



# Accuracy of sonography for non-invasive detection of ovarian and deep endometriosis using #Enzian classification: prospective multicenter diagnostic accuracy study

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**KEYWORDS:** #Enzian classification; lesion size; preoperative evaluation; sonography; surgery

## CONTRIBUTION

*What are the novel findings of this work?*

The localization and severity of endometriotic lesions and adhesions, as described using the #Enzian classification for endometriosis, can be diagnosed accurately on preoperative ultrasound.

*What are the clinical implications of this work?*

The recently updated #Enzian classification can be applied accurately both at preoperative ultrasound examination and during surgical resection of endometriosis, thereby enabling the use of uniform terminology for describing endometriosis.

## ABSTRACT

**Objective** To compare the preoperative detection of endometriosis using transvaginal sonography (TVS) supplemented by transabdominal sonography (TAS) with surgical assessment of disease, using the #Enzian classification for endometriosis.

**Methods** This was a prospective multicenter diagnostic accuracy study of women undergoing TVS/TAS and radical surgery for deep endometriosis (DE) at different tertiary referral centers. The localization and grade of severity of the endometriotic lesions and adhesions were described according to the criteria of the #Enzian classification, both at preoperative ultrasound exami-

nation and during surgery. According to the #Enzian classification, the small pelvis is divided into three compartments for DE: A (rectovaginal septum and vagina); B (uterosacral and cardinal ligaments, parametrium and pelvic sidewalls); and C (rectum). In addition, further locations (F) are classified as adenomyosis (FA), urinary bladder involvement (FB) and ureteric involvement with signs of obstruction (FU). Other intestinal locations (FI) and other extragenital locations (FO) are also included. Ovarian endometriosis and adhesions at the level of the tubo-ovarian unit are listed as O and T, respectively. The #Enzian grade of severity (Grade 1–3) was determined for #Enzian compartments O, T, A, B and C based on the size of the lesion or the severity of the adhesions. Concordance between preoperative assessment using TVS/TAS and evaluation at surgery was assessed. The sensitivity, specificity, positive and negative predictive values and accuracy of TVS/TAS in the detection of endometriotic lesions/adhesions in the different #Enzian compartments were calculated.

**Results** In total, 745 women were included in the analysis. Preoperative TVS/TAS and surgical findings showed a concordance rate ranging between 86% and 99% for the presence or absence of endometriotic lesions/adhesions, depending on the evaluated #Enzian compartment. The concordance rate between TVS and surgery ranged between 71% and 92% for different severity grades, in #Enzian compartments O, T, A, B and C. Determining the presence or absence of adhesions at the level of

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the tubo-ovarian unit and classifying them accurately as Grade 1, 2 or 3 on TVS was more difficult than determining the presence and severity of endometriotic lesions in #Enzian compartments O, A, B and C. The sensitivity of TVS/TAS for the detection of endometriotic lesions ranged from 50% (#Enzian compartment FI) to 95% (#Enzian compartment A), specificity from 86% (#Enzian compartment T<sub>left</sub>) to 99% (#Enzian compartment FI) and 100% (#Enzian compartments FB, FU and FO), positive predictive value from 90% (#Enzian compartment T<sub>right</sub>) to 100% (#Enzian compartment FO), negative predictive value from 74% (#Enzian compartment B<sub>left</sub>) to 99% (#Enzian compartments FB and FU) and accuracy from 88% (#Enzian compartment B<sub>right</sub>) to 99% (#Enzian compartment FB).

**Conclusions** The localization and severity of endometriotic lesions/adhesions, as described and classified according to the #Enzian classification, can be diagnosed accurately and non-invasively using TVS/TAS. The #Enzian classification provides a uniform classification system for describing endometriotic lesions, which can be used both at TVS/TAS and during surgical evaluation. © 2021 International Society of Ultrasound in Obstetrics and Gynecology.

## INTRODUCTION

Deep endometriosis (DE) is the most severe manifestation of endometriosis and may involve different structures and organs, such as the rectum, vagina, urinary bladder, uterosacral ligaments, parametrium or rectovaginal septum (RVS)<sup>1–4</sup>. In an attempt to describe more precisely the localization and extent of endometriotic lesions, different classification systems have been developed<sup>5–7</sup>, most of which focus on superficial disease and adhesions. In contrast, the Enzian classification was developed with the aim of better describing the localization and severity of DE lesions<sup>8</sup> and has been used in addition to other classifications, such as the revised American Society for Reproductive Medicine (rASRM) score, which was designed mainly for the purpose of evaluating fertility in women with endometriosis. Similar to other classifications, the Enzian classification is based on the intraoperative assessment of endometriotic lesions utilizing radical resection to determine accurately the extent of DE. However, there is an increasing need for a classification system that may also be applied to non-invasive imaging techniques, such as sonography and magnetic resonance imaging, which have been shown to diagnose accurately DE lesions<sup>9–12</sup>. This need, as well as the addition of peritoneal and ovarian endometriosis and associated adhesions, led to the development of the updated #Enzian classification<sup>13</sup>, which is designed for use at non-invasive imaging evaluation as well as during surgical assessment. By utilizing uniform terminology, this classification may facilitate communication between sonographers and surgeons, with the aim of being able to compare findings between centers and for clinical and research purposes. In addition, accurate presurgical

evaluation and description of the localization and severity of DE lesions, especially in cases of colorectal DE and bladder involvement, may provide clear guidance during surgical planning on an interdisciplinary level<sup>14–18</sup>.

A recent retrospective analysis from a single tertiary referral center<sup>19</sup> of ultrasound imaging data and surgical findings in women with DE showed a high overall diagnostic accuracy of presurgical transvaginal sonography (TVS) supplemented with transabdominal sonography (TAS) for detecting endometriotic lesions or adhesions and determining their size and severity grade in different compartments, as described using the #Enzian classification. The aim of the present work was to further evaluate the applicability and accuracy of TVS/TAS using the #Enzian classification for the assessment of endometriosis before radical surgery for DE in a large, prospective international tertiary referral multicenter setting.

## METHODS

This was a prospective multicenter diagnostic accuracy study. Consecutive women aged 18 years or older who underwent preoperative sonographic evaluation followed by surgical treatment for DE at several tertiary referral centers for endometriosis between January 2020 and May 2021 were included. Exclusion criteria were suspected or diagnosed malignancy and a history of colorectal surgery or surgery for DE including vaginal resection, full-thickness bowel resection or excision of a DE lesion of the urinary bladder. The following centers participated in this study: (1) Department of Gynecology, Center for Endometriosis, Hospital St John of God and Rudolfinerhaus Private Clinic Vienna, Austria; (2) Department of Obstetrics and Gynecology, Faculty of Medicine, Semmelweis University, Budapest, Hungary; (3) Department of Gynecology and Minimally Invasive Unit, Vita Batel Hospital, Curitiba, Brazil, together with the Department of Radiology, Roentgen Diagnóstico Institute, Curitiba, Paraná, Brazil; (4) Endoscopica Malzoni, Center for Advanced Pelvic Surgery, Avellino, Italy; (5) Department of Obstetrics and Gynecology, Nordwest Hospital, Frankfurt, Germany; (6) Acute Gynaecology, Early Pregnancy and Advanced Endoscopy Surgery Unit, Nepean Hospital, Kingswood, NSW, Australia; and (7) Department of Obstetrics and Gynecology, McMaster University, Hamilton, Canada. The study was approved by the local institutional review boards and informed consent was obtained from all participants. The study was registered on ClinicalTrials.gov (ID NCT04399668). The STARD guidelines were followed for this study<sup>20</sup>.

Demographic and clinical characteristics of the included women were recorded, such as age, body mass index, gravidity, parity, preoperative presence of dysmenorrhea, dyschezia, dyspareunia, infertility, rectal bleeding, constipation or diarrhea, as well as the intraoperatively determined rASRM stage. Preoperative sonographic assessment of endometriotic lesions was performed within

3 months before surgery by either a gynecologist or a radiologist (depending on the organization of the particular center) with extensive experience in gynecologic sonography, in particular in the field of endometriosis. Sonographic evaluation was performed using TVS supplemented by TAS, for example to evaluate the kidneys regarding hydronephrosis in the presence of DE or to evaluate the presence of endometriotic lesions in cases of upper abdominal pain. All operations were performed by gynecologic surgeons with extensive experience in advanced minimally invasive surgery, in particular for DE, in a multidisciplinary setting. The surgeons were not blinded to the findings of preoperative evaluation by TVS/TAS, as TVS/TAS assessment is performed routinely to plan the surgical intervention in all the participating centers. All women underwent full radical resection of all visible endometriotic lesions followed by histological confirmation.

The localization and severity grade of the endometriotic lesions/adhesions were described according to the criteria of the #Enzian classification (Figure 1)<sup>13,21</sup>, both at preoperative ultrasound examination and during surgery. In the #Enzian classification<sup>13</sup>, the terms and definitions for the description of DE are based on the International Deep Endometriosis Analysis group consensus opinion<sup>21</sup>. According to the #Enzian classification, the small pelvis

is divided into three compartments for DE, with their anatomical correlates as follows: compartment A comprises the RVS and vagina, including the torus uteri; compartment B comprises the uterosacral and cardinal ligaments, parametrium and pelvic sidewalls; and compartment C comprises the rectum (defined as up to 16 cm from the anal verge). In addition, further locations (F) are classified as adenomyosis (FA), urinary bladder involvement (FB) or ureteric involvement with signs of obstruction (FU). Bowel disease cranial to the rectosigmoid junction (FI; > 16 cm from the anal verge; sigmoid colon, transverse colon, cecum, appendix and small bowel) and other extragenital locations, such as the abdominal wall, diaphragm and nerves, are also included. All these other extragenital locations were considered collectively and described as #Enzian compartment FO in the present study. Peritoneal disease, ovarian endometriosis and adhesions at the level of the tubo-ovarian unit are listed as P, O and T, respectively. According to the #Enzian classification, tubal patency can be evaluated optionally using TVS and may be recorded as part of #Enzian compartment T. Data on tubal patency were not included in the present study. #Enzian compartment P (peritoneum) was not analyzed, as it can be assessed only at surgery but not on TVS/TAS. Furthermore, #Enzian compartment FA was

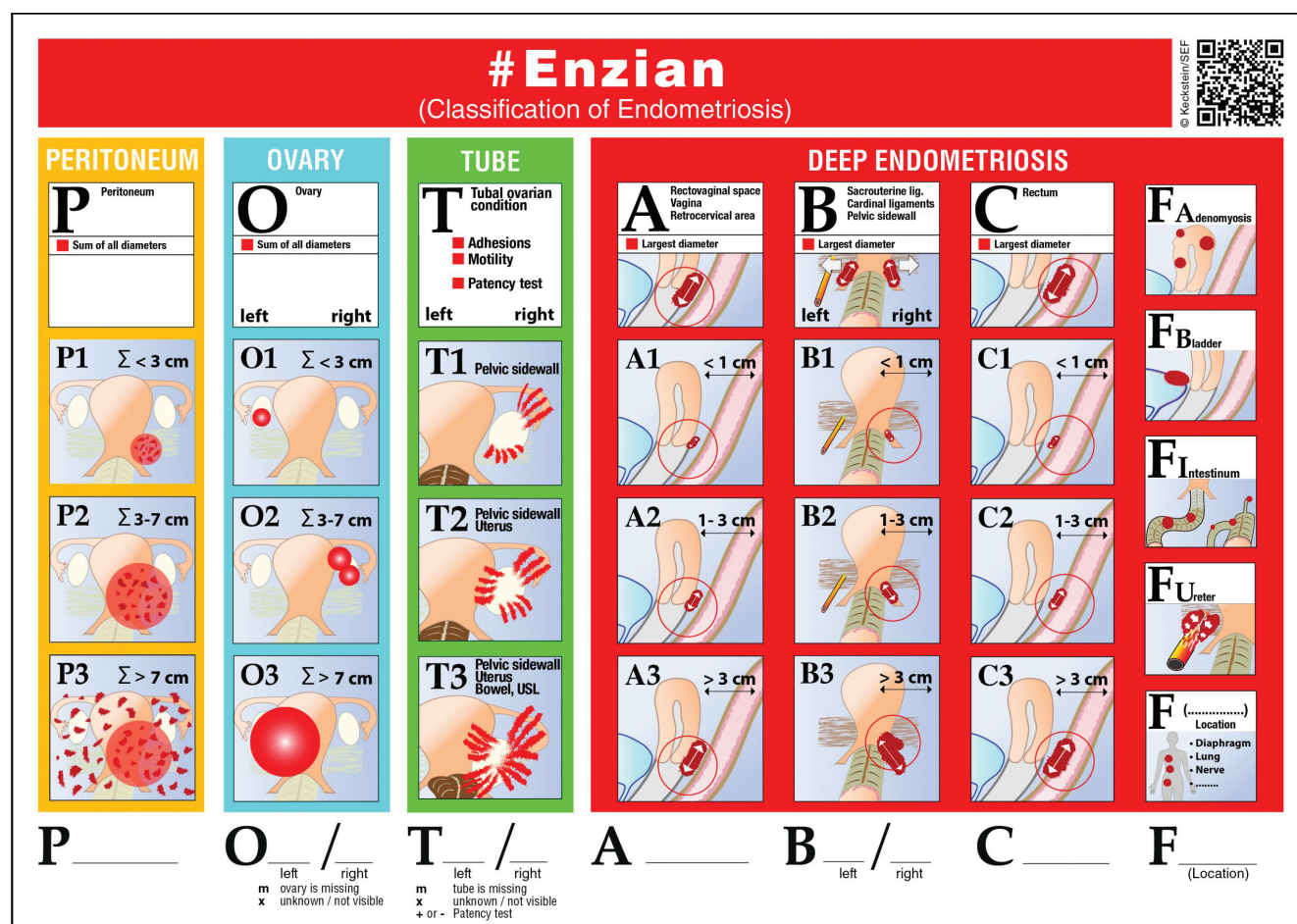


Figure 1 #Enzian classification of endometriosis.



not evaluated because definitive histological diagnosis regarding adenomyosis was not available for all cases. The endometriotic lesions in all other #Enzian compartments were confirmed histologically. #Enzian compartments O, T, A, B, C, FB, FU and FI were evaluated using TVS, and #Enzian compartments FI and FO were evaluated using TAS.

According to the #Enzian classification, the severity of lesions in #Enzian compartments A, B and C is classified based on maximum lesion length as Grade 1 (<1 cm), Grade 2 (1–3 cm) or Grade 3 (>3 cm). For lesions in #Enzian compartment O, severity is classified based on the sum of the maximum diameters of all ovarian endometriotic lesions as Grade 1 (<3 cm), Grade 2 (3–7 cm) or Grade 3 (>7 cm). For adhesions in #Enzian compartment T, severity is classified as Grade 1 (mild), Grade 2 (moderate) or Grade 3 (severe). For lesions in #Enzian compartments FA, FB, FU, FI and FO, severity is not determined according to the #Enzian classification.

For #Enzian compartments O, T and B, each side (left/right) was considered and noted separately. Furthermore, the absence of ovaries or tubes on one or both sides was recorded, as were unclear findings regarding the ovary on preoperative sonography (for example, when the ovary could not be visualized).

## Statistical analysis

Data on the included women are given as mean  $\pm$  SD or  $n$  (%), as appropriate. The concordance in severity grade between preoperative assessment by TVS and evaluation at surgery was calculated for endometriotic lesions/adhesions in #Enzian compartments O, T, A, B and C. Furthermore, the concordance between preoperative TVS/TAS examination and surgical assessment regarding the involvement of #Enzian compartments FB, FU, FI and FO was calculated. The sensitivity and specificity, with 95% CIs, of TVS/TAS for the detection of endometriotic lesions/adhesions in each #Enzian compartment were assessed. Additionally, the positive predictive value (PPV), negative predictive value (NPV) and accuracy, with 95% CIs, of TVS/TAS for the detection of endometriotic lesions/adhesions in the different #Enzian compartments were calculated for each specific compartment, both overall and separately for each associated severity grade.

## RESULTS

A total of 745 women undergoing preoperative TVS/TAS examination followed by radical surgical resection of DE at the participating centers were included in the study. Demographic and clinical characteristics of the women are shown in Table 1.

Table 2 shows the sensitivity, specificity, PPV, NPV and accuracy of preoperative TVS/TAS examination for the detection of endometriotic lesions/adhesions in each #Enzian compartment. Sensitivity ranged from 78% to 95%, except for #Enzian compartments FI (50%) and FO (57%), and specificity ranged from 86% to 100%.

PPV ranged from 90% to 100%, NPV ranged from 74% to 99% and accuracy ranged from 88% to 99%. The PPV, NPV and accuracy of preoperative TVS/TAS for the detection of endometriotic lesions/adhesions in #Enzian compartments O, T, A, B and C according to severity grade are summarized in Table S1.

For #Enzian compartments O, T, A, B and C, Figure 2 shows the percentage of cases in which the severity grade of the endometriotic lesion/adhesions, according to the #Enzian classification, was exactly concordant between preoperative TVS and surgical assessment, as well as the percentage of cases in which the severity grade differed by one, two or three grades. Cross-tabulation of the findings at preoperative TVS and at surgery in #Enzian compartments O, T, A, B and C, according to severity grade, is shown in Table 3. For all #Enzian compartments except for T (concordance rate of 71% for T<sub>left</sub> and 75% for T<sub>right</sub>), the proportion of cases with complete concordance in severity grade ranged between 79% and 92%. In most cases with discordant severity grade between TVS and surgical assessment, there was a difference of only one severity grade. A difference of two severity grades was observed in only 1% (#Enzian compartments C and O<sub>left</sub>) to 6% (#Enzian compartment T<sub>right</sub>) of cases. A difference of three severity grades occurred in only one case for #Enzian compartment O<sub>right</sub>, two cases for #Enzian compartment O<sub>left</sub> and 1% of cases

**Table 1** Demographic and clinical characteristics of 745 women with deep endometriosis

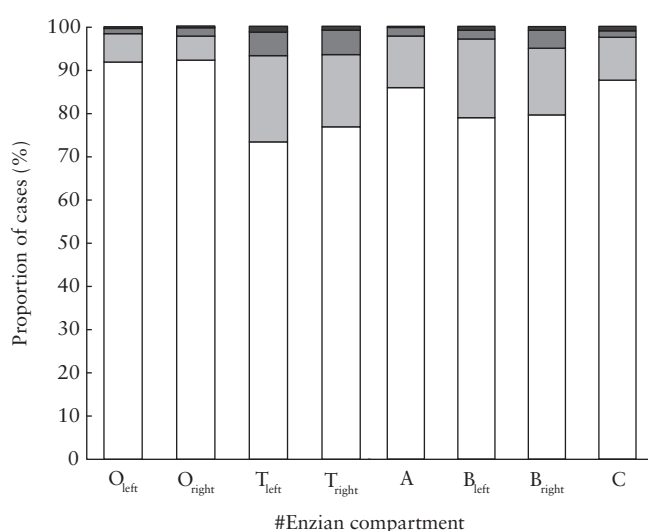
Characteristic	Value
Age (years)	35 $\pm$ 6
Body mass index (kg/m <sup>2</sup> )	24 $\pm$ 5
Gravidity	
0	522 (70)
1	140 (19)
2	52 (7)
3	20 (3)
$\geq 4$	11 (1)
Parity	
0	597 (80)
1	97 (13)
2	39 (5)
3	11 (1)
4	1 (0.1)
Preoperative symptom	
Dysmenorrhea	720 (97)
Dyschezia	406 (54)
Dyspareunia	437 (59)
Infertility	319 (43)
Rectal bleeding	47 (6)
Constipation	234 (31)
Diarrhea	183 (25)
rASRM stage	
1	38 (5)
2	122 (16)
3	268 (36)
4	317 (43)

Data are given as mean  $\pm$  SD or  $n$  (%). rASRM, revised American Society for Reproductive Medicine.

**Table 2** Diagnostic performance of preoperative ultrasound in the detection of endometriotic lesions/adhesions in different #Enzian compartments

#Enzian compartment	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
O <sub>left</sub>	90 (86–94)	96 (94–98)	94 (91–96)	94 (92–96)	94 (92–96)
O <sub>right</sub>	89 (84–92)	98 (96–99)	94 (91–97)	95 (93–96)	95 (93–96)
T <sub>left</sub>	90 (87–93)	86 (82–90)	91 (88–93)	86 (82–89)	89 (86–91)
T <sub>right</sub>	88 (84–91)	90 (87–93)	90 (87–92)	88 (85–91)	89 (86–91)
A	95 (92–96)	93 (89–96)	97 (96–98)	88 (83–91)	94 (92–96)
B <sub>left</sub>	91 (88–93)	88 (83–93)	96 (95–98)	74 (68–78)	90 (88–92)
B <sub>right</sub>	83 (79–87)	94 (91–96)	94 (91–96)	83 (80–86)	88 (86–91)
C	93 (90–95)	95 (92–98)	97 (95–98)	90 (86–92)	94 (92–96)
FB	94 (87–98)	100 (99–100)	98 (91–99)	99 (98–100)	99 (98–100)
FU	78 (63–89)	100 (99–100)	95 (81–99)	99 (97–99)	98 (97–99)
FI	50 (41–59)	99 (98–100)	94 (85–98)	91 (89–93)	91 (89–93)
FO	57 (37–76)	100 (99–100)	100*	98 (98–99)	98 (97–99)

Values in parentheses are 95% CI. \*95% CI not calculable. A, vagina and rectovaginal septum; B, uterosacral ligament, cardinal ligament, parametrium and pelvic sidewall; C, rectum; FB, urinary bladder; FI, other intestinal locations; FO, other extragenital locations; FU, ureters; NPV, negative predictive value; O, ovary; PPV, positive predictive value; T, tubo-ovarian unit.



**Figure 2** Concordance between preoperative ultrasound and surgical assessment in #Enzian severity grade of endometriotic lesions/adhesions in #Enzian compartments O, T, A, B and C. □, no difference in severity grade; ▨, difference of one severity grade; ▩, difference of two severity grades; ■, difference of three severity grades. It should be noted that, for example, a difference of two severity grades in this representation may be due to a Grade 2 lesion/adhesion being missed on preoperative transvaginal sonography (TVS) or a Grade 2 lesion/adhesion being seen on TVS that could not be detected at surgery, as well as due to classification of the severity of a lesion/adhesion as Grade 1 on TVS and Grade 3 at surgery or *vice versa*. A, vagina and rectovaginal septum; B, uterosacral ligament, cardinal ligament, parametrium and pelvic sidewall; C, rectum; O, ovary; T, tubo-ovarian unit.

for #Enzian compartments B<sub>left</sub>, B<sub>right</sub>, C, T<sub>left</sub> and T<sub>right</sub>. It should be noted that determining the presence or absence of adhesions at the level of the tubo-ovarian unit and classifying them accurately as Grade 1 (T1), 2 (T2) or 3 (T3) on TVS was more difficult than determining the presence and severity of endometriotic lesions in #Enzian compartments O, A, B and C. Adhesions in #Enzian compartment T that were diagnosed as T1 on TVS were diagnosed as T3 at surgery in 1% of cases on both the left

and the right side, while adhesions that were described preoperatively as T3 were classified intraoperatively as T1 in 2% of cases on the left side and in 1% on the right side. Furthermore, there were more false-positive and false-negative findings for #Enzian compartment T (in 6% of cases for the left side and in 5% of cases for the right side, for both) than for the other #Enzian compartments.

For #Enzian compartments FB, FU, FI and FO, for which there is no distinction between different severity grades according to the #Enzian classification, the rate of concordance between TVS/TAS and surgery was 99% for #Enzian compartments FB and FU, 91% for #Enzian compartment FI and 98% for #Enzian compartment FO (Table 4). When similarly considering only the mere presence or absence of a lesion/adhesion in #Enzian compartments O, T, A, B and C, independently of severity grade, the concordance rate ranged between 86% (#Enzian compartment T<sub>right</sub>) and 95% (#Enzian compartment C) (Table 3).

The proportion of cases with a false-positive result, i.e. an endometriotic lesion/adhesion seen on preoperative TVS/TAS that was not confirmed at surgery, ranged between 0% and 3%, except for in #Enzian compartments T<sub>left</sub> (6%, of which almost all were classified as T1 or T2 on TVS) and T<sub>right</sub> (5%, of which almost all were classified as T1 or T2 on TVS). No false-positive cases were observed for #Enzian compartment FO, two were observed for #Enzian compartments FB and FU and four were observed for #Enzian compartment FI, resulting in high specificity (100% for #Enzian compartments FO, FB and FU and 99% for #Enzian compartment FI) and PPV (94–100%) for the presence of a lesion in these compartments. The proportion of cases with a false-negative result, i.e. an endometriotic lesion/adhesion not detected on preoperative TVS/TAS but seen at surgery, ranged from 1% (#Enzian FB and FU) to 8% (#Enzian B<sub>left</sub> and FI) and 9% (#Enzian B<sub>right</sub>). In the vast majority of cases with a false-negative result, for all #Enzian compartments, the severity of the lesion/adhesions was classified as Grade 1 at surgery.

**Table 3** Concordance between preoperative ultrasound and surgical assessment in the #Enzian severity grade of endometriotic lesions/adhesions in #Enzian compartments O, T, A, B and C

#Enzian compartment / severity on ultrasound	Severity at surgical assessment			
	No lesion/adhesion	Grade 1	Grade 2	Grade 3
O <sub>left</sub> *				
No lesion	58.7	2.8	0.7	0.1
Grade 1	1.5	11.5	0.7	0.0
Grade 2	0.5	0.8	16.8	0.1
Grade 3	0.1	0.0	0.5	3.4
O <sub>right</sub> †				
No lesion	66.0	2.6	0.8	0.1
Grade 1	0.5	10.5	0.8	0.0
Grade 2	0.5	0.8	10.9	0.4
Grade 3	0.0	0.0	0.4	3.6
T <sub>left</sub> ‡				
No adhesion	33.0	4.0	0.9	0.5
Grade 1	2.8	14.6	3.4	0.9
Grade 2	1.9	3.8	9.4	2.7
Grade 3	0.5	1.5	2.6	13.6
T <sub>right</sub> §				
No adhesion	43.9	4.3	1.3	0.4
Grade 1	2.6	12.9	1.3	1.1
Grade 2	2.0	3.5	8.2	3.2
Grade 3	0.3	1.1	1.3	9.9
A				
No lesion	26.8	3.1	0.7	0.0
Grade 1	1.2	8.1	2.3	0.4
Grade 2	0.7	2.0	33.7	1.9
Grade 3	0.0	0.3	1.5	17.4
B <sub>left</sub>				
No lesion	20.3	5.5	1.2	0.5
Grade 1	2.1	25.4	4.4	0.4
Grade 2	0.4	4.3	29.4	1.5
Grade 3	0.1	0.0	0.4	4.6
B <sub>right</sub>				
No lesion	44.4	5.0	3.4	0.5
Grade 1	2.0	22.8	3.9	0.0
Grade 2	0.7	3.6	11.5	0.8
Grade 3	0.1	0.1	0.1	0.9
C				
No lesion	36.6	3.0	0.5	0.8
Grade 1	1.2	3.9	0.9	0.4
Grade 2	0.5	0.7	20.4	2.7
Grade 3	0.0	0.0	1.5	26.8

Data are given as %. \*In one case, the left ovary (O) could not be assessed on preoperative ultrasound and was classified as having no lesion at surgery; in 12 cases, the left ovary was missing. †In 11 cases, the right ovary was missing. ‡In two cases, the left tubo-ovarian unit (T) could not be assessed on preoperative ultrasound (at surgery, it was classified as having no adhesion in one case and as T1 in the other case); in one case, the left tube was recorded as missing on preoperative ultrasound and was classified as T2 at surgery; in 26 cases, the left tube was missing. §In one case, the right tube was recorded as missing on preoperative ultrasound and was classified as T2 at surgery; in 19 cases, the right tube was missing. A, vagina and rectovaginal septum; B, utero-sacral ligament, cardinal ligament, parametrium and pelvic sidewall; C, rectum.

**Table 4** Concordance between preoperative ultrasound and surgical assessment in the detection of endometriotic lesions in #Enzian compartments FB, FU, FI and FO

#Enzian compartment/ ultrasound assessment	Surgical assessment	
	Lesion	No lesion
FB		
Lesion	11.3	0.3
No lesion	0.7	87.8
FU		
Lesion	4.7	0.3
No lesion	1.3	93.7
FI		
Lesion	8.2	0.5
No lesion	8.2	83.1
FO		
Lesion	2.1	0.0
No lesion	1.6	96.2

Data are given as %. FB, urinary bladder; FI, other intestinal locations; FO, other extragenital locations; FU, ureters.

## DISCUSSION

In this prospective multicenter study, we evaluated the accuracy of presurgical TVS/TAS for the non-invasive diagnosis of endometriosis, applying the #Enzian classification<sup>13</sup>. Overall, the sensitivity, specificity, PPV, NPV and accuracy of preoperative TVS/TAS examination for detecting endometriotic lesions/adhesions in the different #Enzian compartments were high, ranging from about 80% to 100%.

The present work demonstrates a high concordance rate, ranging from 86% to 99%, between TVS/TAS and surgical assessment in the detection of endometriotic lesions/adhesions in each specific #Enzian compartment. When taking into account the size of the endometriotic lesion or the severity of the adhesions (i.e. severity grade) in #Enzian compartments O, T, A, B and C, the rate of complete concordance between TVS and surgical assessment ranged from 71% to 92%. In the majority of cases with discordance in severity grade, there was a difference of only one severity grade, with a minority differing by more than one severity grade. In this regard, it should be noted that measurements of endometriotic lesions may differ by only a few mm between TVS and surgical assessment and this is sufficient to change the #Enzian severity grade. This should be taken into account since inaccurate estimation of lesion severity by one grade may be of only minor clinical importance in the planning of surgical procedures and estimation of associated risks.

In line with the findings of a previous retrospective study using the #Enzian classification to evaluate endometriotic lesions and adhesions<sup>19</sup>, difficulties in the diagnosis of tubo-ovarian adhesions were observed in the current study. Mild tubo-ovarian adhesions on TVS (corresponding to T1) were diagnosed as severe at surgery (i.e. T3) in some cases (1% of cases on both the left and right sides), while lesions described preoperatively as T3 were classified intraoperatively as T1 in 2% of cases on the left side and 1% on the right side. Furthermore, false-positive

and false-negative findings were observed in a higher proportion of cases (6% on the left side and 5% on the right side, for both) for #Enzian compartment T than for the other #Enzian compartments. This may, in part, be due to the more subjective evaluation of tubo-ovarian adhesions, in particular of the severity grade, by visualizing and grading ovarian mobility on TVS.

The strength of this study is its multicenter tertiary referral center setting, leading to the recruitment of a large number of women. It is the first work on this scale to demonstrate the value of a multimodal classification system for endometriosis both at TVS/TAS and at surgery. The validity of the findings is therefore high, and they demonstrate the applicability of the #Enzian classification in several large centers treating women with DE. Nevertheless, this work has some limitations. Firstly, the surgeons were not blinded to preoperative TVS/TAS findings. On the one hand, this may have led to possible bias. On the other hand, surgical evaluation of the extent of the disease was performed using quantitative and objective measurement methods. Furthermore, the use of presurgical sonography reflects everyday clinical practice in all the contributing centers and is strongly promoted by the authors. Secondly, it should be noted that all the sonographers and surgeons taking part in this study have extensive clinical experience in their fields, which suggests that the results of this work may be applicable predominantly to tertiary referral settings.

In conclusion, the findings of the present study confirm preliminary data<sup>19</sup> showing that preoperative assessment of the localization and severity grade of endometriotic lesions/adhesions, as described according to the #Enzian classification, can be carried out with high accuracy using ultrasound. This provides further evidence that the #Enzian classification can be used by both sonographers and surgeons to describe endometriotic lesions. This may facilitate communication between specialties, the planning of surgical procedures for DE and the comparison of findings between centers for clinical and research purposes.

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## SUPPORTING INFORMATION ON THE INTERNET

The following supporting information may be found in the online version of this article:



**Table S1** Positive and negative predictive values and accuracy of preoperative ultrasound in the detection of endometriotic lesions/adhesions in #Enzian compartments O, T, A, B and C, according to the #Enzian severity grade