GYNECOLOGY

Are fibroid and bony pelvis characteristics associated with urinary and pelvic symptom severity?

Robyn K. Shaffer, BA; Amy D. Dobberfuhl, MD; Kim-Nhien Vu, MD; Angela M. Fast, MD; Susan Dababou, MD; Cristina Marrocchio, MD; Deirdre A. Lum, MD; David M. Hovsepian, MD; Pejman Ghanouni, MD, PhD; Bertha Chen, MD

BACKGROUND: Urinary and pelvic floor symptoms often are attributed to size and location of uterine fibroid tumors. However, direct supporting evidence that links increased size to worsening symptoms is scant and limited to ultrasound evaluation of fibroid tumors. Because management of fibroid tumors is targeted towards symptomatic relief, the identification of fibroid and pelvic characteristics that are associated with worse symptoms is vital to the optimization of therapies and prevention needless interventions.

OBJECTIVE: We examined the correlation between urinary, pelvic floor and fibroid symptoms, and fibroid size and location using precise uterine fibroid and bony pelvis characteristics that were obtained from magnetic resonance imaging.

STUDY DESIGN: A retrospective review (2013—2017) of a multidisciplinary fibroid clinic identified 338 women who had been examined via pelvic magnetic resonance imaging, Pelvic Floor Distress Inventory questionnaire (score 0—300), and a Uterine Fibroid Symptoms questionnaire (score 1—100). Multiple linear regression analysis was used to assess the influence of clinical factors and magnetic resonance imaging findings on scaled Pelvic Floor Distress Inventory and Uterine Fibroid Symptoms scores. Data were analyzed with statistical software.

RESULTS: Our cohort of 338 women had a median Pelvic Floor Distress Inventory of 72.7 (interquartile range, 41—112.3). Increased Pelvic Floor Distress Inventory score was associated with clinical factors of higher body mass index ($P<.001$), noncommercial insurance ($P<.001$), increased parity ($P=.001$), and a history of incontinence surgery ($P=.003$). Uterine volume, dominant fibroid volume, dimension and location, and fibroid tumor location relative to the bony pelvis structure did not reach significance when compared with pelvic floor symptom severity. The mean Uterine Fibroid Symptoms score was 52.0 (standard deviation, 23.5). An increased Uterine Fibroid Symptoms score was associated with dominant submucosal fibroid tumors ($P=.011$), body mass index ($P<.0016$), and a clinical history of anemia ($P<.001$) or any hormonal treatment for fibroid tumors ($P=.009$).

CONCLUSION: Contrary to common belief, in this cohort of women who sought fibroid care, size and position of fibroid tumors or uterus were not associated with pelvic floor symptom severity. Whereas, bleeding symptom severity was associated with dominant submucosal fibroid tumor and previous hormonal treatment. Careful attention to clinical factors such as body mass index and medical history is recommended when pelvic floor symptoms are evaluated in women with uterine fibroid tumors.

Key words: bony pelvis, fibroid tumor, Pelvic Floor Distress Inventory, questionnaire, urinary symptom, uterine fibroid symptoms

Uterine fibroid tumors affect up to 40—50% of reproductive-age women.[1,2] Women with symptomatic fibroid tumors often experience heavy menstrual bleeding, urinary symptoms, or pelvic pain.[1—3] Management largely aimed at symptom reduction includes medical and surgical interventions that result in direct costs of up to $9.4 billion annually in the United States.[4]

Urinary symptoms that coexist with fibroid tumors are thought to be "bulk-related" and often are attributed to increased uterine size or to the dominant (largest) fibroid and to the proximity of the fibroid to the bladder on the anterior uterus.[5,6] It is also hypothesized that bony pelvic architecture may contribute to pelvic floor symptoms such as "bulk" sensation by confining fibroid tumors within the pelvis.

However, the assumption that specific fibroid symptoms are related to fibroid size or location has not been confirmed; published supporting data are limited. Existing literature largely relies on ultrasound description, which is suboptimal for evaluation of large, and/or numerous fibroid tumors or the bony pelvis.[7,8] The association between urinary and other pelvic floor symptoms with fibroid size and location remains unclear and understudied. Without further understanding of this association, patients who seek relief of their symptoms could be channeled towards unnecessary procedures and risks.

We hypothesize that type and severity of urinary and pelvic floor symptoms are not related directly to fibroid size, location, or position relative to the bony pelvis. The purpose of this study was to characterize the association between validated symptom questionnaires, clinical history, and magnetic resonance imaging (MRI) findings in a population-based cohort of women with symptomatic fibroid tumors.

Materials and Methods

Multidisciplinary fibroid center

Care was provided at a multidisciplinary fibroid center by a team of attending gynecologists and interventional radiologists. This team consisted of the same individuals throughout the study. Patients were self-referred (42.8%) or referred by physicians within our institution or community physicians for care of abnormal uterine bleeding, pelvic

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AJOG at a Glance

Why was this study conducted?

Urinary and pelvic floor symptoms often are attributed to size and location of uterine fibroid tumors; however, evidence is scant and limited to ultrasound evaluation of fibroid tumors. Identification of fibroid and pelvic characteristics that are associated with worse symptoms is vital to optimization of therapies and prevention of needless interventions.

Key findings

Increased Pelvic Floor Distress Inventory score was associated with clinical and demographic factors (body mass index, noncommercial insurance, increased parity, smoking, and history of incontinence surgery). Uterine volume, dominant fibroid volume, dimension and location, and fibroid location relative to the bony pelvis structure were not associated with pelvic floor symptom severity.

What does this add to what is known?

Contrary to common belief, pelvic floor symptom severity was not related to uterine size or anterior fibroid tumor location.

pain, infertility, urinary symptoms, or other complaints that coincides with radiologic evidence of fibroid tumors. All patients were evaluated by the same clinical providers for treatment recommendations.

Study design and cohort

Our study identified 568 adult women who were evaluated sequentially at our multidisciplinary fibroid center from April 2013 to July 2017. We excluded 198 patients who had incomplete Uterine Fibroid Symptoms (UFS) or Pelvic Floor Distress Inventory (PFDI) questionnaires and 23 postmenopausal women. We excluded an additional 9 women who did not have fibroid tumors on pelvic MRI. After applying all exclusion criteria, our final cohort consisted of 338 patients. This retrospective observational study was approved by the Stanford University Institutional Review Board.

Clinical data and MRI review

A retrospective review of patient electronic medical records was conducted for demographic information, presenting symptoms, hormonal medications, obstetric history, and pelvic MRI findings. MRI studies were performed at the institution of the patient's choice and reviewed by the radiologist at our multidisciplinary fibroid center before clinical evaluation, independent of clinical history and previous imaging. MRI characteristics included number of fibroid tumors, size of the dominant fibroid tumors, fibroid location relative to the bony pelvis, uterine size, and additional diagnoses that included adenomyosis, endometriosis, and endometrial polyps. MRI assessment of bony pelvis included sagittal measurement of sacrococcygeal curve length and depth, anterior-posterior outlet length, obstetric and diagonal conjugate lengths, pelvic outlet diameter (Figure 1, A) and axial measurements of interspinous and intertuberous lengths (Figure 1, B) on T2-weighted imaging. Fibroid volume was estimated with the ellipsoid formula ($L \times W \times H \times 0.52$); uterine volume was calculated with the use of postprocessing 3-dimensional uterine segmentation.

PFDI and UFS questionnaires

Our outcome measure included the continuous variable of PFDI score (range, 1−300). We used 3 validated subscores of the PFDI: Urogenital Distress Inventory (UDI-6), which assesses urinary symptoms; Pelvic Organ Prolapse Distress Inventory (POPDI-6), which accounts for prolapse and pelvic pressure; and the Colorectal-Anal Distress Inventory (CRADI-8), which assesses bowel symptoms. We also used the UFS questionnaire (range, 1−100), which assesses bleeding and bulk-related symptoms.[9] Questionnaires were administered at the beginning of the first fibroid clinic visit throughout the study period. The raw PFDI and UFS survey scores were scaled per their validated protocols.[10,11]

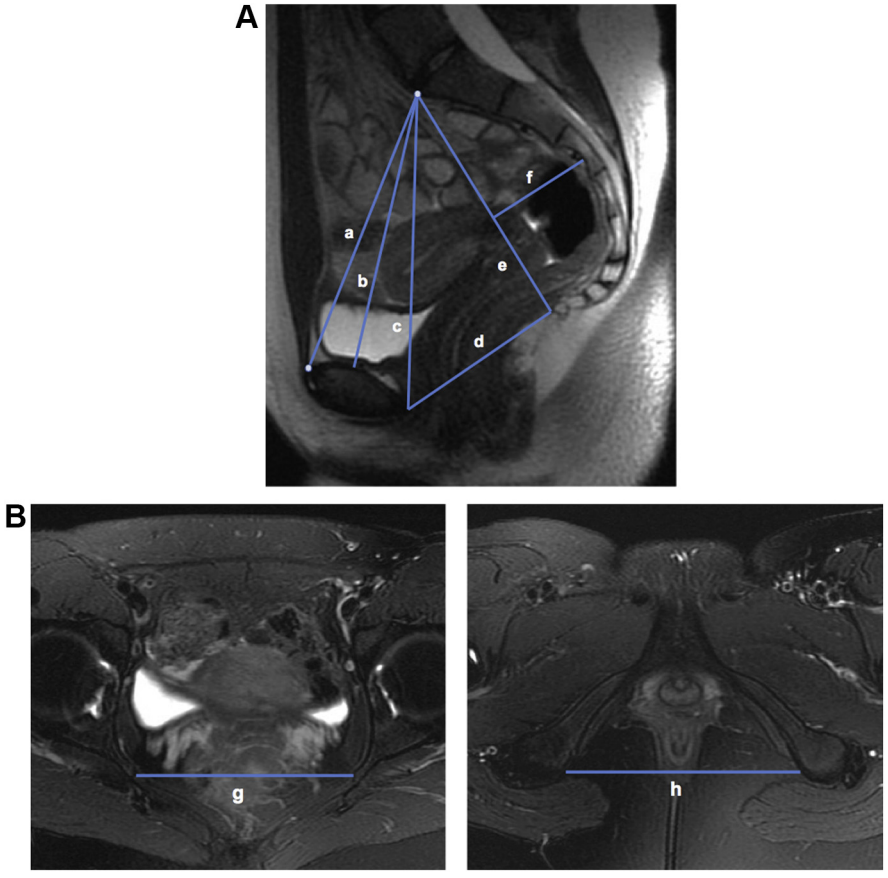
Univariate analysis

Univariate analyses were conducted to evaluate patient and MRI characteristics that were associated with worse PFDI and UFS scores. PFDI scores followed a nonnormal distribution per the Shapiro-Wilk test for normality. Spearman correlation and Wilcoxon rank-sum test were conducted to compare PFDI score with linear and categoric predictors; Kruskal-Wallis rank test was used to assess difference in PFDI score for nonbinary categoric predictors such as race or fibroid position. Pearson correlation and Student's *t* test were used to compare UFS score with linear and binary categoric predictors; 1-way analysis of variance was used to assess the difference in UFS among nonbinary categoric predictors. Bonferroni adjustment was used to correct probability values for multiple comparisons for Kruskal-Wallis and analysis of variance tests in the univariate analysis of factors that are associated with PFDI scores and subscores. Predictor variables of interest included age, body mass index (BMI), race, smoking history, parity, history of cesarean delivery, pelvic surgery or incontinence surgery, medications, and comorbid medical conditions that included adenomyosis, diabetes mellitus, and anemia.

Multivariate analysis

Predictor variables with probability value of $<.05$ in univariate analysis or of specific clinical interest based on published literature were included in a multivariate linear regression of noncorrelated data with a Huber "sandwich" estimator of variance robust to model misspecification. Linear regression was chosen because of the continuous outcome variables of PFDI and UFS scaled scores. Records with missing primary predictor data were excluded from the multivariate analysis (n=6; 1.7% of data); other missing covariate data (n=8) were handled by multiple

FIGURE 1
Magnetic resonance imaging measurement of bony pelvis structures



Sagittal T2-weighted magnetic resonance image with measurement of bony pelvis landmarks: **A,** *a*, Anterior-posterior conjugate; *b*, obstetric conjugate; *c*, diagonal conjugate; *d*, pelvic outlet diameter; *e*, sacrococcygeal curve length; *f*, sacrococcygeal curve depth. **B,** *g*, interspinous length; *h*, intertuberous length.

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imputation. Multiple imputation was conducted with multivariate normal regression for continuous variables and augmented logistic regression for binary categoric variables. A probability value cut-off level ≤.050 was considered significant. Data were analyzed in with STATA statistical software (version 15.1; StataCorp LLC, College Station, TX).

Results

Our final analytic cohort consisted of 338 premenopausal women with uterine fibroid tumors that were characterized by pelvic MRI. Patients had overlapping symptom complexes: 70.1% of the patients (n=237) had menorrhagia; 53.0% of the patients (n=179) had urinary frequency; 39.6% of the patients (n=134) had pelvic pain or dysmenorrhea; 36.4% of the patients (n=123) had both menorrhagia and urinary frequency; 44.4% of the patients (n=150) had had no previous treatment; and 12.7% of the patients (n=43) had undergone a previous myomectomy. Demographic, obstetric, and clinical characteristics are summarized in Tables 1 and 2.

The MRI findings in our cohort are summarized in Table 3. Twenty-one percent of the women (n=71) had a single fibroid tumor; 45.3% of the women (n=153) had >5 fibroid tumors. Dominant fibroid tumors were typically anterior (50.6%; n=171) and intramural (76.0%; n=267); 25.4% of the patients (n=86) had MRI findings of adenomyosis, and 14.2% of the patients (n=48) had evidence of endometriosis.

MRI characteristics of fibroid tumors and bony pelvis

Pelvimetry measurements were obtained with the use of sagittal and axial fat-saturated T2-weighted MRIs (Figure 1). Our analysis showed a weak, but significant, correlation between increasing PFDI score and greater sacrococcygeal curve depth (*rho*=0.122; *P*=.02) and no association between PFDI score and interspinous or intertuberous diameter, AP length, obstetric conjugate, diagonal conjugate, or pelvic outlet lengths (data not shown).

Roughly one-third of women (31.1%; n=105) of the women had fibroid tumors located only within the true pelvis below the pelvic rim; the remaining women had additional fibroid tumors that extended partly or completely into the abdomen that suggested heavy fibroid load in our patient cohort (Figure 2).

Pelvic floor symptoms

Our cohort had a right-skewed PFDI distribution with a median of 72.7 (interquartile range, 41−112.3). The breakdown of PFDI median and interquartile range by subscores in Figure 3 shows that the UDI-6 is most contributory to the total score, followed by the POPDI-6 and the CRADI-8. Increased PFDI scores were associated with demographic factors that included BMI, race, insurance status, and clinical factors such as parity, smoking, diabetes, diuretic use, and history of pelvic surgery on univariate analysis (Table 1).

In univariate analysis, severity of PFDI score was not associated with uterine volume (correlation *rho*=−0.03; *P*=.478), number of fibroid tumors (mean PFDI score, 78.4 [1 fibroid] vs 75.7 [2−5 fibroid tumors] vs 83.7 [>5 fibroid tumors]; *P*=.266), or dominant fibroid location, volume, or position (Table 3). PFDI score was also not associated with the presence of endometriosis or adenomyosis. UDI-6 score

TABLE 1
Association between clinical characteristics and Pelvic Floor Distress Inventory and Uterine Fibroid Symptoms Questionnaire scores

Clinical characteristics	Patient cohort (N=338)	*P* values	
		Pelvic Floor Distress Inventory	Uterine Fibroid Symptoms Questionnaire
Demographics			
Age, y±standard deviation	43.0±6.4	.053[a]	.127[a]
Mean body mass index, kg/m^2±standard deviation	26.1±6.2	<.001	<.001
Race, % (n)		<.001	<.001
White	32.8 (111)		
Hispanic	12.1 (41)		
Black	11.8 (40)		
Asian	27.2 (92)		
Other	16.0 (54)		
Insurance, % (n)		<.001	<.001
Noncommercial (Medicaid/Medicare)	143.3 (45)		
Private	83.7 (283)		
Other/self-pay	3.0 (10)		
Gynecologic history, % (n)			
Parity		<.001	.003
Nulliparous	47.3 (160)		
Primiparous	20.7 (70)		
≥2 Term deliveries	32.0 (108)		
History of ≥1 cesarean delivery	17.7 (60)	.331	.306
History of pelvic/abdominal surgery	35.5 (120)	.001	.007
History of urinary incontinence surgery	1.8 (6)	.022	.899
History of hysteroscopy	13.3 (45)	.713	.301
Any current therapy		.569	.009
Combined oral contraceptives	14.2 (48)		
Progestin-only therapy[b]	9.5 (32)		
Leuprolide	0.6 (2)		
Other nonhormonal therapy[c]	3.8 (13)		
No current therapy	71.9 (243)		
Medical history, % (n)			

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(a subscore that encompasses urinary frequency, urgency, incontinence, and pelvic discomfort) was not associated with uterine volume, number of fibroid tumors, dominant fibroid location, volume, or position. Similarly, there was no association found between pelvic organ prolapse symptom severity (POPDI-6) and fibroid characteristics on MRI. However, PFDI score was associated with fibroid location in the pelvis (P=.035) in the univariate analysis.

Increased PFDI score was associated significantly with only clinical predictors in multivariate analysis (Table 4). Women with increased BMI (β=1.87; 95% confidence interval [CI], 0.98−2.77; P<.001) or increased parity (β=7.80; 95% CI, 3.11−12.49; P<.001) had significantly higher PFDI scores. The predictors of the largest increase in PFDI score were noncommercial insurance (β=46.51; 95% CI, 27.4−65.61; P<.001) and history of incontinence surgery (β=11.79; 95% CI, 17.19−80.88; P=.003). Although there were significant differences in PFDI-20

TABLE 1
Association between clinical characteristics and Pelvic Floor Distress Inventory and Uterine Fibroid Symptoms Questionnaire scores *(continued)*

Clinical characteristics	Patient cohort (N=338)	*P* values	
		Pelvic Floor Distress Inventory	Uterine Fibroid Symptoms Questionnaire
Smoking (past or current)	8.1 (27)	<.001	.537
Anemia	41.4 (140)	.588	<.001
Diabetes mellitus	4.4 (15)	.009	.009
Medication use			
Diuretic (Loop, Thiazide, K-Sparing)	3.6 (12)	.049	.101
Anticoagulation	2.4 (8)	.449	.020
Thyroid replacement	8.3 (28)	.137	07597
Antidepressant	8.9 (30)	.160	.415

[a] Indicates predictor was of clinical interest and included in the multivariate analysis despite a probability value of >.05; [b] Includes progestin-only pills, injection, and intrauterine device; no patients used the progestin implant; [c] Includes copper intrauterine device, tranexamic acid, or other medications that include nonsteroidal antiinflammatory drugs or alternative medicine.
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scores and subscores with fibroid location relative to the bony pelvis in univariate analysis (Table 3), these associations did not reach significance on multivariate analysis. Anterior fibroid tumors (β=0.61; 95% CI, −13.66 to −14.88; *P*=.933) and uterine volume (β=−0.006; 95% CI, −0.01 to −0.01; *P*=.078) also did not reach significance when associated with increased PFDI scores. Multivariate analysis of similar covariates with a primary outcome of PFDI subscores did not reveal additional significant findings.

Colorectal-anal distress symptoms

In univariate analysis, patients with fibroid tumors partially out of the pelvis reported significantly fewer colorectal symptoms (CRADI-8) than patients with fibroid tumors completely within the pelvis (mean difference, −5.9 points; *P*=.015) or patients with fibroid tumors outside of the pelvis (mean difference, −7.2 points; *P*=.033; Table 3). Higher CRADI-8 score was significantly, but weakly, associated with deeper sacrococcygeal curve (*rho*=0.104; *P*=.05) and with the ratio of fibroid to pelvic width (fibroid width/interspinous diameter; *rho*=0.312; *P*<.001) and the ratio of fibroid to pelvic depth (longest fibroid dimension in the midsagittal plane/obstetric conjugate distance; *rho*=0.285; *P*<.001). Patients with posterior dominant fibroid location had higher CRADI-8 scores (mean difference, +5.4 points), but this was not statistically significant in multivariate analysis (data not shown).

TABLE 2
Self-reported symptoms, treatment history and surgical history of clinical cohort

Clinical presentation	Patients reporting, % (n)
Gynecologic symptoms	
Menorrhagia	70.1 (237)
Urinary frequency	53.0 (179)
Fatigue or history of anemia	40.83 (138)
Pelvic pain or dysmenorrhea	39.6 (134)
Nocturia	39.1 (132)
Pelvic pressure	36.1 (122)
Constipation	18.1 (61)
Infertility	5.3 (18)
Asymptomatic	2.6 (9)
Previous treatments	
No previous therapy	44.4 (150)
Medical therapy (any type)	40.8 (138)
Myomectomy (abdominal or laparoscopic)	12.7 (43)
Intrauterine device	11.5 (39)
Hysteroscopy (with resection or ablation)	5.6 (19)
Uterine artery embolization	1.5 (5)
High frequency ultrasound ablation	0.9 (3)

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TABLE 2
Self-reported symptoms, treatment history and surgical history of clinical cohort *(continued)*

Clinical presentation	Patients reporting, % (n)
Gynecologic surgical history	
Pelvic/abdominal surgery (any)	35.5 (120)
≥1 Cesarean delivery	17.8 (60)
Hysteroscopy (any)	13.3 (45)
Tubal ligation	3.6 (12)
Urinary incontinence surgery	1.8 (6)

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Bleeding symptoms and fatigue

Our cohort had a normal UFS distribution, with a mean score of 52.8 (standard deviation, ±23.5): 7.8% of the women (n=26) had dominant submucosal/intracavitary fibroid tumors, and 43.2% of the women (n=146) had at least 1 (including but not necessarily dominant) submucosal/intracavitary fibroid tumor. On univariate analysis, submucosal/intracavitary dominant fibroid location was associated with worse UFS score (mean difference, +14.5 points; P=.016); uterine volume and fibroid position on the uterus (eg, anterior, posterior) were not associated with UFS score. No other fibroid characteristics that were evaluated by MRI were associated with UFS score, which includes fibroid location relative to the bony pelvis (mean difference, 1.86 points between fibroid tumors above and below pelvis; P=1.00). Although comorbid gynecologic conditions of endometriosis (14.2%) and adenomyosis (25.4%) were prevalent in our cohort, neither was associated with UFS severity (mean UFS score, 54.7 vs 52.4 with/without endometriosis; P=.548; mean UFS score, 55.7 vs 51.8 with/without adenomyosis; P=.185) on univariate analysis.

Multivariate analysis of UFS score association with fibroid location, fibroid position, uterine volume, and clinical and demographic factors is shown in Table 5. Patients with increased BMI (β=0.73; 95% CI, 0.35−1.10; P<.001), a clinical history of anemia (β=13.88;

TABLE 3
Association between fibroid characteristics determined by magnetic resonance imaging and Pelvic Floor Distress Inventory scores and subscores

		P value			
Fibroid characteristics	Patient cohort (N=338)	Pelvic Floor Distress Inventory−20	Urinary Distress Index−6	Colorectal-Anal Distress Index−8	Pelvic Organ Prolapse Distress Index−8
Number of fibroid tumors, % (n)		.266	.336	.325	.239
1	21.0 (71)				
2−5	33.7 (114)				
>5	45.3 (153)				
Dominant fibroid location, % (n)[a]		.140[b]	.192	.042	.541
Anterior	50.6 (171)				
Fundal	16.9 (57)				
Posterior	32.0 (108)				
Dominant fibroid wall position, % (n)		.403	.586	.146	.431
Intramural	76.0 (257)				
Subserosal	8.0 (27)				
Submucosal/intracavitary	7.7 (26)				
Pedunculated/other	8.3 (28)				
Fibroid relation to bony pelvis, % (n)[a]		.035	.046	.005	.506
All fibroid tumors within pelvis	31.1 (105)				
Fibroid tumor partially out of pelvis	53.9 (182)				
Fibroid tumor 100% out of pelvis	13.9 (47)				

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TABLE 3
Association between fibroid characteristics determined by magnetic resonance imaging and Pelvic Floor Distress Inventory scores and subscores *(continued)*

Fibroid characteristics	Patient cohort (N=338)	*P* value			
		Pelvic Floor Distress Inventory–20	Urinary Distress Index–6	Colorectal-Anal Distress Index–8	Pelvic Organ Prolapse Distress Index–8
Mean dominant fibroid volume, cc±standard deviation	203.9 (300.9)	.375	.829	.002	.627
Mean dominant fibroid length, cm±standard deviation	6.5 (3.3)	.482	.712	.006	.743
Mean uterine volume, cc±standard deviation	630.3 (668.4)	.478[b]	.682	.006	.834
Comorbid diagnoses, % (n)					
Adenomyosis	25.4 (86)	.954	.475	.700	.861
Endometriosis	14.2 (48)	.909	.615	.828	.402

[a] Six records are missing because of inability to evaluate the fibroid location or bony pelvis on uploaded magnetic resonance imaging scans; [b] Indicates predictor was of clinical interest and included in the multivariate analysis despite a probability value of >.05.

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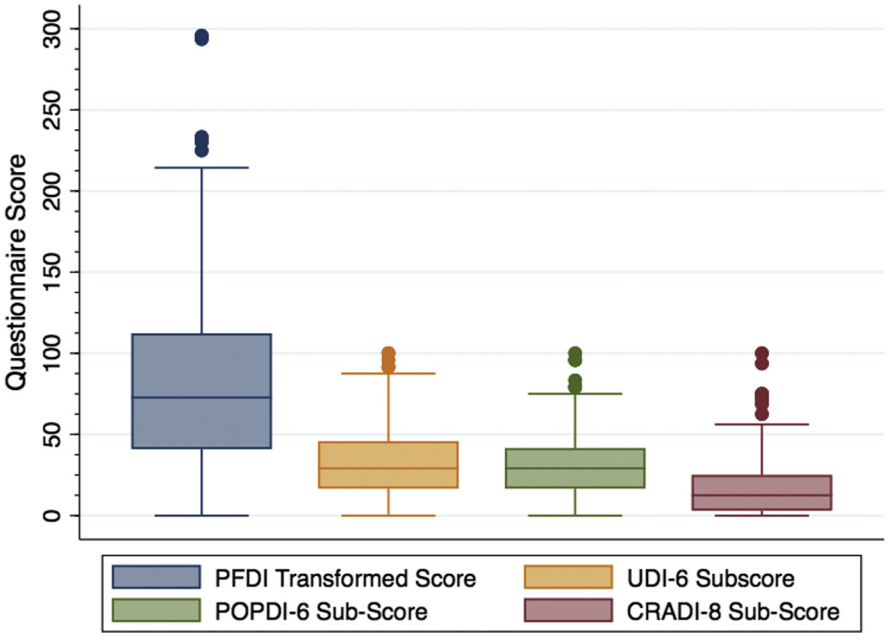
95% CI, 9.37−18.38; *P*<.001), and any hormonal treatment for fibroid tumors (*β*=6.40; 95% CI, 1.62−11.18; *P*=.009) had a significantly increased UFS score. A dominant submucosal or intracavitary fibroid tumor was associated with a near 12-point increase in UFS symptom score (*β*=11.56; 95% CI, 2.65−20.47; *P*=.011) compared with an intramural dominant fibroid tumor. Patients who self-identified as Asian race had significantly lower (*β*=-8.57; 95% CI, −14.24 to −2.90; *P*<.003) UFS scores compared with white women.

FIGURE 2
Fibroid tumor location relative to bony pelvis structure



In 189 patients, at least 1 fibroid tumor rose through the anterior-posterior conjugate partially above the pelvis. In 56 patients, at least 1 fibroid tumor was located above the anterior-posterior conjugate completely outside the pelvis. Data are unavailable in 4 patients whose magnetic resonance images were from external imaging centers and did not have appropriate views to evaluate the complete bony pelvis.

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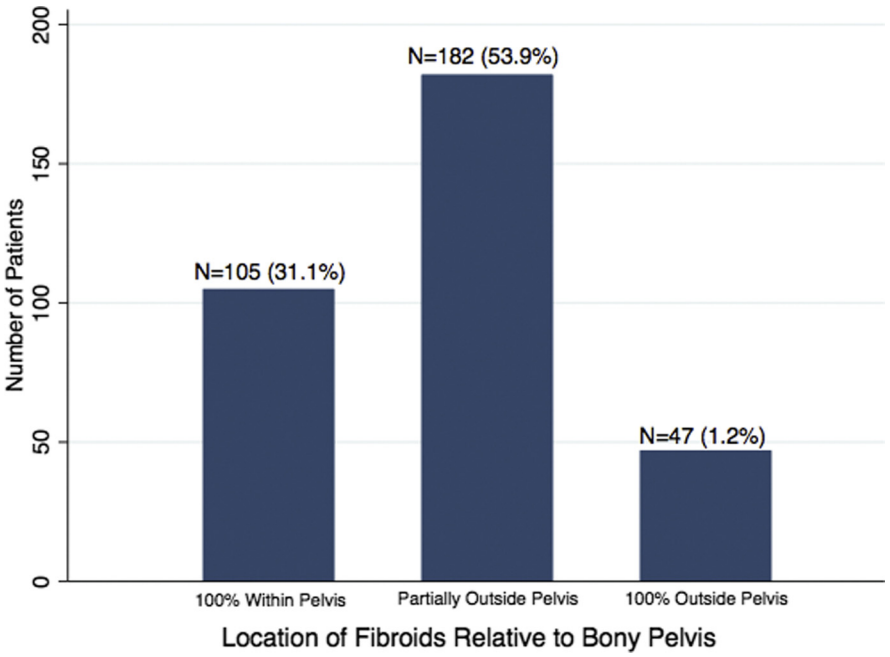
Comment

Fibroid size and location are thought to be primary contributors to urinary and pelvic symptoms. In this retrospective analysis of a patient cohort from a multidisciplinary fibroid clinic, we assessed associations between fibroid tumors and bony pelvis characteristics, clinical history, and symptom severity. Contrary to common belief, in this study, urinary and pelvic floor symptom severities were not associated with uterine size, fibroid location, or bony pelvis characteristics. This finding adds to the growing literature that suggests that this common belief may not be supported by clinical research.[5,12,13]

Previous investigators have shown an increased risk of pelvic floor disorders that are associated with deeper sacrococcygeal curve and longer interspinous diameter and a reduced risk in patients with longer obstetric conjugate length and longer anterior-posterior outlet

FIGURE 3
Breakdown of Pelvic Floor Distress Inventory median and interquartile range by subscore



Median (*horizontal line*) and interquartile range (*horizontal upper* and lower lines of box) and minimum/maximum (*whiskers*) are shown for the nonnormal distribution of the Pelvic Floor Distress inventory questionnaire and its subscores: Urinary Distress Index—6 (median, 29.1; interquartile range, 12.5-45.8), Pelvic Organ Prolapse Distress Index—6 (median, 29.1; interquartile range, 16.6-41.6), and Colorectal-Anal Distress Index—8 (median, 12.5; interquartile range, 3.1-25). *Solid dots* represent statistical outliers.

CRADI, Colorectal-Anal Distress Index; *PFDI*, Pelvic Floor Distress Inventory; *POPDI*, Pelvic Organ Prolapse Distress Index; *UDI*, Urinary Distress Index.

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length.[14] In this study, although fibroid location relative to the bony pelvis varied significantly with uterine and fibroid volume and was associated with PFDI on univariate comparison, there was no significant relationship between pelvic architecture and PFDI score on multivariate analysis.

The median PFDI score in this study was 72.7, which is similar to a cohort of 145 women with fibroid tumors in Los Angeles County (PFDI mean score, 64.2±69.7) in women with >12-week uteri) and slightly lower than a cohort of 45 women with mixed pelvic floor disorders who underwent surgery in Cleveland, OH (mean score, 121.6).[10,13] The right-skewed PFDI results of our study may reflect a referral bias in which patients were more likely to be referred for bleeding or other nonurinary symptoms. Significant risk factors for worse PFDI scores in our cohort included only demographic and clinical predictors, such as parity, BMI, history of incontinence/pelvic surgery, and insurance status. Parity and obesity have been shown to be associated with pelvic floor disorders in national surveys, regardless of fibroid presence.[15,16]

We included the analysis of UFS scores to verify that our cohort is representative of cohorts in the established fibroid literature.[3,5] The association of submucosal or intracavitary fibroid with menorrhagia has been well-documented.[1,3,12] Our data are consistent with this because submucosal dominant fibroid location was the single significant predictor of increased UFS score among all characteristics determined by MRI, including fibroid position and uterine size.

We report a novel finding that Asian women have significantly lower UFS scores compared with white women. We note that our patient population has a significantly higher percentage of Asian women (28.1%) compared with other larger studies (FIBROID registry, 2.8% Asian; Embolisation versus Hysterectomy trial, 11.4% non-white and non-African).[3,17] Prevalence of fibroid tumors in Asian women has been shown previously to be comparable with prevalence in black and Hispanic women.[18] Although lower scores reported by Asian women may be, in part, due to the confounding influence of lower BMI in our Asian patient cohort, race remains significant after adjustment for BMI on multivariate analysis. Previous studies have shown that Asian women report fewer symptoms related to menopause and endometriosis relative to its prevalence, which possibly suggests a cultural tendency to underreport symptoms compared with other ethnicities.[19-21] It remains unclear whether this finding is due to underlying referral bias in our clinic population; differences in symptom severity by ethnicity warrants further consideration.

Noncommercial insurance significantly predicted worse PFDI scores. Because noncommercial insurance was not associated with increased fibroid or uterine size, this possibly reflects increased time before accessing care or other social determinants of health not captured in our study. Previous studies have been limited to employer-insured women and did not find significant predictors within socioeconomic strata.[22,23] Inclusion of women with noncommercial insurance will be necessary to account for socioeconomic variability in future studies.

Strengths of our study include the use of MRI for precise evaluation of fibroid tumors relative to the uterus and bony pelvis structure compared with ultrasound evaluation and patient evaluation with the use of prospectively collected and psychometrically validated

TABLE 4
Multivariate linear regression of Pelvic Floor Distress Inventory

Variable	β Coefficient	95% Lower confidence limit	95% Upper confidence limit	Adjusted *P* value
Demographics				
Age	0.47	−0.39	1.34	.281
Body mass index	1.87	0.98	2.77	<.001
Race (reference: white)				
Hispanic	9.53	−8.23	27.30	.292
Black	0.63	−16.29	17.56	.941
Asian	−8.17	−21.49	5.15	.229
Other	2.14	−13.92	18.21	.793
Insurance (reference: private)				
Noncommercial	46.51	27.42	65.61	<.001
Self-pay/other	2.10	−24.21	28.42	.875
Medical history				
Parity	7.80	3.11	12.49	.001
Smoking	18.99	−4.24	42.22	.109
Diuretic	−3.09	−30.39	24.22	.824
Diabetes mellitus	4.52	−24.04	33.09	.756
Incontinence surgery	49.04	17.19	80.88	.003
Pelvic/abdominal surgery	11.79	0.65	22.93	.038
Magnetic resonance imaging findings				
Uterus volume	−0.006	−0.01	0.01	.078
Fibroid position (reference: fundal)				
Anterior	0.61	−13.66	14.88	.933
Posterior	7.09	−9.15	23.33	.391
Fibroid relation to pelvis (reference: 100% within pelvis)				
Fibroid tumors partially above pelvis	3.02	−9.83	15.88	0644
Fibroid 100% above pelvis	7.65	−8.76	24.06	.360

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questionnaires rather than self-reporting of urinary and bleeding symptoms. We note that the PFDI-20 was designed for a general urogynecology setting and is not validated specifically for fibroid symptoms. Because these questionnaires were obtained during routine clinical care, patients reported their symptoms without the artificial bias introduced by participating in a prospective study.

Our cohort was limited to a single clinical site, and some patients had missing questionnaires, which may limit the generalizability of our findings. The excluded patients were significantly older than our study cohort although with similar racial distribution, uterine volume, and medical comorbidities (data not shown). Therefore, our results are more relevant to the younger premenopausal patients. The standard deviation of PFDI scores was high. For future studies that need to detect small differences between means, we recommend either a larger sample or a response survey with less variability. Although primary clinical information was collected by standardized questionnaires, clinical notes were written by physicians that introduced variability into the detail of clinical information that was acquired. Because, pelvic examination was documented inconsistently, our analysis does not account for physical examination evidence of pelvic organ prolapse. However, there was no prolapse beyond the introitus in our cohort.

Additionally, our study is limited to characterization of the "dominant"

TABLE 5
Multivariate linear regression of Uterine Fibroid Symptoms Questionnaire score

Variable	β Coefficient	95% Lower confidence limit	95% Upper confidence limit	Adjusted *P* value
Demographics				
Age	0.07	−0.31	0.44	.724
Body mass index	0.73	0.35	1.10	<.001
Race (reference: white)				
Hispanic	−1.81	−9.60	5.98	.648
Black	−7.13	−14.79	0.53	.068
Asian	−8.57	−14.24	−2.90	.003
Other	−5.77	−12.41	0.87	.089
Insurance (reference: private)				
Noncommercial	5.19	−1.63	12.01	.135
Self-pay/other	0.62	−12.43	13.66	.926
Medical history				
Parity (term births)	1.20	−0.96	3.37	.274
Any hormonal therapy	6.40	1.62	11.18	.009
Anemia	13.88	9.37	18.38	<.001
Diabetes	9.46	−1.07	19.99	.078
Anticoagulation	13.35	−1.09	27.79	.070
History pelvic/abdominal surgery	4.56	0.10	9.02	.045
Magnetic resonance imaging findings				
Uterus volume	0.01	−0.01	0.01	.077
Fibroid position (reference: fundal)				
Anterior	3.57	−2.99	10.14	.285
Posterior	6.74	−0.24	13.71	.058
Wall position (reference: intramural)				
Subserosal	5.17	−2.05	12.40	.160
Intracavitary/submucosal	11.56	2.65	20.47	.011
Pedunculated/exophytic	−4.32	−13.00	4.35	.328

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fibroid tumor. We included uterine volume and number of fibroid tumors in our analysis to account for the overall burden of multiple fibroid tumors, but symptom correlation may miss symptoms caused by a nondominant fibroid tumor in a particular position. Last, the comorbid diagnoses of endometriosis and adenomyosis were defined by MRI and were not verified by pathologic evidence.

Management of uterine fibroid tumors is targeted largely towards symptomatic relief. Surgical and interventional radiologic management of fibroid tumors, which includes embolization, myomectomy, and hysterectomy, has been shown to improve symptoms that are attributed to fibroid tumors; however, documentation of fibroid size, number, and position is not often detailed.[24,25] As such, it is unclear whether this benefit is due to a reduction in fibroid size or other biologic causes.

Investigation of the driving factors of symptoms that are associated with uterine fibroid tumors, rather than purely attributing those symptoms to fibroid size or location, is vital to the prevention of needless interventions that are costly and morbid and for the development of new therapies. UFS severity and decreased quality of life may be related significantly to the presence of a submucosal fibroid tumor or clinical factors that predispose patients to excessive bleeding and anemia. On the other hand, urinary and pelvic floor symptoms in women with fibroid tumors may be worsened by medical comorbidities rather than specific fibroid characteristics. Future research

should be directed to further clarify the drivers of urinary/pelvic symptoms in women with uterine fibroid tumors. ■

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Author and article information

From the Departments of Urology (Dr Dobberfuhl), Radiology (Drs Vu, Fast, Hovsepian, and Ghanouni), and Obstetrics & Gynecology (Drs Lum and Chen), Stanford University School of Medicine (Ms Shaffer), Stanford, CA; and the Department of Radiology, Sapienza University, Rome, Italy (Drs Dababou and Marrocchio).

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Corresponding author: Bertha Chen, MD. bchen@stanford.edu