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MAJOR PAPER

Differentiation of Seromucinous Borderline Tumor from Serous Borderline Tumor on MR Imaging

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Purpose: Seromucinous borderline tumor (SMBT) is a newly categorized ovarian tumor in the 2014 revised World Health Organization (WHO) classification. SMBT is similar to serous borderline tumor (SBT) on MRI reflecting their pathological findings. This study was conducted to demonstrate the usefulness of MRI findings and quantitative values for differentiating SMBT from SBT.

Methods: This retrospective study examined 23 lesions (20 patients) from SMBT and 26 lesions (22 patients) from SBT. The following quantitative values were evaluated using receiver-operating characteristics analysis: overall and solid portion sizes, intracystic fluid signal intensity (SI) ratio compared with skeletal muscle on T_1weighted image (T_1WI) and T_2weighted image (T_2WI), contrast enhancement (CE) ratio, and mean and minimum apparent diffusion coefficient values of the solid portion. Two radiologists evaluated the prevalence of MRI finding characteristics of SMBT and SBT. The SI of the intracystic fluid on T_1WI and T_2WI and the association with endometriosis were evaluated visually.

Results: The CE ratio was significantly higher in SBT ($P = 0.007$). It achieved the highest area under the curve (AUC) (0.739). The fluid SI ratio on T_1WI was higher in SMBT ($P = 0.036$, AUC = 0.676). Exophytic growth of the solid portion was observed only in SBT ($P = 0.011$). Intracystic fluid SI of SMBT was higher on T_1WI and lower on T_2WI in visual evaluation ($P = 0.008$ and 0.007, respectively). Findings suggesting endometriosis were observed more frequently in SMBT patients ($P = 0.019$).

Conclusion: Higher CE ratio of the solid portion and exophytic growth were findings suggesting SBT. Higher intracystic fluid SI on T_1WI and lower SI on T_2WI suggested SMBT. MRI findings suggesting endometriosis favored the diagnosis of SMBT.

Keywords: *seromucinous borderline tumor, serous borderline tumor, endometriosis, ovary, magnetic resonance imaging*

Introduction

In 2014, World Health Organization (WHO) classifications included the new pathological classification of seromucinous borderline tumor (SMBT), which combined previously diagnosed as endocervical-like mucinous borderline tumor/Müllerian mucinous borderline tumor (MMBT) and Müllerian mixed epithelial borderline tumor (MEBT).[1] SMBT resembles serous borderline tumor (SBT) in that both tumors typically show papillary projection inside cystic spaces grossly, and present hierarchical branching with broad fibrous stroma microscopically.[2] These tumors are pathologically differentiated by their lining epithelium. Recently, MRI findings characteristic of SMBT were reported in comparison with endometriosis-related malignant ovarian tumor.[3] Characteristic findings of SMBT reflecting its gross and microscopic features were similar to findings that were reported as characteristic of SBT.[4–6]

In spite of their similar appearance, they have clinically different characteristics. More than 80% of SMBT are described as stage I. It presents peritoneal dissemination with frequency of less than 15%.[7,8] The recurrence rate is extremely low and death from SMBT is very rare.[8,9] On the

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other hand, SBT presents peritoneal dissemination at a frequency of 35–40%.[10,11] Although stage I SBT also has a good prognosis, SBT with peritoneal dissemination has a higher recurrence rate and a lower survival rate.[12,13]

For these reasons, preoperative MR imaging differentiation of SMBT from SBT is clinically valuable, but it is often challenging to distinguish SBT from SMBT on MRI. No report of the relevant literature describes research comparing the MRI findings of SMBT and SBT, or presents useful findings and quantitative values for the differentiation between these two tumors. This study was conducted to demonstrate MRI findings and quantitative values as useful for differentiating SMBT from SBT.

Materials and Methods

This single center retrospective study was approved by our institutional review board, which waived the requirement for written informed consent.

Patients

Pathological and radiological records at our institute between January 2000 and April 2016 were searched for ovarian SMBT and SBT. Twenty five SMBT patients were identified, among whom 6 patients had bilateral lesions. Patients without preoperative MRI (2 patients, 2 lesions), those that were too small to detect on MRI (3 lesions), and those without detailed clinical records (3 patients, 3 lesions) were excluded from our study. Twenty nine SBT patients were identified, among whom 5 patients had bilateral lesions. Patients without preoperative MRI (4 patients, 4 lesions) were excluded, as were patients without sufficiently detailed clinical records (2 patients, 2 lesions), one with a lesion too small to detect on MRI, and 1 patient (1 lesion) who presented with torsion and rupture. Altogether, 20 SMBT patients (23 lesions) and 22 SBT patients (26 lesions) were included in the study. Some SMBT patients (16 patients, 19 lesions) examined in this study were also included in our earlier study of differentiation of SMBT from endometriosis-related malignant ovarian tumors.[3]

MRI protocol

MRI examinations were performed using a 1.5T unit (Symphony or Avanto; Siemens Health Care Erlagen, Germany, Signa; General Electric Medical Systems, Milwaukee, WI, USA) or a 3T unit (Trio, Skyra; Siemens Healthcare, Erlagen) using a phased-array coil. Before MR examination, 20 mg of butyl scopolamine (Buscopan; Nippon Boehringer Ingelheim Co. Ltd., Tokyo, Japan) was administered intramuscularly to minimize motion artifacts attributable to bowel peristalsis unless contraindicated or upon patients' refusal. Our routine MR sequences included sagittal T_1-wighted image (T_1WI) (repetition time [TR]/echo time [TE] 400–655/11–30, flip angle [FA] 80°, matrix 528 × 224–348, slice thickness [ST] 4–6 mm), T_2-weighted image (T_2WI) (TR/TE 3730–7760/81–120, FA 150°, matrix 448–512 × 204–512, ST 4–5 mm), diffusion-weighted image (DWI) (TR/TE 2300–5900/63–87, FA 90°, matrix 128 × 73–128, ST 4–5 mm), axial T_1WI with fat suppression and T_2WI, and sagittal and axial contrast-enhanced T_1WI (Fast spin echo; TR/TE 450–650/9.3–30, FA 90–170°, matrix 320–512 × 176–348, ST 4–6 mm, Gradient echo; TR/TE 3.2–3.4/1.2–1.3, FA 10°, matrix 320–384 × 198–230 ST 4 mm) with or without fat suppression. Contrast-enhanced T_1WI was performed after intravenous injection of 0.2 mL/kg gadolinium contrast agent (Magnevist; Bayer Yakuhin Ltd., Osaka, Japan). Regarding DWI, applied b values for each patient had some variation: b = 1000 s/mm^2, b = 0 and 1000 s/mm^2, b = 0, 500, and 1000 s/mm^2, and b = 0, 100, 500, 1000 s/mm^2. When two or more b values were available, apparent diffusion coefficient (ADC) values were calculated by fitting the acquired b-values to mono-exponential model using least-squares method. The noise threshold was set as 10, which means that ADC values were calculated using only more than 10 signal intensity. Contrast-enhanced MR images were obtained in 18 of the 20 patients (21 of 23 lesions) of SMBT and 19 of the 22 patients (23 of 26 lesions) of SBT. DWI were obtained in 17 of the 20 patients (20 of 23 lesions) of SMBT and 18 of the 22 patients (21 of 26 lesions) of SBT. ADC map was available in 16 of the 20 patients (19 of 23 lesions) of SMBT and 14 of the 22 patients (17 of 26 lesions) of SBT.

Clinical characteristics

One board-certified genitourinary radiologist with 10 years of experience searched the clinical records for patients' clinical information including pathological reports. We checked the number of patients with increased concentrations of the following tumor markers: CEA (≥5.0 ng/ml), CA19-9 (≥37.0 U/ml), and CA125 (≥35.0 U/ml). Surgical stage according to the International Federation of Gynecology and Obstetrics (FIGO), presence of endometriosis pathologically, macroscopic exophytic growth of tumors and whether fertility-sparing surgery was performed were also explored.

Quantitative analysis

One radiologist performed quantitative evaluation of each tumor and measurement of the following parameters: overall and solid portion sizes of the tumor, signal intensity (SI) of the iliopsoas muscle, fluid SI on T_1WI and T_2WI in the cystic portion of the tumor, SI of the solid portion on pre- and post-contrast-enhanced T_1WI, and mean and minimum ADC values of the solid portion. The overall size was defined as the maximal diameter of the tumor. The solid portion size was defined as the height of the solid portion from the wall of the tumor. For the evaluation of SI of the fluid and iliopsoas muscle, an oval-shaped region of interest (ROI) was set. When the tumor showed a multicystic appearance, ROI was set in the cyst that contained the largest solid nodule. Quantitative evaluation was performed twice with an interval of

at least 3 weeks. The average of the two measurements was applied for additional analyses.

For the measurement of SI and ADC values, polygonal ROI were placed manually on the entire solid portion to cover as large an area as possible while avoiding areas such as intratumoral cyst, hemorrhage and necrosis by referring to other sequences such as T_2WI and contrast and non-contrast enhanced T_1WI. For tumors containing multiple solid nodules, the largest nodule was investigated. The SI ratio was calculated as follows: fluid SI ratio (on T_1WI or T_2WI) = fluid SI in the cystic portion of the tumor (on T_1WI or T_2WI)/ SI of the iliopsoas muscle (on T_1WI or T_2WI); contrast-enhancement SI ratio (CE ratio) = SI of the solid portion on post-contrast enhanced T_1WI/SI of the solid portion on pre-contrast enhanced T_1WI. All image analyses were done using a clinical workstation (Centricity RA1000; GE Healthcare, Barrington, IL).

Qualitative analysis

Two board-certified genitourinary radiologists (10 and 8 years of experience, respectively) evaluated MR images by consensus. They were blind to the clinical data of each patient and the pathological diagnosis of each tumor. The two radiologists were instructed to record whether the following imaging findings were positive or negative as a binary outcome. The imaging findings about the tumors were 1) nodule in cyst appearance, 2) exophytic growth, 3) multilocular appearance, 4) papillary solid nodule, 5) T_2WI high SI solid portion, and 6) T_2WI low SI core. "Nodule in cyst appearance" was defined as positive when the cystic tumor had a mural nodule. "Exophytic growth" was defined as positive when the tumor accompanies exophytic growth component on the surface of the ovary. Representative MR images of SBT with exophytic growth are presented in Fig. 1. "Multilocular appearance" was defined as positive when the tumor consisted of multiple cystic components. "Papillary solid nodule" was defined as positive when the tumor presented minute papillary contour on their surface. "T_2WI high SI solid portion" was defined as positive when the tumor showed high SI solid portion equal to water or subcutaneous fat. "T_2WI low SI core" was defined as positive when intratumoral low intensity solid portion was equal to that of the skeletal muscle on T_2WI. Both readers made an effort not to consider intratumoral hemorrhage as "T_2WI low SI core" by referring to other sequences. Representative MR images of SMBT and SBT are presented in Fig. 2. Two readers classified the SI of the solid portion of the tumor on DWI as high (similar to nerve root), moderate (similar to the small intestine), or low (similar to background signal). The readers qualitatively evaluated the SI of the fluid in the cystic portion of the tumor on T_1WI and T_2WI. The SI was on T_1WI was classified as high (similar to subcutaneous fat), intermediate (SI between high and low) and low (similar to urine). That on T_2WI was classified as high (similar to urine), intermediate (SI between high and low) and low (similar to skeletal muscle). When the tumor showed multicystic appearance, the readers evaluated the fluid SI of the cyst that contained the largest solid nodule. Both readers visually evaluated the degree of contrast enhancement of the solid portion of the tumor. When the solid portion of the tumor showed similar or higher, slightly lower and clearly lower SI on contrast enhanced T_1WI, the degrees of contrast enhancement were judged respectively as high, moderate, and low. The two readers also evaluated whether each patient had MR findings suggesting endometriotic cyst and pelvic endometriosis. The MR imaging finding suggesting endometriotic cyst was "the T_2 shading sign," which means T_2 shortening (corresponding to low SI on T_2WI) in an adnexal cyst that shows high SI on T_1WI.[14,15] Regarding pelvic endometriosis, we adopted a finding suggesting deep pelvic endometriosis, which corresponded to solid endometriotic masses or nodules showing low SI on T_2WI with irregular or indistinct margins.[16] The lesion sometimes included a high SI portion on T_1WI and T_2WI, which corresponded respectively to bloody content and ectopic endometrial gland.[17]

Statistical analysis

Statistical analyses were applied using commercially available software (JMP ver. 12.2.0; SAS Institute Inc., Cary, NC, USA) and EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).[18] Mann–Whitney U tests were applied to compare

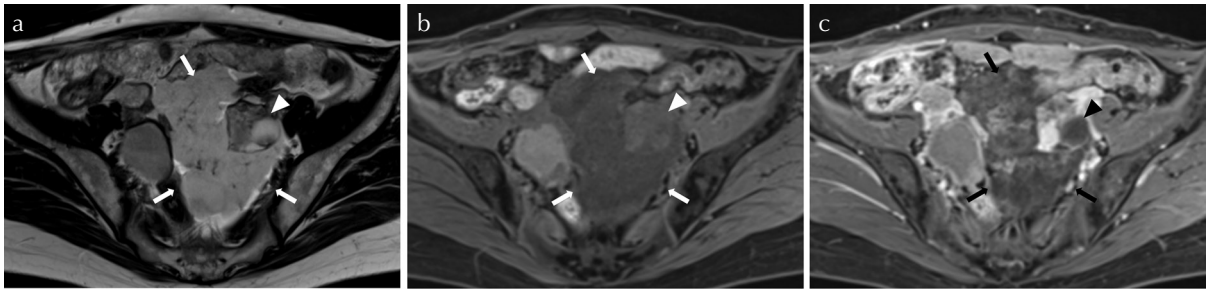

Fig. 1 48-year-old woman with serous borderline tumor (SBT) presenting exophytic growth. (**a**) T_2-weighted image. (**b**) Fat-suppressed T_1-weighted image. (**c**) Fat-suppressed contrast-enhancement T_1-weighted image. Characteristic MR imaging findings of surface type SBT are presented in panels (**a**–**c**). The tumor shows exophytic growth (arrows) from the left ovary (arrowheads).

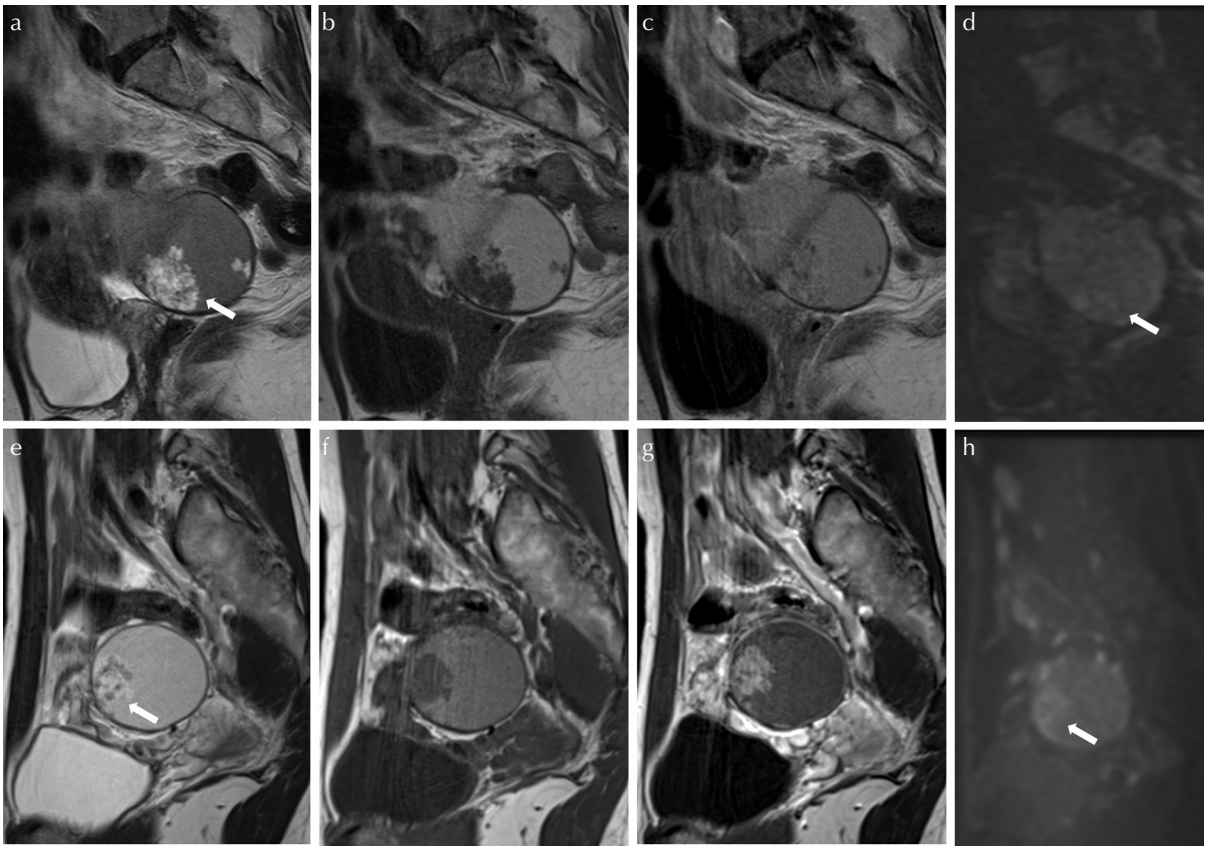

Fig. 2 55-year-old woman with seromucinous borderline tumor (SMBT) (**a**–**d**) and 29-year-old woman with serous borderline tumor (SBT) (**e**–**h**). (**a**, **e**) T_2-weighted image (T_2WI). (**b**, **f**) T_1-weighted image (T_1WI). (**c**, **g**) Contrast- enhanced T_1WI. (**d**, **h**) Diffusion-weighted image (DWI). On T_2WI (**a**, **e**), the solid portion of both tumors shows high signal intensity (SI) with a low-intensity core (arrows). Intracystic fluid shows intermediate SI for SMBT and high SI for SBT. On T_1WI (**b**, **f**), intracystic fluid presents high SI for SMBT and intermediate SI for SBT. Solid portions of both tumors show intermediate–high SI on DWI (arrows), with similar MR imaging findings for SMBT and SBT.

continuous variables between the SMBT and SBT. Fisher's two-sided exact test was used to analyze categorical data. Receiver operating characteristics (ROC) curves were calculated for overall and solid portion sizes of the tumor, fluid SI ratio on T_1WI and T_2WI, CE ratio, and mean and minimum ADC values. The ROC curve was used to calculate the area under the curve (AUC) and to ascertain the optimal cutoff value for diagnosing SMBT, defined as the value providing the largest sum of sensitivity and specificity. A P-value < 0.05 was inferred as significant.

Table 1. Clinical features of SMBT and SBT patients

	SMBT (n = 20)	SBT (n = 22)	P value
Age	42 (24–66)	45.5 (23–83)	0.96
CEA	0 (0)	1 (5)	1.0
CA 19-9	12 (60)	7 (32)	0.12
CA 125	13 (65)	13 (59)	0.76
bilateral	3 (15)	5 (23)	0.70

Data are presented median [min–max] for age, and n (%) for patients with elevated tumor markers and bilateral lesions. SMBT, seromucinous borderline tumor; SBT, serous borderline tumor.

Results

Clinical characteristics

Age, frequency of patients with elevated tumor markers, and bilateral tumor occurrence in each pathological group are presented in Table 1. No significant difference was found between the two groups related to these parameters. Regarding SMBT patients (n = 20), 14 patients were in stage Ia, 1 in stage Ib, 4 in stage Ic and 1 in stage III. Regarding SBT patients (n = 22), 14 patients were in stage Ia, 1 in stage Ib, 1 in stage Ic and 6 in stage III. Pathological evidence of endometriosis was confirmed in 16/20 SMBT patients and 1/22 SBT patients. Macroscopically, 1/23 SMBT case and 8/26 SBT cases showed exophytic growth. Regarding surgical procedures, fertility sparing surgery was performed in 9/20 SMBT patients and 7/22 SBT patients.

Quantitative evaluation

Results of the quantitative evaluation of SMBT and SBT are presented in Table 2. The fluid SI ratio on T_1WI was

Table 2. Results of MR quantitative evaluation

	SMBT	SBT	*P* value
Overall size (cm)	7.0 (5.6–10.4)	6.5 (5.1–10.8)	0.66
Solid portion size (cm)	1.8 (0.9–2.9)	1.5 (1.0–2.7)	0.85
Fluid SI ratio on T_1WI	2.3 (1.3–3.4)	1.6 (1.2–1.8)	0.036
Fluid SI ratio on T_2WI	5.9 (3.7–8.5)	7.9 (6.7–8.9)	0.056
CE ratio	1.8 (1.6–2.0)	2.2 (1.7–2.6)	0.007
Mean ADC (10^{-3} mm^2/s)	1.80 (1.54–1.96)	1.62 (1.50–1.96)	0.60
Min ADC (10^{-3} mm^2/s)	1.18 (0.81–1.59)	1.22 (1.03–1.59)	0.54

Data are presented as median (interquartile range). SMBT, seromucinous borderline tumor; SBT, serous borderline tumor; SI, signal intensity; T_1WI, T_1-weighted image; T_2WI, T_2-weighted image; CE, contrast enhancement; ADC, apparent diffusion coefficient.

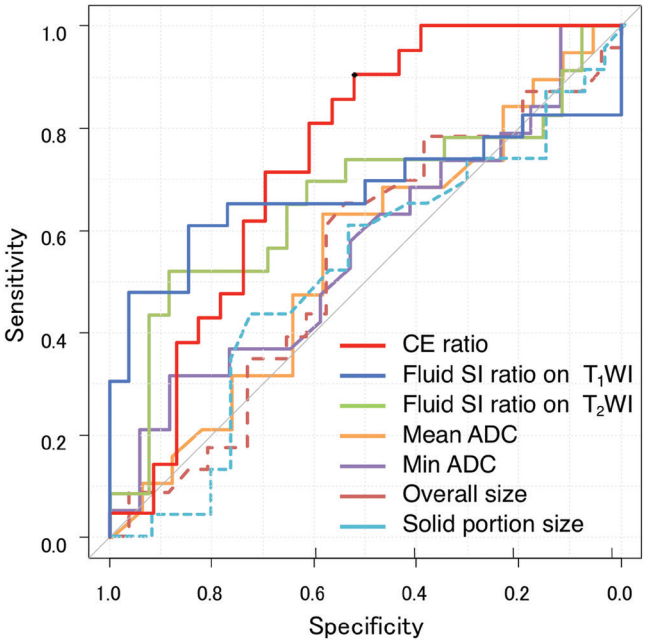

Fig. 3 Receiver operating characteristic (ROC) curves of the quantitative values. CE, contrast enhancement; SI, signal intensity; T_1WI, T_1-weighted image; T_2WI, T_2-weighted image; ADC, apparent diffusion coefficient.

significantly higher in SMBT ($P = 0.036$). The CE ratio was significantly higher in SBT ($P = 0.007$). No significant difference was found between two other quantitative values of groups.

ROC analysis

The CE ratio achieved the highest AUC (0.739) with subsequent fluid SI ratio on T_1WI (AUC = 0.676), fluid SI ratio on T_2WI (AUC = 0.661), minimum ADC value (AUC = 0.562), mean ADC value (AUC = 0.553), overall size (AUC = 0.538), and the solid portion size (AUC = 0.518) (Fig. 3). The cutoff value, sensitivity and specificity of each parameter for diagnosing SMBT were the following: CE ratio (2.18 >, 0.91, 0.52), fluid SI ratio on T_1WI (2.24 <, 0.61, 0.85), fluid SI ratio on T_2WI (5.9 >, 0.52, 0.89), minimum ADC value (0.87×10^{-3} mm^2/s >, 0.32, 0.88), mean ADC value (1.73×10^{-3} mm^2/s <, 0.63, 0.59), overall size (6.7 cm <, 0.65, 0.54) and solid portion size (1.95 cm <, 0.44, 0.73).

Table 3. Results of the lesion-based analysis of MR imaging findings

	SMBT ($n = 23$)	SBT ($n = 26$)	*P* value
Nodule in cyst appearance	23 (100)	26 (100)	1.0
Exophytic growth	0 (0)	7 (30)	0.011
Multilocular appearance	14 (61)	14 (54)	0.77
Papillary solid nodule	17 (74)	26 (100)	0.007
T_2WI high SI solid portion	17 (74)	22 (85)	0.48
T_2WI low SI core	14 (61)	21 (81)	0.20

Data are *n* (%) for each imaging finding. SMBT, seromucinous borderline tumor; SBT, serous borderline tumor; T_2WI, T_2-weighted image; SI, signal intensity.

Qualitative evaluation

Results of the lesion-based analysis of MR imaging findings are presented in Table 3. "Exophytic growth" was found only in SBT. "Papillary solid nodule" was found more frequently in SBT at a significant level ($P = 0.007$). Regarding other MR imaging findings, no statistically significant difference was found between the two groups. The SI of the solid portion on DWI, fluid SI on T_1WI and T_2WI and the degree of contrast enhancement of the solid portion was presented in Table 4. The SI of the solid portion on DWI showed no statistically significant difference ($P = 0.27$). Fluid SI on T_1WI and T_2WI showed significant difference between SMBT and SBT ($P = 0.008$ and 0.007, respectively). No significant difference was found for the degree of contrast enhancement of the solid portion ($P = 0.14$).

"Ovarian endometriosis" and "pelvic endometriosis" were found more frequently in SMBT patients (8/20 and 5/20 for SMBT, 3/22 and 2/22 for SBT, respectively), although no significant difference was found ($P = 0.08$ and 0.23, respectively). Patients with at least one finding of "ovarian endometriosis" and "pelvic endometriosis" were found more frequently among the SMBT group (10/20 for SMBT and 3/22 for SBT) at a statistically significant level ($P = 0.019$).

Discussion

Our study showed that while SMBT and SBT shared many MR imaging findings and quantitative values, some different findings obtained can be useful for differentiating them. Regarding MR imaging findings, exophytic growth was found only in SBT. Papillary solid nodule was found

Table 4. Results of the signal intensity of the solid portion on diffusion-weighted image, fluid signal intensity on T_1-weighted image and T_2-weighted image and the degree of contrast enhancement of the solid portion

	Solid portion SI on DWI		Fluid SI on T_1WI		Fluid SI on T_2WI		Degree of CE of the solid portion	
	SMBT	SBT	SMBT	SBT	SMBT	SBT	SMBT	SBT
Low	0 (0)	1 (4.8)	6 (26)	12 (46)	3 (13)	0 (0)	3 (14)	1 (4.3)
Moderate	9 (45)	13 (62)	8 (35)	13 (50)	11 (48)	3 (12)	13 (62)	10 (43)
High	11 (55)	7 (33)	9 (39)	1 (3.8)	9 (39)	23 (88)	5 (24)	12 (52)

Data are *n* (%) for each imaging finding. SI, signal intensity; DWI, diffusion-weighted image; T_1WI, T_1-weighted image; T_2WI, T_2-weighted image; CE, contrast enhancement; SMBT, seromucinous borderline tumor; SBT, serous borderline tumor.

more frequently in SBT. Patients with MRI findings suggesting endometriosis were observed more frequently in SMBT. Accordingly, fluid SI in the cystic portion of SMBT was higher on T_1WI and lower on T_2WI than SBT with visual evaluation. Regarding quantitative values, the CE ratio of the solid portion was higher in SBT, presenting the highest AUC.

SMBT and SBT have a similar appearance both macroscopically and microscopically.[2] Both tumors typically have papillary projection inside cystic portion grossly. The solid portion of both tumors often consists of edematous stroma and fibrous stalk microscopically.[3,4] Indeed, our results demonstrated that both tumors shared some characteristic findings also on MRI, such as "T_2WI high SI solid portion," which corresponded to edematous stroma of the solid portion and "T_2WI low SI core," which reflected fibrous stalk pathologically. All SMBT and SBT presented "nodule in cyst appearance"; most SMBT and all SBT showed "papillary solid nodule." Our study also showed that "exophytic growth" was the characteristic finding of SBT, which was reported to be found as a gross finding up to 70%.[5,10,19] Zhao et al. reported that 37% of SBT showed mixed cystic-solid morphology and 16% solid morphology on MRI, which corresponds to exophytic growth in our research.[4] An earlier pathological report demonstrated that 4/30 cases of Müllerian mucinous papillary tumor presented papillae on their surface (two cases in stage I and the other two cases in stage III).[7] In the present study, 1/23 SMBT case showed tiny papillae on the surface of the tumor macroscopically. However, that was too small to detect on MRI. Considering that only one case report demonstrates SMBT with exophytic growth on MRI, SMBT with exophytic growth on MRI is very rare compared with SBT.[20] Therefore, exophytic growth on MRI is a useful finding for differentiating SBT from SMBT.

Reportedly, 30–70% of SMBT are associated with endometriosis, while the association of SBT with endometriosis have not been established.[7,21] In fact, endometriosis was confirmed pathologically in 16/20 patients of SMBT and 1/22 patient of SBT in this research. Regarding the evaluation of MRI findings suggesting endometriosis, "ovarian endometriosis" and "pelvic endometriosis" on MRI were found more frequently in SMBT. However, no significant differences were found between the two groups. One reason for the false positive cases related to the presence of endometriosis might be that these findings suggesting endometriosis did not necessarily correspond to the presence of the endometriosis pathologically. Recently, a report demonstrated the classic T_2-shading sign was not exclusive of endometriomas. The sign can be found for other pathological entities including malignant ovarian tumors.[22] Although pelvic adhesion for some reasons might be the cause of the two false positive SBT cases related to the pelvic endometriosis, we were unable to find an exact explanation for that in the operation and pathological records. Although diagnosis of the presence of endometriosis completely by MRI was difficult, patients with at least one of each finding suggesting endometriosis were found more frequently in SMBT patients at a statistically significant level. This was a useful finding for the differential diagnosis. Regarding the fluid SI in the cystic portion of the tumor, fluid SI of SMBT was higher on T_1WI and lower on T_2WI than SBT. Above all, our results demonstrated that the fluid showing high SI on T_1WI and low SI on T_2WI were highly suggestive of SMBT. The same result was obtained in the quantitative analysis of the fluid signal. This result is explainable by the fact that SMBT was frequently associated with endometriosis and that it often contained blood products in the cystic portion of the tumor. Zhao et al. reported that the SI of intracystic content of the SBTs was low on T_1WI and high on T_2WI in most of their cases (88%), and that our result was consistent with this report.[4]

As for the quantitative value, CE ratio was most useful for differentiation between SMBT and SBT. Pathologically, SMBT tends to present edematous stroma more conspicuously than SBT.[1] Therefore, SMBT contains less vasculature in its papillae compared with SBT. Probably for this reason, SMBT showed a lower CE ratio than SBT. Other quantitative values did not present significant difference between the two groups. These results also reflect the similarity of SMBT and SBT in terms of their macroscopic and microscopic findings.

This study had several limitations. The first is its retrospective nature and small sample size. Although a larger prospective study would be preferred, performing such a study would be practically difficult because of the rare occurrence of SMBT and SBT. Furthermore, some

variation was found for the MRI scanners and their respective acquired sequences. Therefore, we analyzed ADC values acquired with MRI machines of different magnetic field strength (1.5T or 3T) and with variable MRI parameters, which might affect the calculated ADC values. Moreover, DWI and contrast-enhanced images were not available for some patients. However, this was unavoidable because we included long-term patients. Finally, we only included patients who underwent MRI, which might cause selection bias.

Conclusion

This study revealed similarities and differences of MR imaging findings and quantitative values between SMBT and SBT. In terms of MR imaging findings, exophytic growth of the solid portion is much more suggestive finding of SBT rather than SMBT. Regarding the intracystic fluid, high SI on T_1WI and low SI on T_2WI were suggestive of SMBT. Regarding quantitative values, the CE ratio of the solid portion was higher in SBT compared with SMBT. These MR features can be useful for differentiation between SMBT and SBT.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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