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ORIGINAL ARTICLE

Prospective evaluation of paravaginal defect repair with and without apical suspension: a 6-month postoperative follow-up with MRI, clinical examination, and questionnaires

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Abstract

Introduction and hypothesis Paravaginal defect (PVD) has been suggested as one of the main contributors to the development of prolapse in the anterior vaginal wall (AVW). We aimed to evaluate the descent of pelvic organs, presence of vaginal H configuration, and pubococcygeus (PC) muscle defect by pelvic magnetic resonance imaging (MRI), together with subjective symptoms of prolapse, before and 6 months after PVD repair. We also aimed to evaluate risk factors of recurrence.

Methods Fifty women with PVD diagnosed by gynecological examination and scheduled for vaginal PVD repair were planned for enrollment. Preoperatively and 6 months postoperatively, subjective symptoms were evaluated using the International Consultation on Incontinence Questionnaire–Vaginal Symptoms (ICIQ-VS) together with MRI of the pelvis to evaluate defects in the PC muscle, vaginal shape, and pelvic organ descent.

Results Forty-six women completed the study. Twenty had PVD repair alone, whereas 26 also had concomitant surgery performed. Prolapse grade, subjective symptoms, sexual problems, and quality of life (QoL) were significantly improved at follow-up. Missing vaginal H configuration was observed in 21 women before operation and was correlated with PC muscle defect. Recurrence rate was 39%, and significantly more women with recurrence had PC muscle defects and missing H configuration.

Conclusion Vaginal PVD repair alone or combined with concomitant surgery significantly reduces objective prolapse and subjective symptoms. We could not demonstrate MRI findings of missing H configuration to be a sign of PVD but, rather, a sign of defect in the PC muscle. Risk of recurrence is significantly higher in women with major PC muscle defects and missing H configuration.

Keywords Paravaginal defect · PVD · MRI · Levator ani defects · Pubococcygeus defect · Paravaginal defect repair

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Abbreviations

POP	Pelvic organ prolapse
PVD	Paravaginal defect
AVW	Anterior vaginal wall
ATFP	Arcus tendineus fascia pelvis
MRI	Magnetic resonance imaging
POP-Q	Pelvic Organ Prolapse Quantification System
ICIQ-VS	International Consultation on Incontinence Questionnaire–Vaginal Symptoms
VSS	Vaginal symptom score
SMS	Sexual matter score
QoL	Quality of life score
ICIQ-UI-SF	International Consultation on Incontinence Questionnaire–Urinary Incontinence-Short Form
PC	Pubococcygeus

PCL Pubococcygeal line
PGI-I Patient Global Impression of Improvement

Introduction

In Denmark, the lifetime risk of undergoing at least one pelvic organ prolapse (POP) surgery is 19%. The anterior vaginal wall (AVW) is the most common site of repair compared with the apex and the posterior vaginal wall [1]. The AVW is also the site with the highest rate of recurrence after surgery; subjective and objective recurrence rates in the 20 and 40% range is not uncommon [2]. For the individual woman, prolapse negatively affects physical and mental well-being, with a possible negative influence on quality of life (QoL). Prolapse also represents a socioeconomic burden to society, and recurrence of prolapse is, therefore, a problem for both the society and for the individual woman who needs repeated surgery [3]. Different anatomic defects have been suggested as a cause of or contributor to the development of AVW prolapse. These include defects in the levator ani muscle [especially the pubococcygeus (PC) muscle], detachment of the pubocervical fascia from the arcus tendineus fascia pelvis (ATFP), thinning of the pubocervical fascia, and stretching of the uterosacral and cardinal ligaments [4]. It has been suggested that recurrence after AVW prolapse surgery might be explained by missing site-specific repair of ignored anatomical defects or defects not possible to repair [5].

Detachment of the pubocervical fascia from the ATFP at vaginal level II is also called a paravaginal defect (PVD), which can lead to AVW prolapse [6]. Magnetic resonance imaging (MRI) studies have found paravaginal descent to be one of the major predictors of AVW prolapse [7]. During gynecologic examination, PVD can be observed as descent of the AVW, missing lateral sulcus at the side of the defect, and preserved rugal folds [8]. Even though several authors have evaluated clinical examination for establishing the a PVD diagnosis and concluded that the method is inconsistent and has low reproducibility, gynecological examination is still the method of choice when evaluating women with AVW descent and possible PVD. [9–11]. Literature regarding methods to help diagnose the PVD is sparse. Therefore, we were interested in evaluating MRI as a method to support the clinical diagnosis of PVD. This prospective study aimed to evaluate the anatomical location of pelvic organs during rest and straining, presence of PVD, and defects in the levator muscles using pelvic MRI in women undergoing surgery for PVD. The study further aimed to correlate these findings with objective and subjective outcome 6 months after surgery.

Method

The Danish Data Protection Agency (2008-58-0028) and the local ethics committee (N-20150001) approved the study. All women signed a written consent form before inclusion and consented to the use of clinical data for scientific purposes. Fifty consecutive women with a clinical diagnosis of PVD and AVW prolapse on examination at the outpatient clinic at Aarhus University Hospital, Denmark, were prospectively enrolled in this study between March 2015 and January 2017. Inclusion criteria were age >18 years, capability of reading and understanding Danish, symptomatic AVW prolapse due to PVD evaluated by gynecological examination, and acceptance of undergoing PVD repair. Exclusion criteria were metal implants in the body and body circumference >180 cm. Participants were evaluated at enrollment and 6 months after operation. Preoperative status and surgical outcome were evaluated by gynecological examination, questionnaires, and MRI of the pelvis at rest and during straining.

Gynecological examination

Grade of prolapse was staged according to the Pelvic Organ Prolapse Quantification System (POP-Q) [12]. The PVD diagnosis was established with the woman in the supine position and the AVW examined during rest and Valsalva while a curved sponge forceps was held against the vaginal wall so that each side of the lateral vagina joined to the ATFP. If the AVW prolapse was replaced by the forceps, it was identified as presence of PVD [8, 9]. The method used was earlier described [9–11]. No other method to detect PVD during gynecological examination has been evaluated, and this method is used in the daily clinical setting.

Questionnaires

A paper version of the International Consultation on Incontinence Questionnaire—Vaginal Symptoms (ICIQ-VS), validated in Danish, was completed by each woman. The questionnaire evaluates subjective vaginal symptoms, sexual matters, and QoL. Likewise, a paper version of the International Consultation on Incontinence Questionnaire—Urinary Incontinence Short Form (ICIQ-UI-SF) was completed [13, 14].

MRI

Within 3 months of the initial gynecological examination, an MRI scan of the pelvis was performed using 1.5- or 3-T platforms, with pelvic phased-array or cardiac coil and with the woman in the supine position. No enema, bowel filling, or contrast was used. Anatomic T2-weighted images in three planes, field of view 240, and slice thickness 4 mm during rest were acquired; sagittal T2-weighted images were followed by axial/short-axis T2-weighted images of the entire pelvis from the subcutaneous part of the external sphincter to the promontory, angulated perpendicular to the sphincter. Coronal/long-axis T2-weighted images were obtained angulated parallel to the sphincter, covering the pelvis from the pubic bone to the sacrum. Sequences during rest were followed by sagittal and coronal/long-axis single-shot T2-weighted

sequences during straining. Acquisitions during straining were obtained in the midsagittal plane with nine slices of 4 mm each and gap 0.8 mm, in total covering 4.3 cm in the midsagittal plane. The coronal/long-axis sequences during straining were obtained parallel to the sphincters using 11 slices of 5 mm each and a gap of 0.5 mm, in total covering 6 cm in the oblique anteroposterior (AP) plane. The single-shot sequences had a duration of 8–13 s and were repeated up to three to four times in each plane to increase the chance of demonstrating maximum descent during straining. Before MR examination, patients received detailed information on how to strain during scanning, and all patients had become familiar with the straining procedure during gynecological examination. A senior radiologist with >9 years of experience in pelvic MRI was blinded to results of the gynecological examination and evaluated the images.

Parameters

Three parameters were chosen for this study: resting images in the axial and coronal planes were evaluated for defects in the PC muscle of the levator ani. The right and left sides of the muscle were scored as either having no defect (0), defect <50% (1), >50% (2), or entirely absent (3) [15]. Scores for each side were totalled, and muscle defect was said to be either nonexisting (0), mild (1–3), or major (4–6 or unilateral 3).

At the midsagittal image, a reference line from the lower border of the symphysis pubis to the articulation between S5 and the coccyx bone was constructed [pubococcygeal line (PCL)] (Fig. 1). The distance between the PCL and the base of the bladder/anterior cervical lip was measured during straining. Measurement above the PCL was given a negative value; measurement below was positive. A mild cystocele/apical decent was present if the bladder base/cervix descended 1–3 cm below the PCL. If the descent was >6 cm below the line, it was defined as severe, and in between, it was said to be moderate [16, 17].

At vaginal level II, the vagina and pubocervical fascia are strongly attached to the ATFP, and on axial images, the vagina appears H-shaped due to this attachment (Fig. 1). The pubocervical fascia is not depicted by MRI, but several authors have suggested an altered vaginal shape as an indication of PVD. [18–20]. At vaginal level II, axial T2-weighted images at rest were evaluated to determine whether the normal H configuration was present. If one side of the H was missing, the PVD was said to be unilateral (right or left), and if both sides of the H were missing, the defect was bilateral.

Operation technique

Vaginal paravaginal repair was routinely performed under local anesthesia with bilateral pudendal block using 7 ml of bupivacaine 5 mg/ml. Furthermore, infiltration anesthesia was established with 20 ml mepivacaine 5 mg/ml and adrenaline 5 μg/ml or 40 ml lidocaine 2.5 mg/ml and adrenaline 5 μg/ml. If needed, light sedation and pain relief were achieved by intravenous administration of alfentanil, propofol, or fentanyl. The anterior vaginal mucosa was opened in the midline from 2 cm below the external urethral orifice to the cervix. Blunt dissection was performed to access the paravaginal space and the ATFP. With the Capio™ Suture Capturing Device (Boston Scientific, Marlborough, MA, USA), three polydioxanone 0 sutures were placed in the ATFP approximately 1, 2, and 3 cm from the ischial spine. If only unilateral PVD was found, the contralateral vaginal sulcus was not opened. In case of a concomitant apical defect, a suture was placed in the sacrospinous ligament 1.5 cm medial to the ischial spine. The pubocervical fascia was duplicated with a continuous polydioxanone 3–0 suture. Sutures from the ATFP were attached to the lateral part of the pubocervical fascia, whereas the suture from the sacrospinous ligament was attached to the cardinal ligament. Vaginal mucosa was trimmed and closed with a running polyglactin 3–0 suture. Prophylactic antibiotics were not given. At the end of the operation, all women had a cystoscopy to ensure normal function of ureters. After the operation, the vagina was packed for 3 h. During this period, the woman had an indwelling bladder catheter. Patients were discharged from hospital when feeling well and if residual urine was <150 ml after spontaneous voiding. Surgeries were performed by senior doctors with >7 years of experience in performing PVD repair. Whether to perform the PVD repair, side of repair, and decision to perform concomitant surgery were based solely on the clinical examination performed by the surgeon on the day of operation, and the surgeon was blinded to MRI findings.

Follow-up was planned for 6 months postoperatively. POP-Q measurements were used to evaluate objective grade of prolapse, whereas subjective vaginal symptoms and urinary incontinence were assessed using the ICIQ-V and ICIQ-UI-SF. Satisfaction after the operation was evaluated using the Patient Global Impression of Improvement questionnaire (PGI-I) [21]. Recurrence of prolapse was defined as grade 3 or 4 prolapse in the same compartment with or without subjective symptoms of prolapse, or grade 2 prolapse with symptoms (ICIQ-VS answer sometimes, most of the time, or all of the time in item 5a or 6a), or reoperation for prolapse in the same compartment.

To evaluate whether the PVD repair altered changes in the location of the bladder and cervix, MRI during Valsalva before and 6 months after the operation were performed, and mean distances between the PCL and bladder/cervix before and after operation were compared.

Statistics IBM SPSS statistics 22.0 (SPSS, Chicago, IL, USA) was used for statistical analyses. Observations before and after operation were compared using means and paired *t* test for the POP-Q observations and the distance to the PCL determined by MRI; median values and the Wilcoxon signed-rank test were used on questionnaire data. Comparison of women with and without recurrence was tested using parametric and nonparametric tests. The level of significance was set to a *p* value of 0.05.

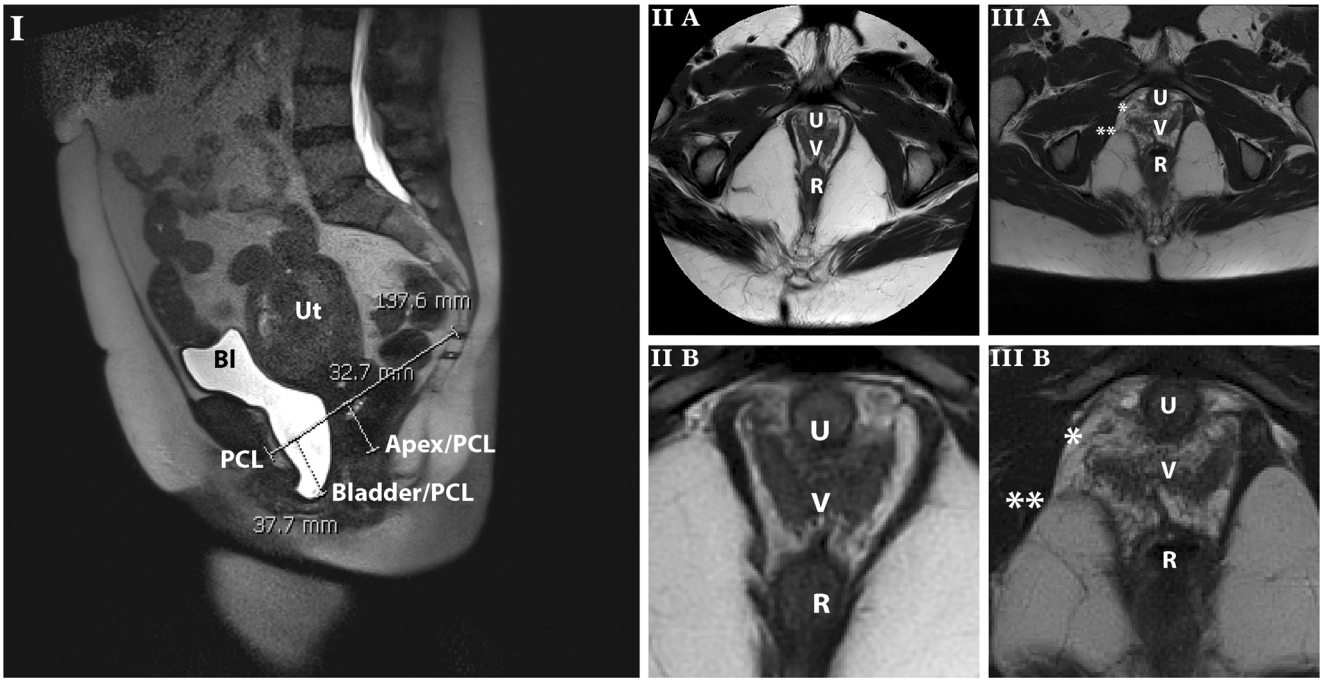

Fig. 1 Magnetic resonance images (MRI) of the pelvis. *Image I* Dynamic MRI in the midsagittal plane illustrates measurements of bladder and apical descent according to the pubococcygeal line (PCL). *Image II A, B* Resting images in the axial plane illustrate normal H configuration and no muscle defect. *Image II A, B* Resting images in the axial plane illustrating a missing H on the right side (*) and defect in the right pubococcygeus muscle (**). Left side is intact. *Bl* urine bladder, *Ut* uterus, *PCL* pubococcygeal line, *Bladder/PCL* distance from PCL to the bladder base, *Apex/PCL* distance from PCL to anterior cervical lip, *U* urethra, *V* vagina, *R* rectum>

Results

Fifty women were evaluated; one declined the operation, one was perioperatively evaluated not to have a PVD and an anterior colporrhaphy only was performed. Two women were lost to follow-up, leaving 46 women in the study group. Table 1 shows baseline data.

Operations performed were vaginal PVD repair alone, as described above ($n = 20$), or PVR repair combined with the following procedures: sacrospinous ligament fixation ($n = 16$), perineorrhaphy ($n = 6$), sacrospinous ligament fixation and perineorrhaphy ($n = 3$), and posterior colporrhaphy, sacrospinous ligament fixation plus perineorrhaphy ($n = 1$). Right-sided PVD repair was performed in 34 women, two had left-sided repair, and ten had bilateral repair.

Mean operation time was 52.6 min [95% confidence interval (CI) 48.4–56.8]. All women were operated on using local anesthesia, as described above; only one woman had general anesthesia due to fear of pain. Perioperative bleeding was 53 ml (95% CI 35–71). In 44 women, it was possible to apply

Table 1 Baseline data for the study group

	Number	Median–range, mean (95% CI), or no. (%)
Age (years)	46	39.0 (27.0–67.0)
Median (range)		
Births	46	2.0 (1–0-4.0)
Cesarean sections	46	0.0 (0.0–2.0)
BMI (kg/m^2)	46	24.8 (23.8–25.8)
Smokers	46	4 (8.7%)
Postmenopausal	46	12 (26.1%)[a]
Prior POP surgery	46	7 (15.2%)[b]
Prior incontinence surgery	46	0
Prior hysterectomy	46	0

POP pelvic organ prolapse, *AVW* anterior vaginal wall, *PVW* posterior vaginal wall, *CI* confidence interval

[a] Eleven received local estrogen (91.7%)

[b] Four had AVW repair, 2 had both AVW and PVW repair, 1 had PVW repair

three sutures between the ATFP and the pubocervical fascia, but in two women, due to anatomic difficulties, only two sutures were used (both women had bilateral repair). Of the 46 women, 40 were discharged within the first 24 h after operation, four within 24–48 h, and two remained at the hospital for >48 h. Pain due to vaginal hematoma and urinary retention were the causes of the two hospital stays >48 h.

Postoperatively, five women had urinary retention and were treated with self-catheterization for <7 days. Four women developed a vaginal wall hematoma (one needed reoperation due to continued vaginal bleeding; one experienced fever and urinary retention and was treated with antibiotics for urinary infection and self-catheterization for 3 days). Two women had fever with an unknown infectious focus (one had sepsis, needed hospitalization, and recovered after antibiotic treatment). The mean time between operation and follow-up was 195.4 days (95% CI 183.6–207.1).

Gynecological examination

Table 2 shows mean POP-Q measurements before and after the operation. Two women had no POP-Q measurement before the operation but were evaluated according to the Baden-Walker classification [22]. Significant reduction in descent was found in the AVW but not in the apical compartment. Before the operation, 89% (41/46) had grade 2 and 11% (5/46) grade 3 AVW prolapse. Six months after the operation, 57% (26/46) had grade 2 and 2% (1/46) had grade 3 AVW prolapse.

Apical descent grade 2 was diagnosed in seven women after the operation. Four were operated with PVD repair and sacrospinous ligament fixation; three had no apical descent before the operation.

Table 2 Distribution of Pelvic Organ Quantification System (POP-Q) measurements before and after operation

No.	Before operation			After operation			*P* value*
	No.	Mean	SD	No.	Mean	SD	
Aa	44	−0.9	0.8	46	−1.2	1.3	<0.001
Ba	44	0.3	0.9	46	−1.1	1.3	<0.001
C	44	−3.6	2.2	46	−3.7	2.3	1.00
Gh	44	4.0	1.1	46	3.9	0.8	0.40
Pb	44	3.3	0.9	46	3.7	0.7	0.01
TvL	44	8.7	1.0	46	8.8	0.9	0.42
Ap	44	−2.4	1.0	46	−2.5	0.7	0.55
Bp	44	−2.3	1.0	46	−2.5	0.8	0.33
D	44	−6.4	1.3	46	−6.1	1.2	0.23

All measured from the hymen during straining

Aa, *Ba* anterior vaginal wall, *C* apical compartment, *Ap*, *Bp* posterior vaginal wall, *Gh* genital hiatus height, *Pb* perineal body height, *TvL* total vaginal length at rest

*Paired *t* test

Questionnaires

Subjective symptoms before and after the operation are given in Table 3. Significantly, fewer women had symptoms of prolapse after the operation, and sexual matters and QoL were significantly improved. Before the operation, 14 women did not have an active sex life due to vaginal problems; after the operation that number was reduced to three. The incontinence score was significantly improved as well. When evaluated by PGI-I, 78% felt better: six (17%) very much better, 16 (44%) much better, and six (17%) slightly better; eight (22%) felt no change and ten did not complete the PGI-I.

MRI

Before the operation, 31 (67%) women had mild or major PC muscle defect on MRI. Bilateral defect was present in 17 (55%) and right- and left-sided defect in ten (32%) and four (13%), respectively. Missing H configuration was found in 21 (46%) women: three (6.5%) isolated right-sided and two (4.3%) isolated left-sided defect, and 16 (34.8%) both sides. Moreover, all women with missing H configuration had a defect in the PC muscle. Findings of H configuration (missing or normal) were not changed by the operation in any of the women. MRI locations of the bladder base and cervix before and after the operation are presented in Table 4. Both compartments were located significantly higher after the operation, but still, 32 had mild to moderate and one had severe bladder prolapse.

Table 3 Median scores of ICIQ-VS and ICIQ-UI SF before and 6 months after PVD repair

	Before operation		After operation		*P* value
	n	Median (range)	*n*	Median (range)	
ICIQ-VS					
VSS	46	26.0 (8–47)	46	12.5 (2–36)	<0.001
SMS	29	37.0 (0–58)	36	9.0 (0–58)	<0.001
QoL	46	8.0 (2–10)	46	2.0 (0–10)	<0.001
ICIQ-UI SF	46	10.0 (0–16)	38	2.0 (0–15)	<0.01
PGI-I			Number (%) in each category		
Very much better			6 (17%)		
Much better			16 (44%)		
Slightly better			6 (17%)		
No change			8 (22%)		
Missing data			10		

Wilcoxon signed rank test was used for statistical analysis *PVD* paravaginal defect repair, *ICIQ-VS* International Consultation on Incontinence Questionnaire—Vaginal Symptoms, *VSS* vaginal symptom score (0–53), *SMS* sexual matter score (0–58), *QoL* quality of life (0–10), *ICIQ-UI SF* International Consultation on Incontinence Questionnaire–Urinary Incontinence Short Form (0–21), *PGI-I* Patient Global Impression of Improvement

Table 4 Dynamic magnetic resonance imaging (MRI) findings before and 6 months after operation for distance between PCL and bladder base and severity of descent and between anterior cervical lip and PCL and severity of descent

	Before PVD repair	After PVD repair	*P* value
AVW			
Bladder/PCL distance, mean (95% CI)	2.7 (2.2–3.2)	2.0 (1.5–2.4)	0.001
Anterior descent according to the PCL ($n = 46$)			
None	7	13	
Mild	18	22	
Moderate	21	10	
Severe	0	1	
Apex			
Cervix/PCL distance, mean (95% CI)	2.0 (1.6–2.5)	1.6 (1.2–2.1)	0.032
Apical descent according to the PCL ($n = 46$)			
None	12	14	
Mild	23	23	
Moderate	0	0	
Severe	11	9	

Paired sample *t* test used for statistical analysis *AVW* anterior vaginal wall, *PVD* paravaginal defect, *PCL* pubococcygeal line, *CI* confidence interval

Recurrence

Recurrence was defined as grade 2 prolapse + symptoms or grade 3–4 prolapse at follow-up. After the operation, 18 of 46 (39%) had recurrent AVW prolapse (17 grade 2 and one grade 3 AVW). There was no significant difference in recurrence among women with or without apical suspension. Of the 20 women with apical suspension, seven (35%) had recurrence, whereas 11 (45%) had recurrence in the nonapical suspension group ($p = 0.615$). Of the 18 women with recurrent AVW prolapse, eight also had prolapse grade ≥2 in other compartments, including four who had apical suspension performed but experienced recurrence in that compartment as well. As shown in Table 5, women with recurrence had a significantly higher degree of PC muscle defect and missing H configuration together with a significantly greater descent of the bladder base. Relative risk (RR) of recurrence when missing the H shape was 5.9 (95% CI 2.0–17.8, $p = 0.001$), 4.4 (95% CI 1.1–17.0, $p = 0.03$) for major PC muscle defects compared with no defects, and 3.2 (95% CI 0.8–13.4, $p = 0.11$) for mild defects compared with normal.

To test whether concomitant surgeries had an influence on outcome, we did the above calculations only on the 20 women who did not have concomitant surgery. The results from these calculations were the same as for the entire cohort of 46 women, but significant reduction in bladder-base and cervical descent measured by MRI could not be demonstrated, and defects in the PC muscle could not be verified as a risk factor for recurrence. We believe this is due to the small sample size of 20.

Discussion

In this prospective study, we demonstrate that PVD repair alone or with concomitant surgery significantly reduces subjective symptoms of vaginal prolapse, sexual bother, and urinary incontinence. Moreover, QoL improved. Subjective outcomes are supported by clinical examinations and MRI findings. However, 39% had recurrent AVW prolapse. Age, severity of subjective symptoms, and prolapse grade measured by POP-Q were not correlated with risk of recurrence, whereas MRI findings of bladder-base descent, missing H configuration, and PC muscle defects were strong predictors of recurrence after surgery.

POP-Q measurements demonstrated a significant reduction in AVW descent; however, 27 women had prolapse grade ≥2, and 66.7% of them had subjective symptoms of prolapse. Of the 18 women with recurrence, eight had prolapse in other compartments as well, and subjective symptoms may have arisen from or been amplified by descent in those compartments. Thus, subjective symptoms should not only be interpreted as AVW surgery failure.

Measuring AVW descent on MRI during maximum Valsalva has shown to be a valuable tool in the evaluation of prolapse with good correlation to POP-Q measurement of AVW descent and subjective symptoms of a bulge in the vagina and with high inter- and intra-observer reliability [23, 24]. In this study, dynamic MRI scans demonstrated a significant reduction in mean AVW descent according to the PCL.

Neither degree of preoperative descent measured by POP-Q nor severity of symptoms measured by questionnaires preoperatively were significantly different between women with and without recurrence. Prior studies have shown the severity of prolapse descent (grade 3–4) measured by POP-Q to be a predictor for recurrence [25]. We found no significant difference in POP grade in our women with recurrence, probably due to the low number of women (5) with grade 3 prolapse. However, the degree of bladder descent measured by MRI predicted a higher risk of recurrence, supporting our theory. Comparison between women with and without recurrence showed that preoperative defect in the PC muscle and missing H configuration on MRI also predict a higher risk of recurrence. All these parameters are

Table 5 Characteristics of women with and without recurrence 6 months after operation

	No recurrence (28)	Recurrence (18)	*P* value
Age, median (range)	38 (27–67)	39.5 (29–56)	0.660*
Births, median (range)	2 (1–4)	2 (1–4)	0.903*
Cesarean sections, median (range)	0 (0–1)	0 (0–2)	0.271*
BMI, mean (95%CI)	24.5 (23.2–25.8)	25.2 (23.5–27.0)	0.468**
Smokers, *n* (%)	4 (14.3%)	0 (0%)	0.144***
Previous POP surgery, *n* (%)	4 (14.3%)	3 (16.7%)	1.000***
ICIQ-VS before operation			
VSS, median (range)	25 (8–47)	26 (13–47)	0.830*
SMS, median (range)	29.5 (0–58)	40 (1–47)	0.236*
QoL, median (range)	7 (2–10)	8 (3–10)	0.208*
Gynecological examination before operation			
AVW prolapse grade, median (range)	2 (2–3)	2 (2–3)	0.249*
Apical prolapse grade, median (range)	1 (0–2)	1 (0–3)	0.097*
Operation data			
Operation on apex as well, *n* (%)	13 (46.4%)	7 (38.9%)	0.615***
MRI before operation			
Pubococcygeus muscle defect type, *n* (%)			
None	13 (46.4%)	2 (11.1%)	0.03****
Mild	8 (28.6%)	6 (33.3%)	
Major	7 (25.0%)	10 (55.6%)	
Missing H configuration, *n* (%)	6 (21.4%)	15 (83.3%)	<0.001****
Bladder base/PCL distance, mean (95% CI)	2.04 (1.37–2.71)	3.69 (3.04–4.35)	0.001**
Apex/PCL distance, mean (95% CI)	1.71 (1.15–2.26)	2.56 (1.73–3.40)	0.071**

BMI body mass index, *POP* pelvic organ prolapse, *VSS* vaginal symptom score, *SMS* sexual matter score, *QoL* quality of life, *PCL* pubococcygeal line

* Mann-Whitney *U* test, ***t* test, ***Fisher's Exact test, ****chi-squared test

signs of severe trauma to the pelvic floor. This is consistent with other studies [25]. However, no previous studies have evaluated the importance of a missing H configuration in relation to recurrence. Evaluating missing H configuration and, especially, defects in the PC muscle, could help the surgeon to inform women prior to surgery about the risk of recurrence.

A missing H configuration on MRI has been suggested to represent a PVD. However, we found 21 women with presumed PVD (missing H configuration) and 25 without (preserved H configuration), even though all had PVD when evaluated by gynecological examination and confirmed during the operations. Gynecological examination has been shown to be a poor predictor of PVD, which could explain the difference between the two modalities. An explanation could also be that the H configuration represents not only an intact connection between the pubocervical fascia and the ATFP but also an intact levator ani muscle, as suggested by several authors [19, 20]. We found that a missing H configuration before the operation was still missing after, and an intact H shape before remained intact after. Thus, the operation did not change the vaginal shape seen on MRI. This supports the theory that parameters other than attachment of the fascia to the ATFP might be responsible for the normal H configuration. Our results support the theory that a missing H configuration represents defects in the levator muscle rather than a fascial defect/PVD [4, 20].

The recurrence rate (39%) in our study was in the high range compared with other studies evaluating the effect of PVD repair [26, 27]. Nonresorbable sutures were used in the studies with the lowest recurrence rates, whereas resorbable sutures were used in our study. Our study was not designed to evaluate time between operation and recurrence, but it is the authors' impression that recurrence happened 4–5 months postoperatively; those women reported they felt something snap, and prolapse symptoms reappeared. The use of resorbable sutures, which dissolve within that period, could be an explanation for recurrence. Attachment between the ATFP and pubocervical fascia is strong the first couple of months after operation, but when sutures lose their strength, the adhesion between the two structures weakens, with the risk of recurrence when pressure is applied to the structures [28]. The reasons for using resorbable material in our study were the lower risk of erosion, pain, and dyspareunia after surgery.

Eight women had prior POP surgery (Table 1). Conflicting results have been reported as to whether prior POP surgery increases the risk of recurrence [25]. Including results from our study could lead to higher risk of recurrence, but that could

not be demonstrated in our small cohort. Women in our study population were young compared with other studies examining AVW prolapse recurrence [1, 26, 27]. However, prior studies demonstrated a correlation between younger age and risk of recurrence [29]. It has been hypothesized that younger women have a more complex birth-related defect in their pelvic floor, whereas stretching of the pubocervical fascia is the cause in older women. This might explain the high recurrence rate found in our study.

MRI has never been used to evaluate the efficacy of PVD repair to the extent that our study did. We did not find that a missing H configuration is correlated with the presence of PVD or vice versa. Moreover, our data does not support the theory that an altered vaginal shape seen on MRI can serve as a modality to decide whether or on which side to perform a PVD repair. However, by adding MRI to our clinical examination, we demonstrate a potential benefit regarding risk assessment before surgery. We find this to be highly useful in the clinical decision-making process regarding women with presumed PVD. In Denmark, native tissue repair with resorbable sutures is the surgery of choice, especially in young women. We believe that using permanent sutures or even mesh should be limited to women with a high risk of recurrence, and by identifying them preoperatively, multiple surgeries might be prevented. MRI is an expensive and time-consuming method to evaluate defects in the pelvic floor; however, our findings might encourage further research investigating detection of levator defects and H configuration by ultrasound.

There are several limitations to our study. As mentioned, surgeons were blinded to preoperative MRI findings, and both paravaginal areas were not explored during surgery if only unilateral repair was planned. It would have been scientifically purposeful to open the paravaginal space on both sites during surgery to see whether a defect was present, but due to surgical risks, this was not ethically sound. Most women had no recurrence after surgery, which might be due not only to the lateral fixation alone. All women had plication of the pubocervical fascia during surgery, and many had concomitant surgery.

At the 6-month follow-up, the main investigator was unaware of the subjective symptoms presented by the women and thus was blinded when doing the gynecological examination. However, it was known that a PVD repair had been done, and this unblinding increases the risk of underestimating the recurrence rate [30]. In future research, it would be interesting to perform MRI scans in women with AVW prolapse but no signs of PVD to see to what degree they have an intact H configuration.

Compliance with ethical standards

Conflicts of interest LTS Arenholt has received a speaker honorarium from BK Ultrasound and accepted travel grants from Astellas and Pierre-Fabre. BG Pedersen has no conflicts of interest. K Glavind, S Greisen, and M Glavind-Kristensen have accepted travel grants from Astellas. KM Bek has received speaker honorarium from BK Ultrasound.

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