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Structural Position of the Posterior Vagina and Pelvic Floor in Women with and without Posterior Vaginal Prolapse

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Abstract

Objective—Compare pelvic structure location on MRI during maximal Valsalva among women with posterior prolapse and those with normal support.

Methods and Materials—Cases (n=37) had posterior vaginal wall (PVW) prolapse > +1cm. All underwent mid-sagittal, dynamic MRI. Structure locations (distal vagina, apex, perineal body, external anal sphincter) were determined. PVW length, levator and urogenital hiatus diameters, and prolapse diameter were measured.

Results—Cases had more caudal structures ($p<0.001$) and larger hiatus diameters ($p<0.005$); the posterior wall was longer, while the straight-line distance between the apex and distal vagina was shorter. In enteroceles, the apex was more ventrally displaced compared to rectoceles ($p=0.003$). Unlike apical descent ($r=-0.3$, $p=0.1$), PVW length and point Bp were correlated with MRI prolapse size ($r=0.5$, $p=0.002$; $r=0.7$, $P<0.001$, respectively).

Conclusion—At maximal Valsalva on MRI, structures are more caudal in women with posterior prolapse. The posterior vaginal wall is longer; this length strongly correlates with prolapse size.

Keywords

posterior vaginal wall prolapse; MRI; posterior vaginal wall length

Introduction

Our understanding of the mechanisms of posterior vaginal wall prolapse is still evolving. Various imaging modalities, especially MRI, have proven useful in delineating normal pelvic anatomy,¹⁻⁴ studying changes in pelvic floor descent in the postpartum period,^{5,6} and in diagnosing and staging of pelvic organ prolapse (POP).^{7,8} Changes in the motion of pelvic viscera with aging⁹ and with POP¹⁰ on MRI have been documented and have provided many insights into the mechanisms behind pelvic floor failure.

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Imaging studies that compare women with posterior vaginal wall prolapse to those with normal support to make it possible to quantify the posterior vaginal wall structural deformations that are associated with rectocele and enterocele. To date, the use of MR imaging to study the posterior vaginal wall (PVW) has been limited to delineating normal anatomy (3) and documenting the clinical occurrence of rectocele and enterocele.^{11,12} Our objective was to use MR imaging to detect differences in vaginal wall position and perineal descent as well as posterior vaginal wall length and apical descent between women with PVW prolapse and those with normal support. These investigations will allow us to evaluate parameters not necessarily easily captured on physical exam.

Materials and Methods

This was a secondary analysis of a case-control study at the University of Michigan looking at POP. The study was approved by the university's institutional review board (IRB# 1999-0395). Women were recruited from the urogynecology clinics as well as from community advertisements, and all underwent the pelvic organ prolapse quantification (POP-Q). In order to be considered a case, women had to have prolapse of the PVW that extended at least one centimeter below the hymenal ring. This criterion was met by 35 women in the original study. Women were accepted as controls (n=37) if they were asymptomatic and had normal vaginal support on straining, which was defined as all portions of the vaginal compartment at least 1 cm above the hymen. All women were matched for age, race and number of vaginal deliveries. Women were excluded if they had a prior history of surgery for POP or other pelvic floor dysfunction, if they were pregnant within the last year, had a history of chronic steroid use, previous radiation to the pelvis, or were immunocompromised with an increased risk of infection from testing. Women with a prior hysterectomy were included as long as it had not been done for prolapse and if their prolapse occurred at least 2 years after surgery.

All women underwent a POP-Q examination with all points (except for genital hiatus, levator hiatus and total vaginal length) recorded at maximum Valsalva in the lithotomy position at a 45 degree angle. Genital and levator hiatus measurements were done at rest in order to obtain accurate measurements of the anatomy, not influenced by the size of the subjects' prolapse. Dynamic MRI was performed in the supine position as well. Images were taken in the axial, sagittal and coronal planes using a fast spin proton density technique. Scans were performed on a 1.5 T superconducting magnet (Signa; General Electric Medical Systems, Milwaukee, WI). Slice thickness was 4 mm, with a gap of 1 mm, yielding 5-mm image spacing. Twenty cubic centimeters of ultrasound gel was added to the vagina to better delimit its location and boundaries.

Based on MRI appearance, PVW prolapse among cases was further classified as either rectocele-predominant or enterocele-predominant. In this study, an enterocele was judged to be present when the potential space in the cul-de-sac of Douglas was abnormally dilated by the small intestine or mesenteric fat similar to the definition suggested by Gousse.⁸ Two experienced researchers independently agreed that 9 women had enterocele-predominant posterior prolapse (n=9). Those with rectocele predominant prolapse (n=28) did not have associated enteroceles. One of the 9 enterocele-predominant subjects had a rectocele.

On mid-sagittal MRI images at maximum Valsalva, a sacrococcygeal-inferior pubic point (SCIPP) line (x-axis) and perpendicular y-axis were drawn as described in our previous work.^{13, 14} Using these axes, locations of the distal vagina, vaginal apex (most superior point of the PVW), mid-perineal body and mid external anal sphincter were determined as x,y coordinates in centimeters. The length of the entire posterior vaginal wall from apex to distal vagina, levator and urogenital hiatus diameters, and levator plate angle were measured

using these same mid-sagittal images at maximal Valsalva. These, as well as coordinate locations of structures at maximum Valsalva, were compared among all cases and controls (Figure 1A) and among women with rectocele and enterocele-predominant prolapse using Image J 1.4I (NIH) software.¹⁵ On MRI, the widest anterior-posterior 'prolapse' diameter was also calculated as the distance between the most anterior point of the puborectalis and most ventral point of the PVW, similar to methods described on defecography¹⁶ (Figure 1B). Using the straight-line distance from the vaginal apex to the distal vagina on imaging in cases and controls, we were able to compare the groups and determine a surrogate measure for apical downward displacement (Figure 1B).

Means, standard deviations, and frequency distributions for discrete variables were used to characterize the groups. Comparisons between the groups were made using Student's t-tests. Effect sizes (Cohen's d) were calculated for significant differences. An alpha of <0.05 was considered to be significant.

Results

Overall, there were 35 controls and 37 cases. Women were similar with respect to age, body mass index (BMI), vaginal parity, menopausal status and hysterectomy status (Table I). Similar percentages of women in the two cohorts recalled a history of at least one forceps-assisted vaginal delivery and were currently smokers. Women with PVW prolapse were more likely to be currently using hormone therapy.

Cases had a higher degree of both anterior (points Aa and Ba) and posterior prolapse (points Ap and Bp) as well as larger resting genital hiatuses during clinical POP-Q examination (Table II). Differences in rectoceles and enteroceles on POP-Q were only seen apically (points C and D) (Table II).

At maximum Valsalva on MRI, the apical and perineal structures of cases were more caudally located than controls (apex, distal vagina, perineal body and external anal sphincter, $p < 0.001$); the largest differences were seen in the distal vagina (2.3 cm, Cohen's d: -1.5) and perineal body (2.0 cm, Cohen's d: -1.4) (Figure 2A). The vaginal apex was also more ventrally displaced ($p = 0.001$, Cohen's d: 0.8) in cases. When rectocele-predominant prolapses was compared to enterocele-predominant prolapses, only differences in the apical locations were seen; with enteroceles, the vaginal apex was more ventrally displaced ($p = 0.003$, Cohen's d: 1.0) (Figure 2B).

On MRI, PVW length was longer in cases by a mean of 2.1cm (Cohen's d: -0.8). Similarly, cases had 12% larger levator and 32% larger urogenital hiatus dimensions (Table III). The levator plate angle was 14.3 degrees more caudally located in the cases. Anterior-posterior prolapse diameter was larger in cases compared with controls; women with enterocele-predominant prolapse had the largest prolapse diameters. Downward displacement of the apex relative to the perineum, measured as the straight-line distance from vaginal apex to distal vagina was shorter in cases and did not differ between rectocele and enterocele-predominant prolapse (Table III and Figure 2A and B). While the contour length of the PVW and POP-Q point Bp were highly correlated with MRI prolapse size ($r = 0.5$, $p = 0.002$ and $r = 0.7$, $p < 0.001$, respectively), this apical downward displacement was not ($r = -0.3$, $p = 0.1$).

Comment

In women with posterior vaginal wall (PVW) prolapse at maximal Valsalva on MRI, perineal structures and the vaginal apex are more caudally located than in women with normal support. PVW prolapse is also associated with larger levator and urogenital hiatuses

and longer posterior vaginal walls. Interestingly, the length of the posterior vaginal wall rather than downward apical displacement correlated with prolapse size; this is in contrast to what is seen with anterior vaginal prolapse.¹³

Our findings are novel, as they reflect structural changes associated with many different aspects of the posterior vaginal wall and perineal structures, providing a broad picture of what occurs when posterior vaginal support becomes abnormal. Caudal displacement of the perineal structures, enlargement of the urogenital and levator hiatuses as well as changes in levator plate angles in women with prolapse have previously been documented among anterior predominant prolapse populations. For example, Hsu et al. showed that during Valsalva, women with prolapse had 15% larger levator hiatus length and 24% more caudal PB location in a population of women with predominantly anterior vaginal wall prolapse.¹⁷ Similarly, Ansquer et al. found that anterior and apical compartment prolapse was correlated with increasing hiatus size and levator plate angle; in the posterior compartment, however, anterior rectal bulging with straining was inversely correlated with hiatus size at rest.¹⁸ In these studies and ours, a general process of caudal displacement of the perineal structures and hiatal enlargement in women with prolapse occurs that seems to be independent of whether the anterior or posterior wall prolapse dominates. Clinically, our finding becomes relevant as it suggests that rectoceles and enteroceles are not necessarily just the result of focal, or site-specific, defects in connective tissue or “fascia”, but rather a more overall weakening and deformation of the pelvic floor connective tissues and levator support. This generalized deformation may partly explain why surgical success rates of posterior repairs are relatively modest.^{19,20} Determining the inciting and underlying structural failure that leads to this displacement will be important in future studies, as these insights may influence surgical management of PVW prolapse.

In this study, we found that the length of the posterior vaginal wall on MRI was 22% longer in cases. This finding is similar to Hsu et al. who found, in studying the anterior vaginal wall, that it was an important factor in determining cystocele size.²¹ Additionally, other groups have shown collagen content and turn-over is varied in women with prolapse,^{22, 23} and the longer PVW found in this study again suggests that alterations in the vaginal wall properties may be involved in posterior prolapse development. We also found that the apex in rectoceles and enteroceles was more ventrally displaced, suggesting the although this movement is not the same axis as displacement we see in anterior wall prolapse, movement of the apex is still a component of PVW prolapse. Interestingly, it was the increased length in the PVW and point Bp, not downward displacement, which were significantly correlated with prolapse size on MRI. This is very different from the anterior compartment, where on MRI, half of the observed variation in support can be explained by apical support.²⁴ These findings highlight the differences in the mechanisms of PVW failure compared to other compartments as well as the potential limitations of our current surgical techniques (i.e. posterior colporrhaphy) in correcting the PVW, as a traditional colporrhaphy may not adequately address this increase in the vaginal length itself.

We found that on POP-Q examination, neither total vaginal length nor point C differed between cases and controls. Yet, as described above, significant differences in the length of the PVW and in apical downward displacement were seen on MRI. The shortcomings of POP-Q in characterizing the posterior vaginal wall have been well-documented in the literature, but not with respect to the MRI changes in structural location and pelvic measurements as discovered by this study. In assessing rectoceles on cystodefecoperitoneography and POP-Q, Altman et al. found that POP-Q staging predicted neither radiological size nor visceral involvement in posterior vaginal wall prolapse.²⁵ Similarly, Kenton found no correlation between the fluoroscopic position of the small bowel and/or rectum and any apical or posterior wall POP-Q point.²⁶ Studies have also shown the

superiority of MRI over physical examination in the detection of enteroceles^{8,27} and these differences on MRI (in contrast to a straight cotton swab measurement of total vaginal length and apical displacement on POP-Q) not only show the limitations of the POP-Q in characterizing PVW prolapse, but at the same time, highlight the potentially subtle, yet important, differences that MRI can elucidate in the mechanism of PVW failure. PW length on MRI is likely a more accurate measure of true length, as the contour is not influenced by straightening the vaginal wall with a ruler, cotton-tipped swab, or finger.

Several factors should be taken into account when interpreting the results of this study. First, MR imaging was performed in the supine position, and it is possible that the full extent of women's prolapse was not captured. However, in order to minimize the likelihood of this, women were specifically coached until they produced the same size prolapse they did in clinical exam. Also, we did not opacify the rectum, and it has been shown that with opacification, rectoceles are more easily diagnosed on MRI²⁸ than without. However, improved image resolution during the last decade has made anatomic landmarks much easier to see even without contrast. Additionally, this project focuses on structural deformation rather than symptoms. Only 19-30% of women with rectocele or enterocele²⁹⁻³² have symptoms and that analysis falls outside of the present study's objectives. Also, our sample size was small, making it difficult to distinguish true differences between rectoceles and enteroceles. Finally, while cases did have predominantly posterior prolapse, some had some lesser degree of anterior prolapse as well. It is possible that multi-compartment prolapse (especially if an organ competition is occurring) could influence our findings in the posterior compartment.

It should be noted that these findings are in a selected population with mostly distal rectoceles and few enteroceles. There is great diversity among different types of enterocele and at present, our sample size is not sufficient to fully explore this topic. The large pulsion enterocele often occurs after previous attempts at repair and because this study excluded patients with prior surgery for incontinence and prolapse, they are not part of this investigation. We believe that this population will have more dramatic displacements of the apex that are not seen in this study. Further development of our investigative techniques and expanded examination of other populations should allow future analysis of other combinations of pelvic organ prolapse, including women with enteroceles.

The findings in this study are unique, in that they provide a broad picture of the structural deformations involved in posterior vaginal wall prolapse including not only rectoceles or enteroceles themselves, but also the changes in the surrounding perineal structures. It specifically focuses on mechanisms involved in the least understood mechanism of pelvic organ prolapse, the failure of the posterior compartment and how this failure differs from that of the anterior compartment. The findings of this study also highlight the potential benefit of MRI in the understanding of PVW prolapse. The powerful techniques available in advanced imaging provide a tool that should help in unraveling the puzzle posed by the posterior pelvis leading to more effective treatment strategies.

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Condensation

In women with posterior prolapse on MRI, structures are more caudal at maximum Valsalva. The size of posterior prolapse strongly correlates with vaginal wall length.

Figure 1.

(A) Maximum Valsalva mid-sagittal MRI in a control subject. SCIPP line and pubic symphysis (PS) are shown. Vaginal apex (◆) and distal vagina (■) with intervening posterior vaginal wall (PW), perineal body (●) and external anal sphincter (▲) are visible. The levator plate (LP) and hiatus (LH), as well as the urogenital hiatus (UH) are marked (B) Maximum Valsalva mid-sagittal MRI in a case with maximum prolapse diameter (PD) and straight-line distance (dotted line) between vaginal apex and distal vagina demarcated.

Figure 2.

Perineal and apical structure locations at maximum Valsalva in **(A)** controls and all cases including rectoceles and enteroceles and **(B)** in rectoceles compared to enteroceles. Coordinates marking the vaginal apex (apex), distal vagina (DV), perineal body (PB) and external anal sphincter (EAS) are marked. The straight-line distance from vaginal apex to distal vagina is seen in all three groups. The pubic symphysis (PS) is also demarcated. The dashed line represents the straight-line distance from apex to distal vagina in controls in both panels. (Connecting lines are provided to help identify which points are in the same group, but are not meant to imply the location of the intervening vagina or perineal skin).

Table I

Characteristics of Cohorts

	Cases (n=37)	All Controls (n=35)	P-value
Age (years)	58.9 (11.0)	58.9 (12.1)	1.0
BMI (kg/m ²)	28.6 (6.5)	27.1 (7.1)	0.3
Vaginal parity	2.7 (1.6)	2.8 (1.7)	0.9
Recalled forceps-assisted vaginal delivery (%)	51.9	28.0	0.1
Caucasian (%)	59.5	52.9	0.6
Postmenopausal (%)	84.4	75.8	0.5
Current use of hormone therapy (%)	33.3	5.9	0.006
Hysterectomy (%)	37.8	17.6	0.07
Current smoker (%)	15.2	21.9	0.5

Values reported as means (SD) or percentages of cohort

Table II

Mean POP-Q measurements among controls and cases (S.D.)

	Controls (n=35)	All Cases (n=37)	Rectocele Predominant (n=28)	Enterocele Predominant (n=9)	P-Value Controls v. All Cases	P-Value Rectoceles v. Enteroceles
POP-Q (cm)						
Aa	-1.7 (0.9)	-0.5 (1.5)	-0.6 (1.2)	-0.1 (2.5)	<0.001	0.4
Ba	-1.7 (0.9)	+0.2 (2.4)	-0.1 (1.5)	1.0 (4.2)	<0.001	0.2
C	-6.3 (1.5)	-3.7 (4.1)	-4.9 (3.0)	-0.3 (5.5)	<0.001	0.003
D	-8.4 (1.3)	-6.9 (3.1)	-7.8 (1.2)	-3.4 (5.9)	0.02	0.002
Ap	-1.8 (0.8)	+1.1 (1.4)	+1.3 (1.0)	0.7 (2.1)	<0.001	0.3
Bp	-1.8 (0.8)	+1.8 (2.1)	+1.5 (1.1)	+2.7 (3.7)	<0.001	0.1
GHrest	2.7 (0.8)	4.0 (0.9)	4.1 (0.9)	3.7 (0.3)	<0.001	0.2
LHrest	6.6 (1.5)	7.3 (1.3)	7.4 (1.3)	6.7 (0.6)	0.11	0.2
TVL	10.4 (1.3)	10.4 (1.3)	10.5 (1.2)	9.3 (2.1)	0.90	0.4

Table III

Mean MRI measurement of anatomic differences among groups at maximum Valsalva (SD)

	Controls (n=35)	All Cases (n=37)	Rectocele Predominant (n=28)	Enterocele Predominant (n=9)	P-Value Controls v. All Cases	P-Value Rectocele v. Enterocele
Posterior Wall Length (cm)	9.3 (1.8)	11.4 (3.0)	11.2 (2.6)	12.1 (4.8)	<0.001	0.6
Levator Hiatus (cm)	6.5 (1.2)	7.4 (1.2)	7.2 (1.6)	7.9 (1.2)	0.003	0.2
Urogenital Hiatus (cm)	4.9 (1.2)	7.2 (1.2)	7.0 (1.6)	8.0 (1.2)	<0.001	0.05
Levator Plate Angle (degrees)	14.2 (15.4)	28.5 (17.6)	28.6 (17.5)	28.1 (20.1)	<0.001	0.9
Antero- Posterior Prolapse Diameter (cm)	3.3 (1.2)	5.4 (1.8)	4.9 (1.1)	6.9 (2.1)	<0.001	0.001
Straight- Line Apex to Distal Vagina (cm)	8.0 (0.6)	7.2 (2.4)	7.4 (2.1)	6.6 (2.1)	0.04	0.3