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"T2-hypointense dot sign": A novel and highly suggestive clue for the diagnosis of ovarian torsion☆,☆☆

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ABSTRACT

Purpose: We aimed to describe "T2-hypointense dot sign" for the diagnosis of ovarian torsion and compare its diagnostic capability with whirlpool sign.
Methods: Pelvic MRIs of 31 patients with surgically proven ovarian torsion were used for the analysis. The control group was comprised of 30 patients with adnexal neoplasm and 15 patients with tubo-ovarian abscess. The MRIs of all 76 patients were retrospectively evaluated by two independent radiologists for the presence of T2-hypointense dot sign and whirlpool sign using a three-point scale.
Results: The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy values for the T2-hypointense dot sign for the diagnosis of ovarian torsion for observer 1 and observer 2 were 0.90, 1, 1, 0.93, and 0.96 and 0.87, 1, 1, 0.91, and 0.94, respectively. These same values for the whirlpool sign for observer 1 and observer 2 were 0.58, 1, 1, 0.77, and 0.82 and 0.42, 1, 1, 0.71, and 0.76, respectively. Both signs were definitely negative in patients with adnexal neoplasm and tubo-ovarian abscess. Interobserver agreement was excellent for the T2-hypointense dot sign (κ = 0.83), but poor for the whirlpool sign (κ = 0.31).
Conclusions: The presence of T2-hypointense dot sign could be a valuable clue for the accurate and early diagnosis of ovarian torsion in non-contrast MRI scans.

1. Introduction

Ovarian torsion is defined as the complete or partial rotation of an ovary or ovarian vascular pedicle around its long axis [1]. The clinical presentation of ovarian torsion can be nonspecific and vary among patients [2–7]. Imaging-based diagnosis of ovarian torsion can also be challenging due to a wide range of differential diagnosis [8]. However, early and accurate diagnosis has a vital role in preserving the viability of ovaries and fertility. In addition to the loss of ovarian function, the occurrence of peritonitis, sepsis, and death have also been reported in patients with a delayed or missed diagnosis of ovarian torsion [8–11].

Ultrasonography is the modality of choice for patients with a clinical suspicion of ovarian torsion [1,3]. However, its low sensitivity rate (46%–74%) is a major weakness for diagnosis [12]. Pelvic MRI can be utilized as a problem-solving tool to overcome the limitations of sonography in the diagnosis of pelvic pathologies, including ovarian torsion. Superior soft-tissue contrast resolution, multiplanar imaging capability, and lack of ionizing radiation make MRI a perfect modality of choice, particularly in children and pregnant women [13]. The reported MRI signs of ovarian torsion are similar to those of ultrasound findings, including ovarian enlargement, stromal edema, peripheralized follicles, whirlpool sign, fallopian tube wall thickening, free fluid in the pelvis, and uterine deviation [14]. However, despite the above-mentioned advantages of MRI, the sensitivity of MRI ranges from 77% to 91% for the diagnosis of adnexal torsion. A whirlpool sign and an increased fallopian tube thickness are the two main imaging features encountered in the case of adnexal torsion [13].

We recently noticed a unique MRI sign, seen as a hypointense dot on the pedicle of a torsed ovary, on T2-weighted MRIs of patients with surgically proven ovarian torsion. The aims of this study were to evaluate the reliability of the T2-hypointense dot sign and to compare the diagnostic capability of this sign with the whirlpool sign in the

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imaging-based diagnosis of ovarian torsion.

2. Materials and methods

2.1. Patients

Our retrospective study was approved by an institutional review board, and informed consent was waived because of the retrospective nature of the study. Between January 2008 and December 2017, 31 patients with surgically proven ovarian torsion, not diagnosed sonographically, who underwent a preoperative MRI examination (mean age = 30 years; range = 1–65 years), 30 patients with ovarian tumor (mean age = 44 years; range = 32–67 years), and 15 patients with tubo-ovarian abscess (mean age = 42 years; range = 30–60 years) were included. Five of the patients were pregnant, and five of the patients were children. Patients with ovarian tumors and tubo-ovarian abscesses comprised the control group. The patients' MRI scans and medical records were reviewed retrospectively. In addition, the study cohort was divided into two groups depending on the time interval between the presentation to hospital and MRI examination (early scan "within 12 h" and late scan "after 12 h").

2.2. MRI protocol

MRI examinations were performed with two 1.5 T MRI scanners (Siemens Magnetom Symphony-Quantum; Erlangen, Germany) (Achieva; Philips Healthcare, Best, the Netherlands) equipped with phased-array coils. The T2-weighted scan protocol for each MRI scanner is summarized in Table 1.

2.3. Image review

The MRIs of all the patients were evaluated by two independent radiologists (observer 1 and observer 2) with 15- and 7-years' experience in reading pelvic MRI scans, respectively. The observers evaluated the images for the presence of a T2-hypointense dot sign and a whirlpool sign using a three-point scale: 0 = definitely negative, 1 = inconclusive, 2 = definitely positive. Corresponding areas of the T2-hypointense dot sign on contrast-enhanced T1-weighted images were also evaluated to exclude any vascular structure in the area of a T2-hypointense dot sign on the T2-weighted images. The presence of a T2-hypointense dot sign or a whirlpool sign on at least one of the axial, sagittal, or coronal T2-weighted images was considered definitely positive.

2.4. Statistical analysis

The Statistical Package for Social Sciences (SPSS), Version 22.0 (Chicago, IL, USA), was used for the statistical analysis. The descriptive data are presented as means ± standard deviation and medians (minimum-maximum). The Shapiro–Wilk test was used to analyze the normal distribution assumption of the quantitative outcomes. The sensitivity, specificity, negative and positive predictive values, and accuracy rates for both signs were also evaluated. The interclass correlation coefficient (ICC) between the two radiologists was also evaluated. The correlation was classified as poor (ICC < 0.40), fair to good (ICC = 0.40 to 0.75), or excellent (ICC > 0.75). A *p*-value of < 0.05 was considered statistically significant.

Table 1
T2-weighted MRI examination parameters for the Siemens and Philips scanner.

Parameter	Siemens	Philips
TR/TE (ms)	1000/83	2750/80
Slice thickness (mm)	5	4
FOV (mm)	450	360
Matrix size (mm)	144 × 256	316 × 303
Flip angle	150	90
NEX	2	1

FOV: field of view; NEX: number of excitations.

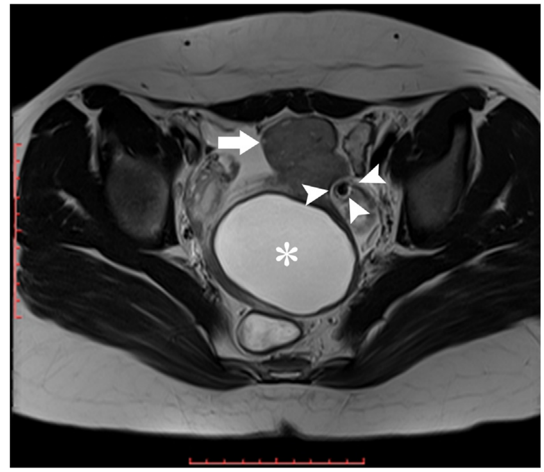

Fig. 1. A 30-year-old woman with left ovarian torsion due to ovarian cyst (asterisk). The arrow indicates enlarged left ovary with peripherally located cysts. A twisted ovarian pedicle and the whirlpool sign are present adjacent to the torsed ovary. At the center of the "whirlpool sign", a "T2-hypointense dot sign" (arrowheads) is present as a hypointense dot on the T2-weighted image.

3. Results

A T2-hypointense dot sign was observed in 28 of the 31 patients (90.3%) and a whirlpool sign was observed in 18 of the 31 patients (58%) with ovarian torsion by observer 1 (Figs. 1 and 2). A T2-hypointense dot sign was observed in 27 of the 31 patients (87%) and a whirlpool sign in 13 of the 31 patients (41.9%) with ovarian torsion by observer 2 (Fig. 3). False negative and inconclusive results for observers 1 and 2 are summarized in Table 2. None of the observers reported a case with a definitely positive result for the whirlpool sign and a negative result for the T2-hypointense dot sign. False negative and inconclusive results for the whirlpool sign and positive results for the T2-hypointense dot sign for observers 1 and 2 in pregnant patients are summarized in Table 3.

The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy values for T2-hypointense dot sign for the diagnosis of ovarian torsion for observer 1 and observer 2 were 0.90, 1, 1, 0.93, and 0.96 and 0.87, 1, 1, 0.91, and 0.94, respectively. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy values for the whirlpool sign for observer 1 and observer 2 were 0.58, 1, 1, 0.77, and 0.82 and 0.42, 1, 1, 0.71, and 0.76, respectively. Both signs were definitely negative in patients with adnexal neoplasm and tubo-ovarian abscess for both observers. Interobserver agreement was excellent for the T2-hypointense dot sign ($\kappa = 0.83$), but poor for the whirlpool sign ($\kappa = 0.31$).

The average time period between the presentation to hospital and MRI examination was 12 h (range = 3–40 h) for patients with ovarian torsion. There were 20 and 11 patients, in early and late scan groups, respectively. Although there was no significant difference between the occurrences of both signs in late scan group, the number of patients with T2 hypointense dot sign was slightly higher compared to patients with whirlpool sign in early scan group.

4. Discussion

We emphasized a novel MRI sign for the diagnosis of ovarian torsion: a T2-hypointense dot sign appears as a hypointense dot on the

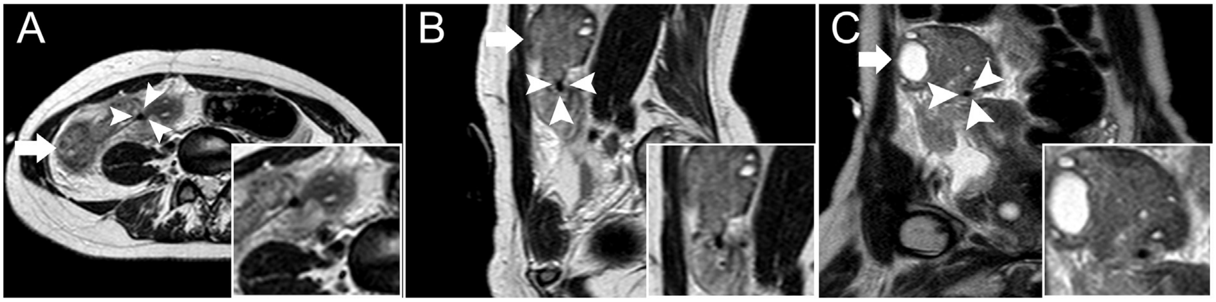

Fig. 2. A 15-year-old girl with right ovarian torsion. Axial (A), sagittal (B), and coronal (C) T2-weighted MR images demonstrate enlarged right ovary (arrows) and presence of "whirlpool sign. The "T2-hypointense dot sign" (arrowheads) is also noted (arrowheads).

pedicle of a torsed ovary on T2-weighted MR images, even in the absence of a whirlpool sign. We investigated the reliability of this sign for the imaging-based diagnosis of ovarian torsion and found higher sensitivity and specificity rates compared with the conventional whirlpool sign. We hypothesized that the ovarian ligaments, such as the suspensory ligament or the utero-ovarian ligament, which are hypointense structures on T2-weighted MRIs, form as a hypointense dot at the center of a twisted pedicle, and the imaged appearance of these ligaments can be detected earlier compared with the gross rotation of the ovarian pedicle, also known as the whirlpool sign. We acknowledge that each pathology involving tubo-ovarian space may thicken ovarian ligaments to a certain degree. However in patients with tubo-ovarian abscess or neoplasm, such insult on ovarian ligaments may not be prominent compared to patients with ovarian torsion. We did not detect T2-hypointense dot sign in patients with adnexal neoplasm and tubo-ovarian abscess in this study. We suggest that the reason for "T2-hypointense dot sign" being undetectable in patients with tuboovarian abscess or neoplasm is lack of adequate influence on ovarian ligaments to become such thickened that MRI may reveal this sing. However, in case of ovarian torsion such impact on ligaments is more obvious that one may detect T2-hipointense dot sign on pelvic MRI of these patients. We also found that the number of patients with T2 hypointense dot sign was slightly higher compared to patients with whirlpool sign, in early scan group. Although definite conclusion cannot be drawn due to small sample size and retrospective nature of the study, we speculate that T2 hypointense dot sign may also refer to early stage of whirlpool sign and both signs may indicate the same incident. Nevertheless the assessment of "T2-hipointense dot sign" is much easier and also objective compared to whirlpool sign. Poor interobserver agreement found in our study also highlights this fact since presence of whirlpool sign may not be easily identified on MRI if it is not complete or obvious (poor Kappa score). In addition assessment of whirlpool sign could be challenging due to accompanying fat tissue inflammation, necrosis, hemorrhage, or edema which are encountered in most of the patients. We acknowledge that

Table 2
False negative and inconclusive results of signs for observers 1 and 2.

	Observer 1 (n = 31)	Observer 2 (n = 31)
	"T2-hypointense dot sign"	"T2-hypointense dot sign"
False negative	3*	4*
Inconclusive	–	–
	"Whirlpool sign"	"Whirlpool sign"
False negative	7	8
Inconclusive	6	11

* "Whirlpool sign" was also negative in these cases.

Table 3
False negative and inconclusive results for "Whirlpool sign" and positive results of "T2-hypointense dot sign" for observer 1 and 2 in pregnant patients.

	Observer 1 (n = 5)	Observer 2 (n = 5)
	"T2-hypointense dot sign"	"T2-hypointense dot sign"
Positive	4	3
	"Whirlpool sign"	"Whirlpool sign"
False negative	3	4
Inconclusive	1	1

lack of radiological pathological correlation in our study is a limitation that inhibits further conclusion. Future studies with emphasis on radiological pathological correlation may reveal the actual reason beyond this issue. Postcontrast images were also evaluated to exclude vascular structures on the corresponding area of the T2-hypointense dot sign, and in some patients, an enlarged ovarian vein was also detected as an additional sign of ovarian torsion. However we could not identify any vascular structure in the torsed ligament on T2 or T1 weighted images.

In cases of recurrent chronic ovarian torsion and for pregnant patients, the evaluation of the whirlpool sign can be difficult due to heterogeneity caused by chronic inflammation, hemorrhage, or compression of the uterus in pregnant patients. In our study, the whirlpool sign

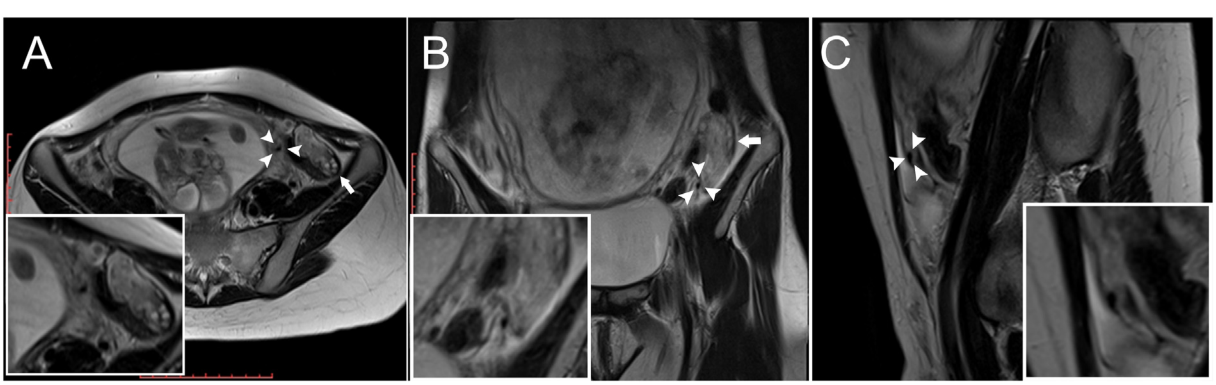

Fig. 3. A 28-year-old pregnant woman with left ovarian torsion. Axial (A) sagittal (B), and coronal (C) T2-weighted MR images demonstrate enlarged right ovary (arrows, A and B) and presence of "T2-hypointense dot sign" (arrowheads, A–C). The whirlpool sign could not be identified (false negative).

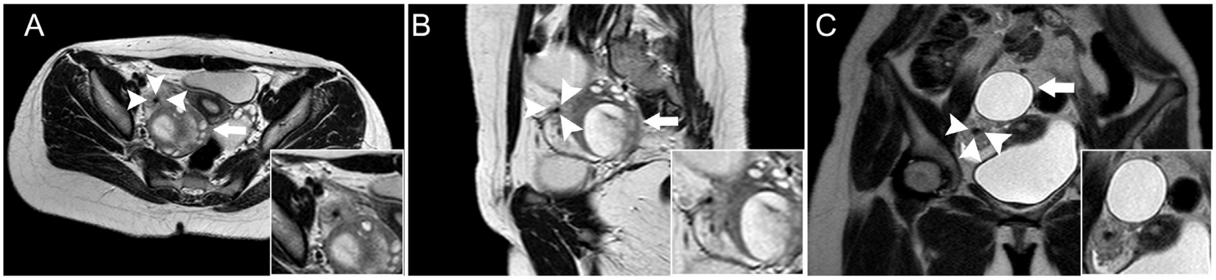

Fig. 4. A 15-year-old girl with right ovarian torsion. Axial (A), sagittal (B), and coronal (C) T2-weighted MR images demonstrate enlarged right ovary (arrows) and the presence of "whirlpool sign" and "T2-hypointense dot sign" (arrowheads).

was positive in only one pregnant patient (observer 1) and the T2-hypointense dot sign was positive in four and three pregnant patients for observers 1 and 2, respectively. This result showed that the T2-hypointense dot sign is a more easily detectable sign and can guide accurate diagnosis. Although MRI is superior to CT and ultrasound for the diagnosis of ovarian torsion, long scan-time is a major drawback of MRI, particularly for pediatric populations [13], and evaluation can be challenging due to inadequate imaging caused by patient motion [13,14]. However, the presence of a T2-hypointense dot sign can be evaluated by using only T2-weighted MRIs; therefore, MRI scans could be well tolerated, particularly in pediatric populations (Fig. 4), without the need for IV sedation due to shortened scan-time. Also, a T2-hypointense dot sign does not require intravenous gadolinium administration, which is particularly important for pediatric populations and pregnant patients. Furthermore, the T2-hypointense dot sign is a more practical MRI sign that can be more easily identified by radiologists who are not experts in this field compared with the whirlpool sign. In our study, the less-experienced radiologist had a lower accuracy value for the whirlpool sign.

Our study had some limitations. First, it was a retrospective case-control study. Second, we were not able to correlate the T2-hypointense dot sign with pathology results. Third, the numbers of pediatric and pregnant patients among the study cohort were low.

In conclusion, to preserve the viability of ovaries and fertility, it is crucial to be able to diagnose ovarian torsion with a more reliable and easily identified MRI sign. Based on our results, we speculate that the T2-hypointense dot sign is a novel and more accurate sign for the imaging-based diagnosis of ovarian torsion. Nevertheless, we acknowledge that further studies with larger patient populations are warranted to support our findings.

Conflict of interests

The authors declare that there is no potential conflict of interests regarding the publication of this paper.

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