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## **Abdominal Imaging**

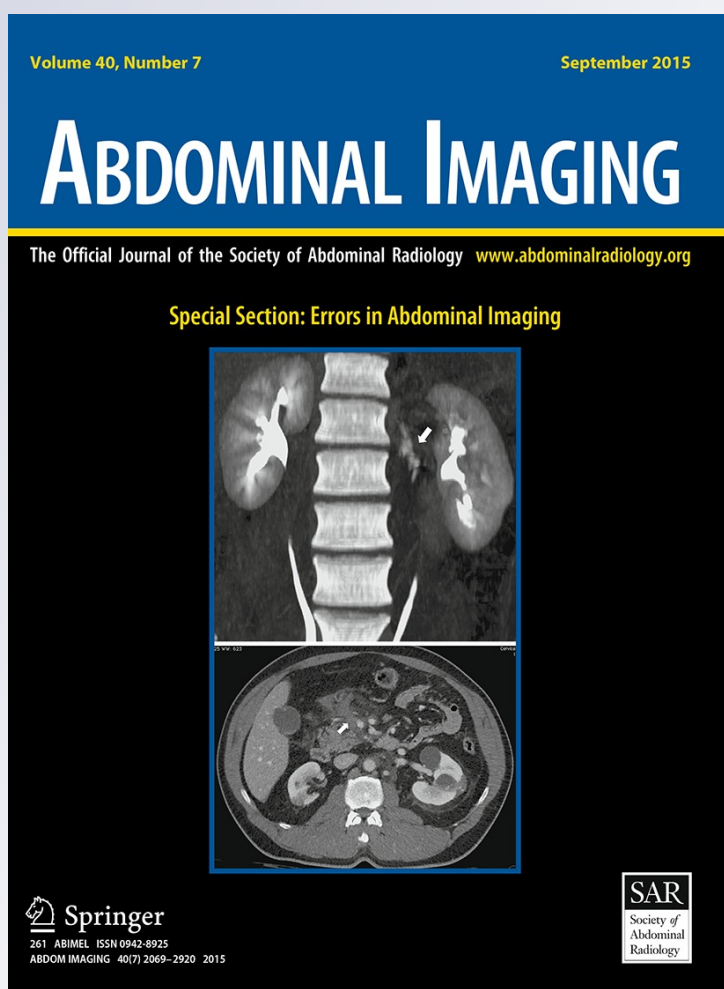
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# The shading sign: is it exclusive of endometriomas?

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## Abstract

**Objectives:** To investigate if the shading sign is an exclusive MRI feature of endometriomas or endometrioid tumors, and to analyze its different patterns.

**Methods:** Three hundred and forty six women with adnexal masses who underwent 1.5/3-T MRI were included in this retrospective, board-approved study. The shading sign was found in 56 patients, but five cases were excluded due to lack of imaging follow-up or histological correlation. The final sample included 51 women. The type of tumor and the pattern of shading were recorded for each case.

**Results:** Thirty endometriomas and five endometrioid carcinomas were found. The remaining 16 cases corresponded to other benign and malignant tumors. The overall sensitivity, specificity, positive predictive value, and negative predictive value were 73%, 93%, 59%, and 96%, respectively. Restricting the analysis to cystic lesions without solid or fat component, sensitivity, specificity, positive predictive value, and negative predictive value were 73%, 96%, 94%, and 80%. Five shading patterns were identified: layering (15.7%), liquid–liquid level (11.8%), homogenous (45.1%), heterogeneous (11.8%), and focal/multifocal shading within a complex mass (19.6%). No significant correlation was found between these patterns and the type of tumor.

**Conclusions:** The shading sign is not exclusive of endometriomas or endometrioid tumors. Homogenous shading was the most prevalent pattern in endometriomas

and half of the cases with focal/multifocal shading within a complex mass were endometrioid carcinomas.

**Key words:** Endometrioma—Endometrioid carcinoma—Magnetic resonance imaging—Gynecology—Imaging

The shading sign is the magnetic resonance imaging (MRI) finding of T2 shortening [low signal on T2-weighted images (T2WI)] in an adnexal cyst that is hyperintense on T1-weighted images (T1WI) [1].

The mechanism of shading is complex: the high viscosity of the cystic fluid and the high concentration of protein and iron from recurrent hemorrhage (that is about 10–20 times the concentration of whole blood) are all pointed as responsible for T2-shortening, leading to signal intensity loss [2]. On the other hand, intra and extracellular methemoglobin markedly shortens the T1 and T2 relaxation times of fluids, resulting in hyperintensity on T1WI and hypointensity on T2WI [3].

Historically, the shading sign has been considered a distinguishing feature of endometriomas on MR imaging. First described in 1987 by Nishimura and his team [4], the shading sign was confirmed to be associated with endometriomas by the work of Togashi et al. [5], in 1991, that evaluated 374 female patients and concluded that a definitive diagnosis of endometrioma could be made when a cyst that was hyperintense on T1WI exhibited hypointense signal on T2WI (shading), reporting a sensitivity of 90% and a specificity of 98%.

However, as shading possibly reflects the chronic nature of an adnexal hemorrhagic lesion, resulting from cyclic bleeding with blood products accumulating over months to years, it is possible that other T1 hyperintense lesions with high concentrations of iron and protein may also have short T2-relaxation time. Accordingly, some papers have shown that T2 shading can also be seen in other hemorrhagic adnexal lesions, namely hemorrhagic cysts. Already in 1993, in a study that included several hemorrhagic adnexal lesions, Outwater and colleagues [6] proved that a cyst with high signal intensity on T1WI and shading T2WI had a mean sensitivity of only 68%, mean specificity of 83%, and mean accuracy of 76% for diagnosis of endometrioma. A recently published paper including 74 cystic hemorrhagic adnexal lesions found the shading sign to be present in endometriomas but also in hemorrhagic cysts and neoplasms, reporting a sensitivity of 93% and specificity of 45% for the diagnosis of endometrioma [7].

The purpose of this study was to investigate if the shading sign is an exclusive MRI feature of endometriomas or endometrioid tumors, and to analyze its different patterns.

## Materials and methods

This is a retrospective, descriptive, board-approved study.

### *Patients*

A total of 346 women with adnexal masses who underwent 1.5- or 3-T MRI were included. The shading sign was found in 56 patients. However, five cases were excluded due to lack of follow-up or histological correlation. The final sample included 51 women, with ages ranging from 19 to 88 years (mean age, 47). Among these 51 patients, 47 underwent 1.5-T MRI and only 4 performed 3-T MRI.

### *MR examination*

Each patient underwent an MRI examination at 1.5- or 3-T unit after inconclusive ultrasound examinations. Our hospital receives oncological patients from several districts of the country, so multiple scanners and protocols were used. For the identification of the shading sign, all the final MR examinations had to include non-fat-saturated T1WI and T2WI in the same plane. Pre- and post-gadolinium fat-saturated T1WI were also required in order to exclude fat content and solid-enhancing lesions.

### *Follow-up and histological examination*

The type of tumor was recorded taking into account clinical and imaging follow-up (6–12 months of interval between examinations), imaging-guided biopsies, and surgical specimens analysis. Some clinical features were used to favor the diagnosis of endometrioma, namely complains of dysmenorrhea and cyclical pelvic pain in

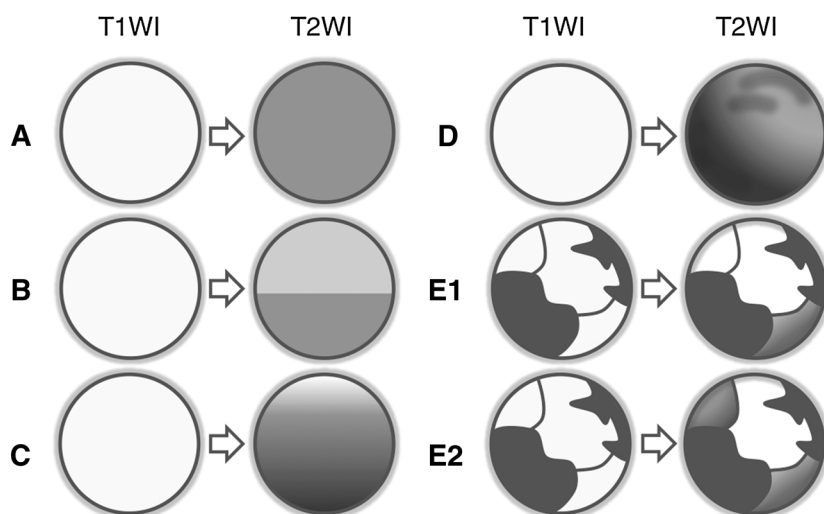
premenopausal patients. The diagnosis of endometrioma was considered on 6–12 months follow-up examinations whenever a purely cystic lesion with hypersignal on T1WI and hyposignal on T2WI did not change its size, morphology, internal structure, and signal intensity evolution between T1WI and T2WI. Since no specific guidelines may be found in the literature regarding the MRI follow-up of endometriomas, this 6–12-month interval was arbitrarily stated and depended on the diagnostic exams brought by the patients at the time of admission at our institute. By establishing this gap time, we were able to both exclude hemorrhagic cysts, which normally disappear after 6–12 weeks, and early malignant transformation, which would be expected to show new solid component or a subjective disappearance or change in the pattern of shading. Senior Pathologists, specialized in gynecological oncology with at least 10 years of experience, reported the biopsy and surgical specimen analysis.

### *MR data evaluation*

One Gynecological Radiologist and two Radiology Fellows (with 19 and 5 years of experience in interpreting pelvic MRI, respectively) retrospectively evaluated MR data of all 346 patients, without prior knowledge of histological results or patient follow-up. The three readers analyzed all examinations and the results were recorded by consensus. We considered the shading sign to be present when a complete or partial loss of the signal intensity is seen within a T1WI hyperintense adnexal cyst or cystic portion of an adnexal complex lesion on the corresponding T2WI. Hyperintensity on T1WI was qualitatively assessed in comparison to the signal intensity of pelvic floor muscles. The pattern of shading was also described for each case and divided in five groups: (a) layering, when the lesion showed progressive layered signal loss on T2WI; (b) liquid–liquid level, when a well-defined level is found within the cyst; (c) homogenous, with complete and regular loss of signal on T2WI; (d) heterogeneous, with complete or partial signal loss but in a nonhomogeneous fashion; (e) focal/multifocal shading within a complex mass, when one or more cystic portions of complex mass show signal loss on T2WI (Fig. 1).

### *Statistical analysis*

Baseline characteristics, sensitivity, and specificity of the shading sign for the diagnosis of endometriomas and association between pathological diagnosis and the patterns of shading using the  $\chi^2$  test, were performed using STATA 13 Statistical Package, StataCorp 4905 Lakeway Dr College Station, TX 77845 USA.



**Fig. 1.** Illustration representing the five patterns of shading (A Homogeneous; B liquid-liquid level; C layering; D heterogeneous; E1 focal shading within a complex mass; E2 multifocal shading within a complex mass).

## Results

Thirty endometriomas (58.8%), five endometrioid carcinomas (9.8%), three serous carcinomas, three serous adenofibromas, three mucinous borderline tumors, three cystic mature teratomas, one unclassifiable primary carcinoma, one mucinous unclassifiable primary tumor, one mucinous borderline tumor within an endometrioid cyst, and one struma ovarii were found among the 51 cases with positive shading.

The diagnosis of 34 tumors was histologically confirmed. In 17 cases (all of them corresponding to endometriomas), the diagnosis was presumed by imaging follow-up with a 6 to 12 months time gap between examinations.

The overall sensitivity and specificity of shading in the diagnosis of endometrioma were 73% (95% confidence interval [CI] 56.8, 85.2) and 93% (95% CI 89.3, 95.5), respectively. Positive and negative predictive values were 59% (95% CI 44.2, 72.1) and 96% (95% CI 93.1, 98.0), respectively. Considering only a cystic lesion without evident solid component, sensitivity, specificity, positive predictive value, and negative predictive value were 73% (95% confidence interval [CI] 56.8, 85.2), 89% (95% CI 76.1, 96.0), 85% (95% CI 69.0, 95.0), and 79% (95% CI 65.5, 88.7), respectively. Restricting now the analysis to cystic lesions without evident solid or fat component, sensitivity, specificity, positive predictive value, and negative predictive value in the diagnosis of endometrioma were 73% (95% confidence interval [CI] 56.8, 85.2), 86% (95% CI 56.2, 97.5), 94% (95% CI 77.8, 98.9), and 52% (95% CI 31.1, 72.6), respectively.

Five shading patterns were identified: layering, liquid-liquid level, homogenous, heterogeneous, and focal/multifocal shading within a complex mass, as described in Table 1. No significant correlation was found between these patterns and the type of tumor. However, the authors emphasize two points: homogenous shading

was the most prevalent pattern in endometriomas (17/30, 57%) and half of the cases with focal/multifocal shading within a complex mass corresponded to endometrioid carcinomas (5/10, 50%).

## Discussion

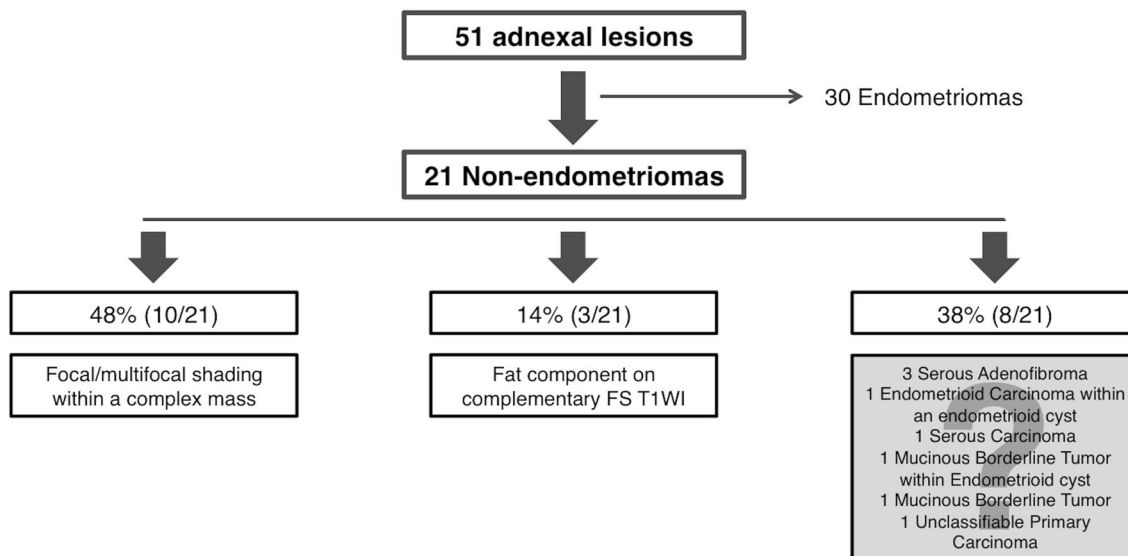
The shading sign has been considered a distinguishing feature of endometriomas at MRI. It corresponds to the complete or partial loss of the signal intensity of a hyperintense adnexal cyst from T1WI to T2WI. However, our daily practice showed us that the same signal loss is seen in other cysts and even in cystic portions of mixed masses. This study demonstrates that the shading sign is not exclusive of neither endometriomas nor endometrioid tumors.

To the best of our knowledge, some studies have been published regarding the diagnostic accuracy of the shading sign for endometriomas, but data in the literature are scarce concerning its patterns and false positives. During this retrospective analysis, the authors found five different shading patterns: layering, liquid-liquid level, homogenous, heterogeneous, and focal/multifocal shading within a complex mass. Despite no significant correlation was proven between shading patterns and histological types of tumor, some points might be highlighted. First, homogenous shading was the most prevalent pattern in endometriomas (17/30), followed by heterogeneous (6/30), layering (5/30) and liquid-liquid level (2/30). Second, all lesions with heterogeneous shading sign were endometriomas (6/6), as well as the majority of lesions with homogenous shading (17/23) and layering shading (5/8). Third, none of the endometriomas presented with focal/multifocal shading within a complex mass. Fourth, half of the cases with focal/multifocal shading within a complex mass corresponded to endometrioid carcinomas (5/10).

**Table 1.** Frequency of each shading pattern

Shading pattern	Endometrioma	Endometrioid carcinoma	Others	Total
Homogeneous	17	0	6	23/51 (45.1)
Heterogeneous	6	0	0	6/51 (11.8)
Layering	5	0	3	8/51 (15.7)
Liquid–liquid level	2	0	4	6/51 (11.8)
Focal/multifocal shading within a complex mass	0	5	5	10/51 (19.6)

Numbers in parentheses are percentages



**Fig. 2.** Flowchart of the non-endometrioma lesions.

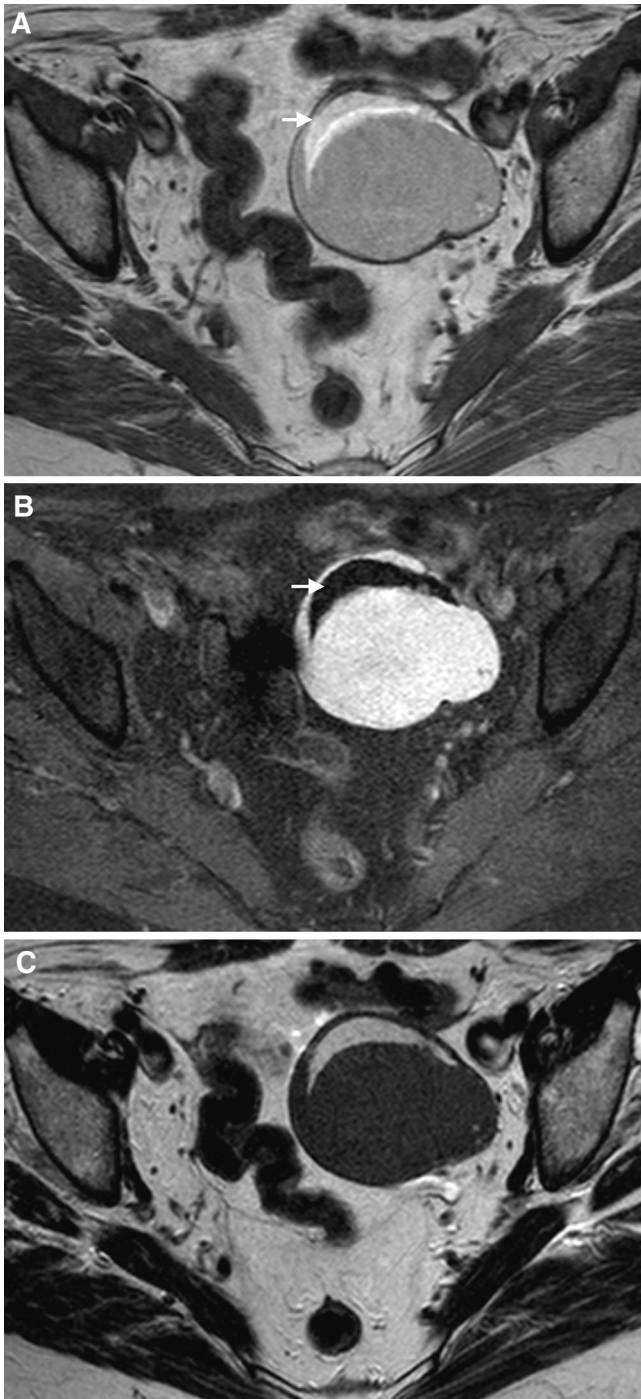
Our sensitivity and specificity levels are similar to other studies like that of Outwater et al. [6]. A more recent study [7] found the shading sign to be present in endometriomas but also in hemorrhagic cysts and neoplasms, having reported a sensitivity of 93% and specificity of 45% for the diagnosis of endometrioma. This specificity level is significantly lower than ours, which may be related to the inclusion of several hemorrhagic cysts with shading sign in that study. Since our sample included mostly patients with suspected oncological disease, none of our cases corresponded to hemorrhagic cysts. This is a potential limitation of our study due to the fact that our institution is a tertiary oncology center.

Considering shading sign only in purely cystic lesions without solid component, positive predictive value increases from 59% to 85%. After restricting the analysis to cystic lesions without evident solid or fat component, positive predictive value increases from 85% to 94%. These results highlight the need of complementary fat-suppressed sequences when hyperintense ovarian lesions are found on T1-WI and post-gadolinium evaluation when solid component is suspected, consequently decreasing the number of false positives of the shading sign.

One important issue is to understand if the existence of shading sign in non-endometrioma lesions hampered

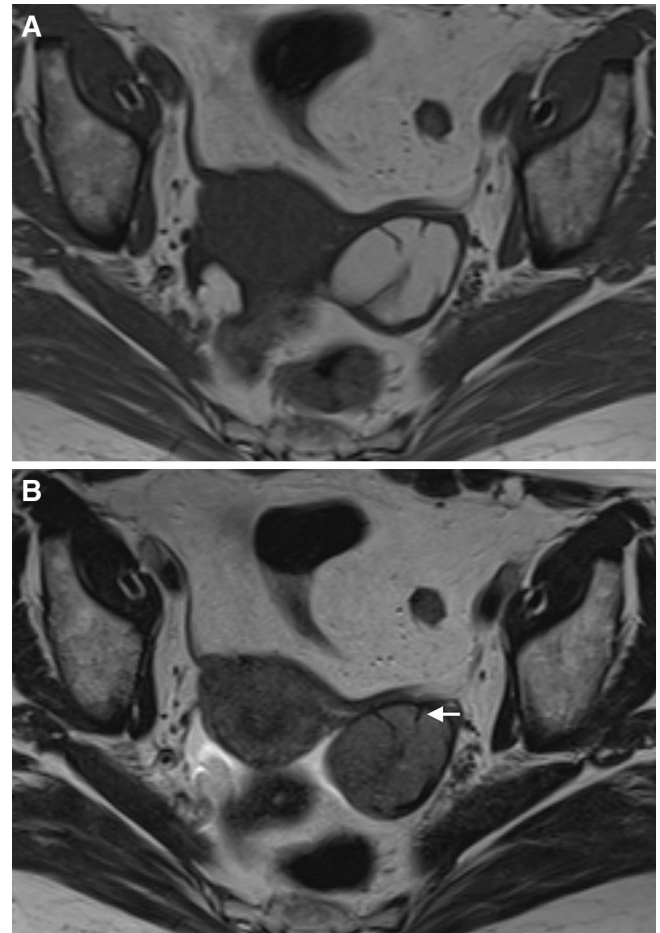
the correct diagnosis (Fig. 2). Among the 51 lesions considered, 21 (41%) were not endometriomas. 48% of these cases (10/21) presented with focal/multifocal shading within a complex mass and imaging analysis was not complicated, because the identification of solid enhancing components easily excluded endometrioma. 14% (3/21) were mature cystic teratomas, undoubtedly identified in complementary fat-saturated sequences (Fig. 3). The other eight tumors (8/21, 38%) include 3 serous adenofibromas (Fig. 4), 1 endometrioid carcinoma within an endometrioid cyst, 1 serous carcinoma, 1 mucinous borderline tumor within an endometrioid cyst (Fig. 5), 1 mucinous borderline tumor, and 1 unclassifiable primary carcinoma. In this kind of tumors, the identification of shading may hamper imaging analysis if no solid enhancing or fibrotic components were clearly found.

Endometriosis constitutes a risk factor for epithelial ovarian cancer [8]. The incidence of malignant transformation in endometriomas reaches 0.6–1.0%, and endometrioid carcinoma is the most commonly reported histological type, followed by clear cell carcinoma [9–11]. We report two cases of malignant transformation within an endometrioid cyst, 1 endometrioid carcinoma and 1 mucinous borderline tumor both presenting with shading



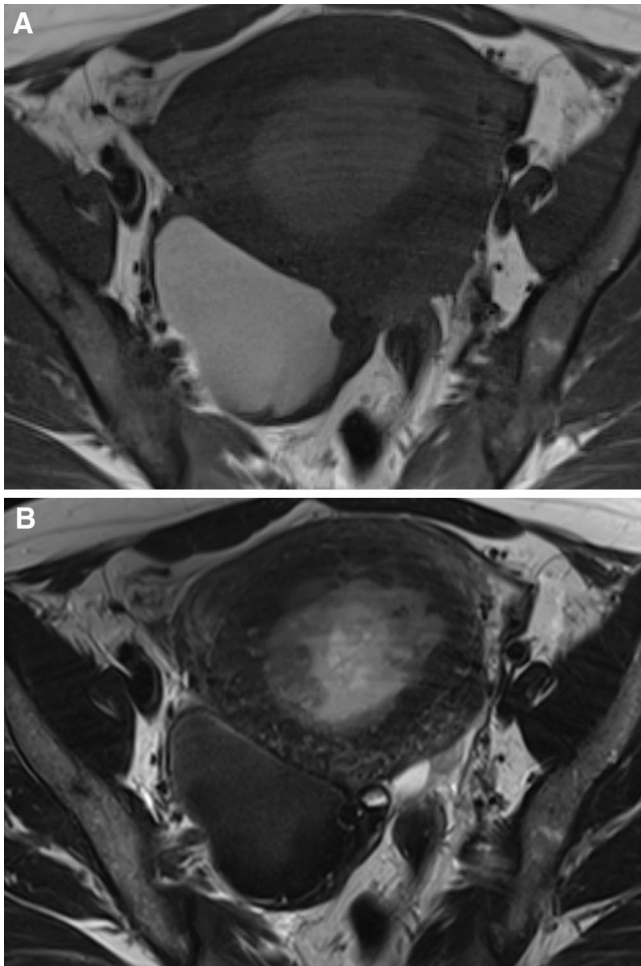
**Fig. 3.** MRI of a cystic mature teratoma of the left ovary in a 69-year-old woman. **A** Axial T1WI shows a cystic lesion with an anterior, hyperintense and crescent-shaped area (*arrow*) that loses signal intensity on **B** non-fat-saturated T1WI (*arrow*), indicating fat component. **C** Axial T2WI reveals homogeneous loss of signal intensity in the larger and dependent portion of the cyst.

sign. A study of Tanaka et al. [9] analyzed a group of endometriomas with malignant transformation, reporting a low incidence of signal hypointensity on T2WI (20%,



**Fig. 4.** MRI of a serous adenofibroma of the left ovary in a 71-year-old woman. **A** Axial T1WI reveals a cystic hyperintense lesion. **B** Axial T2WI shows homogeneous loss of signal intensity and a thick and strongly hypointense wall with some peripheral septa (*arrow*), with no significant enhancement after gadolinium administration (not shown).

corresponding to two of ten cases), when compared to benign endometrial cysts. They speculated that fluid produced by malignant cells dilute hemorrhagic content, increasing tumoral size, and signal intensity on T2WI. The recognition of an ovarian cyst with shading sign that increases in size or shows enhancing mural nodules increases suspicion of malignant transformation within an endometrioma [9, 10]. However, this feature is not pathognomonic, as we can prove in our results (1 serous carcinoma and 1 unclassifiable primary carcinoma presented with shading sign). Moreover, the absence of shading sign is not enough to exclude relation to endometrioma, according to Tanaka et al [9]. It is also important to emphasize that the evaluation of the contrast enhancement of mural nodules within an endometrioma may be difficult if they are small and because of the high signal intensity on T1WI. Dynamic sequences with subtraction images are helpful on this distinction [9].



**Fig. 5.** MRI of a mucinous borderline tumor within an endometrioid cyst of the right ovary in a 50-year-old woman. **A** Axial T1WI shows a hyperintense cystic lesion. **B** Axial T2WI reveals loss of signal intensity with layering pattern. No parietal nodules were obviously found on T2WI or post-gadolinium sequences (not shown). A huge and heterogeneous endometrial lesion is also seen, corresponding to an endometrioid endometrial carcinoma (grade 3).

As previously said, half of the cases with focal/multifocal shading within a complex mass corresponded to endometrioid carcinomas (Fig. 6). Ovarian endometrioid carcinoma is a malignant epithelial tumor that resembles its uterine counterpart [12, 13]. In some cases, an origin from endometriosis in the same ovary or elsewhere in the pelvis can be confirmed, but it is not required for the diagnosis [12]. Despite no significant statistic correlation was established, it was interesting to find that 50% (5/10) of cases with focal/multifocal shading within a complex mass were endometrioid carcinomas. According to this descriptive study, we think that identifying an adnexal complex mass with one or more cystic portions with shading sign raises the suspicion of endometrioid carcinoma. In this setting, radiologists should carefully evaluate the entire pelvis, namely the opposite adnexal area



**Fig. 6.** MRI of an endometrioid carcinoma of the right ovary in a 48-year-old woman. **A** Axial T1WI shows a complex mass, with multiple cystic portions and a central solid component (arrow). **B** Axial T2WI reveals loss of signal intensity in some cysts, essentially at the right side of the tumor (dashed arrow). This is an example of multifocal shading within a complex mass.

and the uterus, since endometrioid carcinomas may be accompanied by pelvic endometriosis (up to 42%) and are associated with carcinoma of the endometrium in 15–20% of cases [12, 13].

Our study had some limitations. First, it was retrospective and descriptive. Second, in 17 lesions (all of them endometriomas), the diagnosis was not surgically proven, but based on clinical criteria and follow-up.

Third, our initial sample essentially covered patients with oncological disease suspicion, which may misjudge some hemorrhagic, inflammatory, and infectious lesions.

In conclusion, the shading sign is not exclusive of endometriomas or endometrioid tumors, despite the moderate-to-high levels of sensitivity and specificity, and may be found in several benign and malignant non-endometrioid adnexal tumors. We have identified five shading patterns, and homogenous shading appears to be the most prevalent pattern in endometriomas. Moreover, the identification of focal/multifocal shading within a complex mass may raise the suspicion of endometrioid carcinomas.

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