# Utility of magnetic resonance imaging in differentiating T1 fat saturated hyperintense lesions

**Authors**

1) **Suhail Rafiq, Senior Resident, Department of Radiodiagnosis and Imaging, GMC Srinagar, India.**
2) **Sheema Posh, Senior Resident, Department of Obstetrics and Gynaecology, SKIMS, India.**
3) **Inayat Ellahi, Senior Resident, Department of Radiodiagnosis and Imaging, GMC Srinagar, India.**
4) **Shabir Bhat, Associate Professor, Department of Radiodiagnosis and Imaging, GMC Srinagar, India.**

**Corresponding Author : Dr. Inayat Ellahi, Senior Resident, Department of Radiodiagnosis and Imaging, GMC Srinagar, India; Email : drmusaib57@gmail.com**

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**Abstract:**

**Background:** Endometriosis is defined as non- neoplastic endometrial glands and stroma residing outside of the uterine cavity and myometrium. Magnetic resonance (MR) imaging has been shown to have higher specificity than ultrasonography (US) for diagnosis of endometriomas. "T2 shading" is the classic MR feature of an endometrioma and is defined as a cystic lesion with hyperintense signal on a T1-weighted image that demonstrates T2 shortening resulting in relative hypointensity on T2-weighted images. A new sign T2 dark spot defined as discrete, markedly hypointense foci within the cyst on T2weighted images with or without T2 shading was found to have higher specificity. **Objectives**: To assess sensitivity and specificity of T2 shading and T2 dark spot for diagnosing endometriomas. **Methods**: This was a prospective study done in collaboration by department of radiodiagnosis and imaging and department of gynecology and obstetrics from January 2019 to December 2019. 56 Females with T1 hyperintensity lesions on fat sat sequences on magnetic resonance imaging with pathologic diagnosis or follow up ultrasound revealing involution or significant decrease in size were assessed for finding sensitivity and specificity of T2 dark spot and T2 shading. **Results**: Multiplicity was found in 58% cases of endometriomas and only 4.1% of hemorrhagic cysts demonstrated multiplicity (p value<0.001). The sensitivity, specificity, positive and negative predictive values for T2 shading are 90.1%, 55.1%, 80.8% and 72.7% respectively. The sensitivity, specificity, positive and negative predictive values for T2 dark spot are 39.3%, 93.1%, 92.3% and 42.1% respectively. **Conclusion:** Both T2 shading and T2 dark spot increase the diagnostic confidence of radiologists in diagnosing endometriomas. T2 shading is sensitive while as T2 dark spot is more specific for endometriomas. Multiplicity of lesions is also in favor of endometriomas. This is particularly helpful to gynecologists in starting early treatment for endometriomas rather than waiting for pathological biopsies.

**Keywords:** Endometriomas, hemorrhagic cyst, T2 shading, T2 dark spot, T1-weighted image, T2-weighted images.

Endometriosis is a chronic gynaecological condition affecting women of reproductive age and may cause pelvic pain and infertility. Endometriosis is defined as non-neoplastic endometrial glands and stroma residing outside of the uterine cavity and myometrium. This ectopic endometrium responds to hormonal stimulation, causing various degrees of cyclic hemorrhage, which results in inflammation, fibrosis, and adhesion formation in the surrounding tissues. Endometriosis most commonly affects women of childbearing age, with a mean age at presentation of 25-29 years. The estimated prevalence of endometriosis is 5-10%, including both symptomatic and asymptomatic females [1]. Approximately 5% of endometriosis is seen in postmenopausal women[2]. The gold standard for the diagnosing pelvic endometriosis is laparoscopy biopsy of lesions with histopathologic confirmation [3]. Endometriosis can cause devastating effect on fertility; radiologists must be familiar with characteristic imaging features of the

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disease. Radiologist must be able to differentiate from other pelvic lesions like hemorrhagic or corpus luteal cysts which don't require any surgical treatment. Magnetic resonance (MR) imaging has been shown to have higher specificity than ultrasonography (US) for diagnosis of endometriomas [4]. "T2 shading" is the classic MR feature of an endometrioma and is defined as a cystic lesion with hyperintense signal on a T1-weighted image that demonstrates T2 shortening resulting in relative hypointensity on T2-weighted images [5]. The cause of T2 shading is repeated hemorrhage leading to high concentration of protein and degraded blood products. This sign was initially reported to have very high specificity (96%) for endometriomas but because other hemorrhagic adnexal lesions like hemorrhagic cysts can lead to T2 shading [6]. This sign was found to have moderate specificity of 83% [7]. A new sign T2 dark spot defined as discrete, markedly hypointense foci within the cyst on T2weighted images with or without T2 shading was found to have higher sensitivity and specificity.

Aim and objectives: To assess sensitivity and specificity of T2 shading and T2 dark spot for diagnosing endometriomas.

**Materials and methods**

This was a prospective study done in collaboration by department of radiodiagnosis and imaging and department of gynaecology and obstetrics from January 2019 to December 2019. Images were acquired with a 3-T MR imaging system (Somatom Skyra) with a phased-array body coil. Sequences that were acquired include T2-weighted axial, sagittal and coronal single-shot fast spin-echo, T1 axial, sagittal and coronal single shot echo with and without fat saturation with FOV of 26.0 cm, section thickness of 5 mm, section interval of 6.0 mm and matrix, 256x256. 56 females with T1 hyperintensity lesions on fat sat sequences on magnetic resonance imaging with pathologic diagnosis or follow up ultrasound revealing involution or significant decrease in size were assessed for finding sensitivity and specificity of T2 dark spot and T2 shading. Since many women had bilateral or multiple lesions total of 90 cystic lesions were assessed. The patients were divided into two groups: Those with T2 shading without T2 dark spot and those with combined T2 dark spot and T2 shading. All dark spots were confirmed on ultrasound to rule out any calcification. There was no group of patients with only T2 dark spot without shading.

Inclusion criteria: All patients with T1 fat saturated hyperintense adnexal lesions on magnetic resonance imaging.

Exclusion criteria: 1) Cystic lesions losing signal of T1 fat Saturation sequences, 2) Lesions with calcification or solid component, 3) Patients with contraindication to MRI or refusal to participate in the study.

Statistical analysis: Categorical values were presented with absolute and relative frequencies (%) and continuous values with mean. Sensitivity, specificity, positive and negative predictive values were calculated.

**Results**

The mean age of women with T1 hyperintense lesions was 32.6 years. Total number of lesions with T1 hyperintensity on MRI was ninety. Sixty one were endometriomas, twenty four were hemorrhagic cysts, three were clear cell carcinomas and two were serous cystadenomas. Total number of lesions that demonstrated T2 shading were 68(75.5%) out of 90. About 55(80.8%) out of 68 lesions that demonstrated T2 dark shading were endometriomas (figure 1), 10(14.7%) out of 68 lesions that demonstrated T2 dark shading were hemorrhagic cysts, two (2.9%) out of 68 lesions that demonstrated T2 dark shading were clear cell carcinoma and one (1.47%) out of 68 lesions that demonstrated T2 dark shading was serous cystadenomas demonstrated T2 shading (table 1 and table 2).

**Table 1: Lesions with T2 dark spot (N=68)**

| **Lesions demonstrating T2 shading** | **Frequency (%)** |
|---|---|
| Endometriomas | 55(80.8%) |
| Hemorrhagic cyst | 10(14.7%) |
| Clear cell carcinoma | 2 (2.9%) |
| Serous Cystadenoma | 1 (1.47%) |

| **Table 2: Statistical analysis table related to T2 shading** | | | |
|---|---|---|---|
| **Results** | **Endometrioma** | | **Total** |
| T2 Shading | Proven | Not proven | |
| Seen | 55(TP) | 13(FP) | 68 |
| Not seen | 6(FN) | 16(TN) | 22 |
| TP - True positive, FP - False positive, FN - False negative, TN - True negative. | | | |

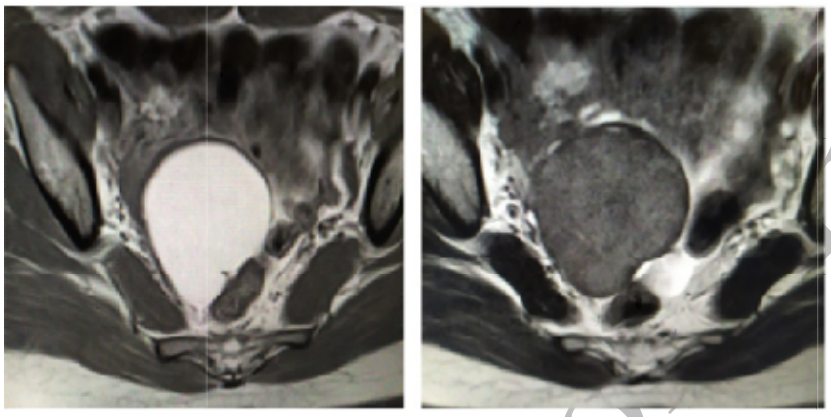

**Figure 1: Axial T1 and T2 weighted images showing T1 hyperintense lesion with T2 shading. No dark spot is seen**

Total number of lesions that demonstrated T2 dark spot were 26(28.8%) out of 90. 24(92.3%) out of 26 lesions that demonstrated T2 dark spot were endometriomas (figure 2 and 3), 2(7.6%) out of 26 lesions that demonstrated T2 dark spot were biopsy proven clear cell carcinomas (table 3 and 4). The average size of T2 dark spot in our study was 7.6mm. Most common shape of T2 dark spot was oval (N=17) followed by round shape (N=6). The mean size of endometrioma and hemorrhagic cyst in our study was 4.2cms and 3.2cms (P value>0.05). Multiplicity was found in 58% cases of endometriomas and only 4.1% of hemorrhagic cysts demonstrated multiplicity (p value <0.001). The sensitivity, specificity, positive and negative predictive values for T2 shading are 90.1%, 55.1%, 80.8% and 72.7% respectively. The sensitivity, specificity, positive and negative predictive values for T2 dark spot are 39.3%, 93.1%, 92.3% and 42.1% respectively.

| **Table 3: Lesions with T2 dark spot** | |
|---|---|
| **Lesions demonstrating T2 dark Spot** | **Frequency (%)** |
| Endometriomas | 24 (92.3%) |
| Clear cell carcinoma | 2 (7.6%) |
| Total | 26 |

| **Table 4: Statistical analysis table related to T2 dark spot** | | | |
|---|---|---|---|
| **Results** | **Endometrioma** | | **Total** |
| T2 dark spot plus shading | Proven | Not proven | |
| Seen | 24(TP) | 2(FP) | 26 |
| Not seen | 37(FN) | 27(TN) | 64 |
| TP - True positive, FP - False positive, FN - False negative, TN - True negative | | | |

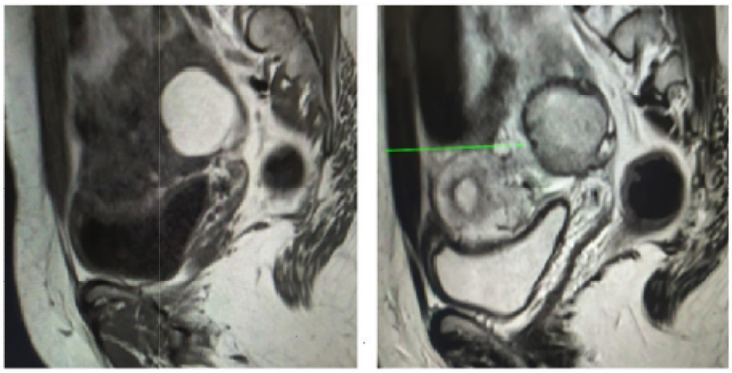

**Figure 2: Sagittal T1 and T2 weighted images showing T1 hyperintense lesion with T2 shading and T2 dark spot (arrow) in proven case of endometrioma.**

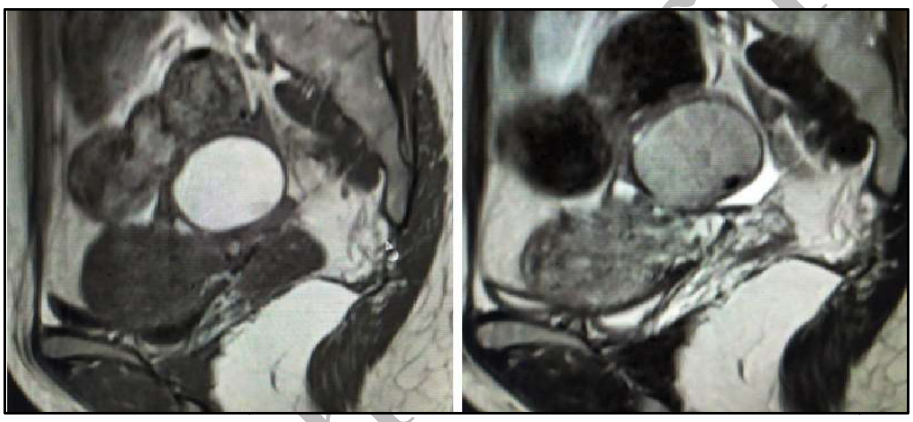

**Figure 3: Sagittal T1 and T2 weighted images revealing T1 hyperintense lesion with T2 shading and T2 dark spot.**



**Discussion**

Diagnosis of endometriomas on MRI is based on the T1 and T2 shortening that occurs due to repeated hemorrhage within these lesions leading to high viscosity, high concentrations of protein, and degraded blood products [8]. The T1 shortening leads to hyperintensity on T1-weighted images, and the T2 shortening leads to relative hypointensity on T2-weighted images, or T2 shading. The findings of multiple hyperintense lesions on T1-weighted images with or without shading or single lesions with T2 shading was described by Togashi et al[6] to be highly sensitive (98%) and specific (96%) for the diagnosis of endometriomas. However, of the 268 nonendometrioma lesions included in the study, there were only 10 hemorrhagic lesions. Five of these were correctly interpreted as nonendometriomas, and five were incorrectly interpreted as endometriomas. Therefore, a subsequent study [7] was performed to examine the same MR imaging criteria applied to only hemorrhagic lesions, and only moderate sensitivity (68%) and moderate specificity (83%) of T2 shading for the diagnosis of endometriomas were found. In our study, multiplicity was seen in 58% (35 of 61) of endometriomas and only 4.1% (one of 24) of hemorrhagic cysts, confirming the specificity of T2 shading in multiple lesions. However, in solitary of endometrioma diagnosis still cannot be made with certainty as 41% of hemorrhagic cysts demonstrated T2 shading in our study, making it less specific. According to our study, the sensitivity, specificity, positive and negative predictive values for T2 shading are 90.1%, 55%, 80% and 72% respectively and the sensitivity, specificity, positive and negative predictive values for T2 Dark spot are 39.3%, 93%, 92% and 42% respectively. This is in accordance to Corwin MT et al[9] who reported Sensitivity, specificity,

positive predictive value, and negative predictive value of T2 dark spots for differentiating endometriomas from other hemorrhagic cystic ovarian masses were 36% , 93%, 89%, and 48%, respectively, and for T2 shading, they were 93%, 45%, 72%, and 81% respectively.

T2 dark spots increases the specificity of diagnosing endometriomas. It represents desiccated and old retracted blood clots that contain a high concentration of protein and/or hemosiderin due to loss of water and high concentration of hemosiderin leading to marked T2 shortening. Retracted blood clots are also seen in hemorrhagic cysts at USG [10] but they are short-lived. They may not have sufficient time to lose free water or have high concentration of hemosiderin to cause marked T2 shortening. The small size of the dark spots may support this theory, as clots decrease in size as they continue to retract. Low sensitivity of T2 dark spots could be explained by the fact that many endometriomas are completely hypointense on T2-weighted images which obscures any dark spots. None of the hemorrhagic cysts demonstrated T2 dark spots, 2 out of 3 biopsy proven clear cell carcinomas demonstrated dark spot. Clear cell carcinomas are a known to arise in endometriosis [11] and are expected to show dark spot and T2 shading. T2 shading has high sensitivity and t2 dark spot has high specificity for endometriomas.

Limitation of our study is that we had pathologic proof in only 10 of 25 hemorrhagic cysts. However, resolution or decreased size at follow-up imaging is an accepted method to diagnose hemorrhagic cysts [12]. Further only non-resolving hemorrhagic cysts or complex hemorrhagic cysts are usually sent for magnetic resonance imaging.

**Conclusion**

Both T2 shading and T2 dark spot increase the diagnostic confidence of radiologists in diagnosing endometriomas. T2 shading is sensitive while as T2 dark spot is specific for endometriomas. Multiplicity of lesions is also in favour of endometriomas. This is particularly helpful to gynaecologists in starting early treatment for endometriomas rather than waiting for pathological biopsies.

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**Conflict of interest:** None. **Disclaimer:** Nil.