and Doppler assessment in characterizing adnexal masses. In addition, it is best method in delineation of local spread to pelvic organs<sup>(10,11)</sup>.

DWI is one of the promising new functional imaging techniques. DWI visualises the random microscopic mobility of water (Brownian motion) and thereby provides a tissue contrast that is

different from that made with conventional T1W and T2W imaging. Diffusion weighted imaging (DWI) reflects changes in proton mobility caused by pathological alterations of tissue cellularity, cellular membrane integrity, extracellular space perfusion, and fluid viscosity due to pathological processes. Altering the gradient amplitude, duration and time interval (b-value, measured in seconds per square millimetre) between paired diffusion gradients alters the sensitivity to the degree of water motion. A higher b value (b=800 or 1,00sec/mm<sup>2</sup>) has been recommended for female pelvic region because it results in more diffusion weighting with better background suppression. By performing DWI using different b-values, quantitative analysis, namely, the calculation of apparent diffusion coefficient (ADC) values, is possible and the ADC values can be displayed as parametric map (ADC map). Restricted diffusion demonstrates high signal on DWI and lower ADC values on ADC map. The clinical application of DWI in adenexal pathologies and its diagnostic role is studied. We used a DWI with a high B value of 50 and 800 sec/mm<sup>2</sup> and a reversed black and white gray scale.

The patients included in this study, based on final imaging diagnoses were categorised into benign and malignant groups. Out of the total 112 complex adenexal masses, 84 were benign and 28 malignant. Benign outnumbered the malignant etiologies. The group of benign lesions included 34 endometriomas, 12 ovarian dermoids, 8 hemorrhagic ovarian cysts, 12 mucinous adenomas, 8 serous cystadenomas and 12 pelvic inflammatory disease.

The group of malignant lesions included 16 serous adenocarcinomas, 2 borderline mucinous cystadenoma and 2 mixed serous endometrioid adenocarcinoma.

### **Endometriomas**

Endometriomas occur as a result of extrauterine implantation of endometrium epithelium. The typical US appearance is a complex cystic ovarian

mass with homogenous low level internal echoes and thick wall which is hypovascular at colour Doppler evaluation. US sensitivity (90.4%) in diagnosing endometriomas is as high as MRI sensitivity (90%); However MRI is usually performed after the US to evaluate other foci of endometriosis and to evaluate pelvic adhesions. Patients were diagnosed as ovarian endometriomas of which 8 had bilateral disease. Bilateral involvement in our study was 23.5 % which is similar to that reported by Dogheim et al (22.2%)<sup>(12)</sup>. The Total number of endometriomas in our study was 34 and they showed the following MRI features:

Morphology of endometriomas is cystic mass with thick nonenhancing wall. The presence of multiple bilateral lesions adds specificity to the diagnosis. Enhancing wall and solid components are not a feature of endometriomas, however seen in cases of malignant change (endometrioid adenocarcinoma and clear cell carcinoma); incidence is 0.6-1.0% and decidualised endometriomas occurring in pregnancy. Visualization of solid components, septations, and a size larger than expected for an endometrioma are features suggestive of malignancy<sup>(13)</sup>

### **Signal intensity**

All 34 endometriomas (100%) in our study showed hyper intensity T1 and T1 fat saturated images and hypo intensity on T2 images which is consistent with the classical MRI features reported in the literature. MRI has been reported to have a sensitivity of 68-90% and specificity of 83-98% for the diagnosis of endometriosis.

The classical MRI features of endometriosis reported in the literature (seen in 100% cases) are: (1) high signal on T1 weighted images (methemoglobin), (2) no loss of this signal on fat suppressed T1 weighted images and (3) dark structures on T2 weighted images. These can be rings or nodules ( hemosiderin staining) in chronic lesions or from deoxyhemoglobin contained within recent bleeding. A key finding is —shading in which there is progressive signal loss due to

T2WI effects in the dependent portion of a lesion due to greater concentrations of blood products. Fluid-fluid levels may be seen which were similar to our study.

#### **Atypical MRI signal pattern in proved endometriomas are:**

T1 hypo signal intensity which are seen in small proportion of cases. Woodward et al. stated that hemosiderin-laden macrophages combined with the fibrous nature of the cyst wall give it a low signal intensity appearance on both T1- and T2-weighted images<sup>(13)</sup>, which was not seen in any of the cases in our study. T2 hyperintense signal / absence of T2 shading in endometriomas needs differentiation from hemorrhagic corpus luteal cysts. Hemorrhagic cysts are usually unilocular as opposed to endometriomas, which are frequently multilocular and bilateral. In addition, hemorrhagic cysts do not exhibit shading on T2-weighted images and will resolve with time. A follow-up examination which can be done with USG and can confirm the diagnosis. The pathological hallmark of endometrioma is visualization of hemosiderin deposition in the cyst wall, helpful especially in the diagnosis of endometriomas that do not exhibit typical MRI findings. Susceptibility-weighted MRI is a relatively new MRI technique that maximizes sensitivity to susceptibility effects and has exquisite sensitivity to blood products such as hemosiderin and deoxyhemoglobin<sup>(14)</sup> with reported 100% sensitivity and specificity to the diagnosis.

Endometriomas showed variable diffusion characteristics in our study, 20 out of our 34 cases showed restriction in the DWI sequence. This is in agreement with the literature, Dogheim et al in their study reported restricted diffusion in five out of 11 cases. The restriction could be phase dependent<sup>(12)</sup> The mean ADC value of endometriomas in our study as 0.8mm<sup>2</sup>/sec.

In neuroradiology, DWI of the hematoma is variable according to the stage, showing restriction in hyperacute and late subacute stages only while not restricted in the other stages. The

presence of restriction in some of our endometriomas could be attributed to the same principle although different morphological changes according to the age of hematoma are not yet evaluated in gynaecological imaging. In a study by Eman Nasr et al. Hemorrhagic cysts and endometriomas showed high signal not only on diffusion images but also on corresponding ADC map and ADC values 1.3 to 1.4 which can be explained as T2 shine through.<sup>(A)</sup>

Contrast was not administered in any of our cases of endometriomas since the classical appearance of bright signal on T1 and hypointense signal on T2 i.e T2 shading is a finding classical of endometrioma. Woodward et al. also stated that administration of gadolinium-based contrast material is not particularly useful in the evaluation of endometriomas. When used, the cyst wall demonstrates a nonspecific, variable enhancement pattern that does not differentiate it from other benign and malignant processes. In addition, a false-positive diagnosis may be made when normally enhancing parametrium is misinterpreted as endometriotic foci. The use of gadolinium should be reserved for those cases in which there is a concern for ovarian carcinoma<sup>(13)</sup>

#### **Dermoids/Mature Cystic Teratomas**

Mature cystic teratoma is the most common ovarian tumour. Incidence peaks at 3rd decade, of which 90% are unilateral which was a significant finding. This benign tumour consists of ectodermal tissue predominantly and is lined with keratinised squamous epithelium and skin appendages as demonstrated histologically. Total number of Dermoids in our study is 12 and showed the following MRI features:

Predominantly cystic or solid – cystic mass with Heterogeneous hyperintense signal on both T1 and T2 images with foci / areas of suppression in the fat sat sequences.

MR is sensitive and specific in the diagnosis of dermoids mainly because of its ability to detect intratumoral fat with the combination of T1-weighted imaging and fat-saturated T1-weighted

imaging. Chemical –selective fat saturated T1Weighted imaging is mandatory for diagnosis of teratomas as hemorrhage or a high concentration of protein can also cause T1 shortening<sup>(15)</sup>. Other MRI findings for cystic teratomas includes layering or floating debris, soft tissue protruberences, and low signal intensity teeth. MRI is also collaborative in identifying complications associated with dermoid cysts such as torsion ,rupture and malignant transformation. On DWI, variable pattern was noted: The cystic contents showed restricted diffusion in four cases. Complex solid and cystic mass showed heterogenous pattern with solid areas appearing dark on both DWI and ADC-T2 black out effect in four cases. Four cases showed peripheral wall restriction along the wall. 2 others were complicated by torsion ,which showed thickening of pedicle, engorged blood vessels on the ipsilateral side, obliteration of fat planes, pelvic ascites and deviation of the uterus to the side of the affected ovary itself, corroborating with Chang et al (16) and in a study by OmneyaY. Dogheim et al. the mature cystic teratoma showed heterogeneous hyperintense T1 and T2 signal that suppressed in the fat sat sequence<sup>(12)</sup>. The mean ADC value in our cases was 0.6mm<sup>(2)</sup>. There was a considerable overlap with malignant group. In a study by Tomohiro Namimoto et al. the cystic components of mature cystic teratomas had significantly lower ADC values than endometriomas, malignantneoplasms, and benign neoplasms. The cystic components if mature cystic teratomas usually fat<sup>(17)</sup>. Because DWI with EPI sequences usually uses a fat saturation RF pulse, the low ADC values of the cystic component of mature cystic teratomas have been attributed to artifacts caused by coexisting fat within the tumor<sup>(18,26)</sup>. Furthermore, mature cystic teratoma is lined with keratinized squamous epithelium in most cases<sup>(28)</sup>. The restricted Brownian movement of water molecules within the keratinoid substance results in a high signal on DWI and a low ADC value, which was first utilized in the diagnosis of intracranial epidermoid

cyst(19). Detecting the keratinoid substance by means of DWI and the ADC value may be useful and serve as an adjunctive tool to ensure the accuracy of the diagnosis, particularly in patients with fatless mature cystic teratoma.

### **Pelvic Inflammatory Disease (PID)**

PID is a common diagnosis among women in reproductive age and sexual activity. PID is usually a clinical and laboratory diagnosis. Imaging studies are performed in uncertain diagnosis or who are not responding to therapy. The total number of PID cases in our is 12, showing varied presentations. Hydrosalpinx with thickened tubes was seen in 6 patients, 4 patients showed tubo-ovarian abscesses and 2 patients showed thickened tubes with no dilatation: salpingitis. All cases were between 2nd to 4th decade. Four of the twelve lesions were diagnosed as tuberculoustubo-ovarian abscesses. Two cases of bilateral tubal thickening was chlamydial salpingitis. MRI shows 95% sensitivity and 89% specificity in the tuboovarian abscess diagnosis. On MRI irregular thick wall, markedly enhancing after contrast administration band stranding in the surrounding fat plane are characteristic. In our study, On MRI, The hydrosalpinx showed fluid attenuations i.e T1W hypointense and hyperintense on T2W images. Tubo-ovarian abscesses showed iso-hypointensity on T1W images and iso-hypointensity on T2W images, with thick irregular walls which enhanced on contrast administration. Two cases of bilateral salpingitis showed T2 iso-hypointensity with significant contrast enhancement. On DWI there was restriction of diffusion of walls in hydrosalpinges which corresponded to the contrast uptake. Cystic pelvic abscess showed restricted diffusion the mean ADC value is 1.5. Bilateral salpingitis showed restricted diffusion, Mean ADC was 0.9.

Relatively low signal intensity on T2W images representative of fibrosis is an important tool in the accurate diagnosis of this condition.

### Benign Ovarian Neoplasms

Cystadenomas are true cystic epithelial ovarian neoplasm. Serouscystadenomas are common and account for 25%of benign ovarian neoplasm. Incidence peaks between 20 and 50 years old, bilaterally in 12-23% cases .The lining of the cyst is flat or may have small papillary projections. The typical MRI appearance of serous cystadenoma is unilocular cyst with thin wall.

Mucinous cystadenomas account for 41% of benign ovarian neoplasms, 2-5% are bilateral Mucinous cystadenomas are larger, multilocular, containing gelatinous material or fluid of various viscosities showing various signal intensities on both T1 –and T2-weighted images-stained glass appearance. Presence of thick wall or septa may suggest borderline lesions while solid component suggests carcinoma. The total number of benign serous cystadenomas is 8 and mucinous cystadenomas is 12.They showed the following MRI features:

All the benign cystadenomas showed hypointense signal on T1W images and hyperintense signal on T2W images. The serous cystadenomas are unilocular,thin walled with no septations or solid components while the mucinous cystadenomas are multilocular, thickwalled, containedseptations with no vegetations or papillary projections. The mean ADC values were 1.7

The 12 mucinous cystadenomas showed complex cystic nature with stained glass appearance. 2 of them showed areas of restricted diffusion (could be attributed to the viscid contents) while the others did not restrict. All of them were given contrast owing to complex nature with multiple internal septations and the absence of internal solid components could not be confirmed in the precontrastsequences. The patients with serous cystadenoma had a simple cystic lesion. No contrast was administrated. Jung et al. reported similar criteria as regards the differentiation between these two pathological entities. It was stated that a tumor that manifests as an unilocular or multilocular cystic mass with homogeneous CT attenuation or MR imaging signal intensity of the

locules, a thin regular wall or septum, and no endocystic or exocystic vegetation is considered to be a benign serous cystadenoma And a tumor that manifests as a multilocular cystic mass that has a thin regular wall and septa or that contains liquids of different attenuation or signal intensity but has no endocystic or exocystic vegetation is considered to be a benign mucinous cystadenoma and that mucinous cystadenomas tend to be larger than serous cystadenomas at presentation <sup>(20)</sup>.

Two out of the each mucinous and serous cystadenomas were complicated by ipsilateral ovarian torsion. Both showed thickening of the ipsilateral fallopian tube, ipsilateral edematous and enlarged ovary and associated ascites. The total number of benign ovarian neoplasms is 1. showed the following MRI features: All the 6 patients with borderline cystadenocarcinomas showed large encapsulated, lobulated, thick walled masses with complex solid cystic components. Masses were heterogeneous in signal intensity showing minimal hyperintense periphery and central hypointensity on T1W images and on T2W images they were hyperintense with hypointenseperiphery. They showed fluid fluid levels. They did not show any fat suppression. On DWI they showed peripheral restriction. The mean ADC value was 0.7

In a study conducted on 283 women with adnexal masses, Hassen et al. stated that the association of morphologic and vascular ultrasound findings could highly suggest the diagnosis of benign or malignant papillary projection. It was concluded that for papillary projections  $\geq 10$  mm, color flow was present in all malignant, in 86% of borderline, and absent in all benign tumors <sup>(21)</sup>. Bouic-Pages et al. stated that the presence of vegetations or papillary excrescences suggests the diagnosis of borderline epithelial tumor and that their number and size are proportionally related to the tumor aggressiveness <sup>(22)</sup>.

### Malignant Ovarian Neoplasms

The total number of Malignant ovarian neoplasms is 20. 16 were malignant mucinous cystadenomas



and 4 are endometrioid CA of ovary. Four patients had associated peritoneal carcinomatosis and liver deposits. They showed the following MRI features:

The Endometrioid CA of ovary showed iso to hyperintense signal on T1W images and hypointense on T2W images. There was not suppression of fat on fatsatimages. on contrast administration there was enhancement of solid areas. DWI images showed restricted diffusion.

The patients with mucinous cystadenocarcinomas had a large multilocular, thickwalled complex solid cystic lesion with stained glass appearance. Iso to hypointense on T1W images and hyperintense solid component & hyperintense cystic components with hypointense solid component on T2W images. showed solid areas and papillary projections. On contrast administration there was wall & septal enhancement. DWI: showed restricted diffusion of septae and solid papillary areas with ADC value of 0.6. Thomassin –Naggara et al reported the following MRI criteria predictive of malignancy; Vegetations, an irregular heterogenous solid component with intermediate signal intensity at T2W imaging, a solid component with high signal on DWI images obtained at High Bvalue, a solid component with type 3 curve on PW images, or associated abdominal or pelvic ascites or peritoneal implants<sup>(23)</sup>. Most evidence in literature indicated hyperintensity on T2 and DWI as a feature suggestive of malignancy in solid component. Salvatore Cappabianca et al. stated that irrespective of the histological type of the mass actual determinant for signal on DWI and ADC value of cystic component is its content and its degree of viscosity. In the same study 4 of 35 malignant lesions showed abnormal behaviour resulting in hypointensity on T2W images, in which the histology revealed abundant desmoplastic component responsible for shortening of T2 relaxation time & at the same time for restriction of Brownian motion of water molecules. The latter feature is responsible for signal on diffusion weighted images and for

measured ADC value, also on basis of marked enhancement shown on images acquired after contrast administration<sup>(24)</sup>.

Similarly knowledge of histopathology features of solid components i.e presence of multiple foci of cellularity, necro-hemorrhage, hyaline& fibrous components allowed us to understand how a normal hypointensity on T2W images could be associated with unexpected hyperintensity on DWI. Considering the discrepancy between the appearance of several lesions on T2W images and DWI where ever necessary the evaluation of images from conventional sequences before and after contrast injection must be done.

### Utility of DWI in Adenexal Lesions

Our study group included 84 benign masses, 28 malignant tumours including 2 borderline tumour. Malignant lesions only showed definite high signal intensity on DWI images.

In contrast none of the benign tumours (cystadenomas) showed restricted signal on DWI.

Our results are comparable to a study by Koyama et al (55) on 35 women to determine the accuracy of DW imaging in the characterisation of ovarian masses in patients undergoing pelvic MRI. Addition of DWI to conventional sequences has increased specificity. There were false positive cases showing restricted diffusion in abscess, and teratomas. Similar cases of false positive cases were reported by Fujii et al<sup>(29)</sup>. Restriction was noted in 20 out of the 34 endometrioma patients.

In benign category: areas of restricted diffusion was seen in 46 out of 84 patients; two mucinous cystadenoma, all PID, 20 endometrioma and 12 mature cystic teratoma.

In the malignant category; all 28 patients showed restricted diffusion with ADC values of 0.5. In our study we have encountered metastatic disease in 8 patients and they showed the following MRI features: There was involvement of pelvic bones predominantly. There is significant alteration of morphology and signal intensity pattern of hemipelvis, involving Ilium, sacroiliac joint and sacrum evident as diffuse marrow hypointensity

on T1w and hyperintensity on T2w/ STIR images. Involvement of spine was also seen. Peritoneal and omental nodules and ascites was seen. Peritoneal cavity is the commonest site for metastasis from gynaecological malignant tumors especially ovarian cancers. There was metastasis to pelvic lymphnodes which showed hypointensity on T1W images and hyperintensity on T2W images. Lin et al. also reported similar findings showing relative ADC values and DWI, ADC in detecting metastatic lymph nodes which showed restricted diffusion and lower ADC values in 50 patients with cervical and uterine cancers <sup>(25)</sup>. Restriction of diffusion was seen in peritoneal metastatic nodules. DWI has a high accuracy at detecting peritoneal dissemination. Mean ADC value was 0.7. The presence of restriction and its principles in cases of benign group are discussed in detail in individual sections. Hence, restricted diffusion is seen in all malignant lesions, However some benign lesions may also show restricted diffusion. As long as interpretation of DWI is combined with the conventional MR images and with realising of the possible pitfalls, it has shown to be effective in the differentiation of benign from malignant adenexal masses. However, an ovarian adenexal mass with a solid component that exhibits low signal on T2W images and a low signal on high b-value diffusion-weighted images is always benign.

**Pitfalls:** T2 shine through effect, T2 black out effect, Ovarian cystic lesions with restricted diffusion, Inflammatory solid lesions with restricted diffusion. & well differentiated malignant tumours.

### ADC Analysis

Determining the threshold of the ADC for diagnosing cystic ovarian tumors is difficult because of their large variance <sup>(20)</sup>. In our study, there was significant overlap of ADC values with benign conditions.

Several authors who carried out studies similar to ours excluded from their series mature cystic teratomas and endometriomas. The DWI features

in these cases totally overlapped those of malignant lesions, which is significant in statistical data. Moreover, both mature cystic teratomas and endometriomas are identified through the use of conventional sequences, without the need for integration with DWI.

### Limitations, Challenges and Future Trends

The main limitation of the study is the small number of cases, which did not allow further detailed statistical analysis. This was due to slow acceptance by the gynecology colleagues to the utility of our technique. Because DWI has relatively poor spatial resolution, detection of small lesions on DWI may be limited. It is necessary to refer to conventional morphological evaluation on T1W and T2W for sufficient identification of lesion boundaries.

A major challenge to widespread to the widespread implementation is the lack of acceptable standard approach to data collection and analysis. Standardisation will allow for improved repeatability and reproducibility based on diffusion indices. Reproducible measurements are particularly important to determine both the limits of using quantitative ADC values.

Therefore, now that these sequences have acquired wider acceptance among our clinical colleagues, we plan to study these sequences on a larger scale using statistical analysis and technology development.

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