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Quantitative Analysis of Uterosacral Ligament Origin and Insertion Points by Magnetic Resonance Imaging

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Abstract

OBJECTIVE— To estimate the percentage of healthy women in whom the uterosacral ligaments are identifiable on standard magnetic resonance imaging (MRI) scans and to determine origin points from the genital tract and insertion points on the pelvic sidewall.

METHODS— Eighty-two asymptomatic women (mean $\pm$ standard deviation age 53 ± 12 years; mean parity 2.5, range 0–7) volunteered for this study. They were eligible if the most dependent vaginal wall point lay at least 1 cm above the hymenal ring remnant during a Valsalva maneuver. Axial proton density MRI of the entire pelvis was analyzed at 5-mm intervals. All results were referenced to the ischial spine. We determined the visibility of the uterosacral ligaments and located their origins from the genital tract and their insertion points on the pelvic sidewall.

RESULTS— Uterosacral ligaments were visible in 61 (87%) of 70 analyzable scans. They extended over a mean cranio-caudal distance of 21 ± 8 mm (range 10–50). Three regions of origin were found: cervix alone, cervix and vagina in the same section, and vagina alone. Thirty-three percent, 63%, and 4% of 254 identified origin points were from these three areas, respectively. Of 259 uterosacral insertion points, 82% overlaid the sacrospinous ligament/coccygeus muscle complex, 7% the sacrum, and 11% the piriformis muscle, the sciatic foramen, or the ischial spine. Although uterosacral ligament morphology was similar bilaterally, its cranio-caudal extent was greater on the right side.

CONCLUSION— In healthy women, the uterosacral ligament origin and insertion points exhibited greater anatomic variation than their name would imply.

Pelvic organ prolapse is a distressing problem for which 6% of all women in America have surgery.¹ It is caused by structural defects in the connective tissue and the muscles that support the pelvic viscera.^{2,3} The uterosacral ligaments have long been regarded as a part of this support system for the pelvic organs.⁴ Nichols,⁵ in his book on vaginal surgery, expressed the widely held opinion that the uterosacral ligaments, together with the cardinal ligament, hold the upper vagina and cervix over the levator plate.

The uterosacral ligaments have been studied both in cadavers and at surgery.^{5–9} However, the borders of the ligament are difficult to establish on dissection, and the removal of the ligament is somewhat arbitrary. As a result, both origin and insertion of the ligament are difficult to define. We are not aware of any studies documenting the visibility and the extent of the uterosacral ligaments in living women.

Magnetic resonance imaging (MRI), a noninvasive technique that allows excellent soft tissue resolution in the living, can depict the endopelvic fascia, the uterosacral ligaments, and related structures with little distortion.^{10–13} The scientific study of these tissues depends on the ability to define the visibility and appearance of the uterosacral ligaments in healthy women without pelvic floor impairments. These attributes may then be compared with those in women with pelvic floor dysfunction.

The purpose of this study, therefore, was to estimate the percentage of healthy women in whom the uterosacral ligaments can be identified on standard MRI scans and to determine where the ligaments originate from the genital tract and where they insert on the pelvic sidewall.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board, and written consent was obtained from all participants. Between May 2001 and January 2003, we solicited 82 women by newspaper advertisement to participate as healthy control subjects in a study of pelvic organ prolapse (IRB Med#: 1999–0395). Subjects were eligible as controls if the most dependent vaginal wall point was at least 1 cm above the hymenal ring remnant during a Valsalva maneuver. This is consistent with pelvic organ prolapse stage 0 and 1 as defined by the International Continence Society.¹⁴ Women were excluded if there was descent of any vaginal wall point greater than 1 cm above the hymenal ring remnant, leakage during a full bladder stress test, a history of hysterectomy or previous surgery for prolapse or incontinence, an abnormal pelvic mass, suspected cancer, a known lower urinary or genital tract disease, recurrent or persistent urinary tract infections, current pregnancy, and/or claustrophobia.

All women underwent a standard MRI tomography of the pelvis on a 1.5-Tesla magnet (Signa; General Electric Medical System, Milwaukee, WI) in the supine position. A 160 × 160-mm field of view and an imaging matrix of 256 × 256 were used. Contrast media was not used, and women did not receive bowel or bladder preparation. Proton density scans (time to repetition 4000 ms, time to echo 15 ms) were obtained with a slice thickness of 4 mm and a slice gap of 1 mm. Axial scans were analyzed in this study. All relevant pelvic structures were assessed relative to the tip of the ischial spine. Their spatial relationship in a craniocaudal direction was described with a resolution of 5 mm, given the slice thickness and the gap between slices. We determined the visibility of the uterosacral ligaments in each image. “Origin” was defined as the point where the connective tissue condensed to a band-like structure lateral to the genital tract. This condensation of connective tissue—the uterosacral ligament—had to be visible in at least 1 image. “Insertion” was defined as the point at the pelvic sidewall where the uterosacral ligament ended. The origin from the genital tract and insertion point on the pelvic sidewall were classified as follows: In each slice, the uterosacral ligament origin from the genital tract was classified as from the cervix (if only cervix and no vagina was seen), as from the vagina and cervix (if both were seen), or as from the vagina (if only vagina and no cervix was seen).

Similarly, the uterosacral insertion point on the pelvic sidewall was classified in each slice according to the structure where the ligament terminated. These structures included the following anatomical landmarks: sacrospinous ligament/coccygeus muscle complex, sacral bone, piriformis muscle, the sciatic foramen, ischial spine.

The position of each single insertion point on the pelvic sidewall between the sacrum and ischium was determined. For this purpose, the distance (in millimeters) from the midline of the sacrum to the medial border of the ischial bone and from the midline to the insertion point were measured (Figure 1).

The authors W.H.U. and J.O.L.D. read all scans to assess the visibility of the uterosacral ligaments and their origin and insertion points. The scans were then independently reread by

W.H.U. who did the quantitative analysis of origin and insertion points. Both investigators were blinded to the clinical information about the study subjects.

In 20 randomly scans, we compared the uterosacral ligament morphology between women's left and right body side regarding differences in the craniocaudal extent and insertion points on the pelvic sidewall. For this purpose, 20 MRI jackets were randomly picked from the stack of 61 scans with visible uterosacral ligaments.

Descriptive statistics consisting of the mean, median, standard deviation, and range were calculated as appropriate.

RESULTS

The study population had a mean ($\pm$ standard deviation) age of 53 ± 12 years (range 30–85 years), a mean parity of 2.5 (range 0–7), and a mean body mass index of 26 ± 5 (range: 18–40); according to self-identification, 88% were Caucasian, 7% African American, and 5% of another race.

82 MRI scans were obtained, and 12 were excluded due to motion artifacts. This left 70 MRI scans for study evaluation. The uterosacral ligaments were visible in 61 (87%) of 70 analyzable MRI scans. The following factors precluded visibility in the remaining 9 scans: a high proportion of subperitoneal fat to connective tissue ($n = 4$), a short distance between cervix and sacrum ($n = 2$), an enlarged uterus ($n = 1$), an overly full rectum ($n = 1$), and engorged parametric and paracolic vessels ($n = 1$). Women whose scans were not analyzable due to motion artifacts or in whom the uterosacral ligaments were not visible did not differ from the study group regarding age or parity.

The mean length ($\pm$ standard deviation) of the uterosacral ligaments in their craniocaudal extent was 21 ± 8 mm (range 10–50 mm), calculated from the number of MRI images between the most cranial and most caudal image with identifiable origin and insertion points.

Among all women, 254 origin points from the genital tract were found. Eight-four (33%) were from the cervix, 161 (63%) were from the portion of the genital tract where the cervix and vagina are both seen in one axial image, and 9 (4%) were from the vagina below the cervix. These three typical regions of origin are demonstrated in Figure 2, and examples of interindividual variability are seen in Figure 3.

Two hundred fifty-nine individual insertion points on the pelvic sidewall were identified, and they were distributed as follows: 213 (82%) occurred on the sacrospinous ligament/coccygeus muscle complex, 19 (7%) on the sacrum, and 27 (11%) on either the piriformis muscle, the area of the sciatic foramen, or the ischial spine. Four typical structures underlying the uterosacral ligament insertion on the pelvic side wall are shown in Figure 2. The distribution of uterosacral insertion points are displayed in Table 1, and the position of these insertion points relative to the body midline are displayed in Table 2. Dedicated comparisons between left and right side in twenty women showed similar uterosacral ligament morphology on both sides in 6 scans (30%), a longer right uterosacral ligament in 10 (50%), and a longer left one in 4 (20%).

DISCUSSION

The peritoneal fold created by the upper margin of the uterosacral ligament is familiar to all gynecologists. However, the full extent of the connection between the genital tract and the pelvic sidewall is not well understood. Our study quantifies the uterosacral ligament origins and insertion points in healthy women as seen on MRIs. The presented description goes beyond what can be accomplished using macroscopic dissection and operative anatomy.

The results show that the origin of the uterosacral ligament from the genital tract extends from the cervix to the upper vagina. The insertion on the pelvic sidewall occurs to the sacrospinous ligament and the coccygeus muscle in 82% of all cases, but in only 7% do the uterosacral ligaments insert on the sacrum. This suggests that the uterosacral ligaments exhibit greater anatomic variability than their name implies, and this might be an important insight for the understanding of the pelvic organ support mechanism.

Campbell⁴ described the uterosacral ligaments as originating from the posterolateral aspect of the cervix at the level of the internal cervical os and from the lateral vaginal fornix. Blaisdell⁶ described uterosacral fibers which attached to the fascia covering the levator ani, coccygeus, and obturator muscles, as well as the presacral fascia. Our findings corroborate these macroscopic findings. Both Campbell⁴ and Blaisdell⁶ observed that the sigmoid's mesentery caused the left uterosacral ligament to appear less prominent. We found that in 50% of all women the left uterosacral ligament was shorter in its craniocaudal extent than on the right side. This may be attributed to the embryologic development of this region which includes rotation and attachment of the sigmoid's mesentery to the left pelvic side wall.

Most authors describe the uterosacral ligaments' insertion on the sacrum opposed to a study of plastinated cross sections in which Fritsch et al¹⁰ could not find a direct attachment to the sacrum. In our study, only 7% of the insertion points were found on the sacrum. This creates further evidence that the uterosacral ligaments rather connect to structures which lie ventral or lateral to the sacral bone than to the bone or its periostium.

There are several limitations to this study. First, imaging in the supine position may not accurately reflect pelvic floor anatomy in the upright position. Unfortunately, limited access to upright MRI scanners offering adequate image resolution precluded us from pursuing such an analysis. Second, filling of the rectum and bladder might also have influenced the appearance of the uterosacral ligaments. While a standardized bowel preparation and bladder filling might reveal different results, this did not appear to be a significant issue because rectal contents only once prohibited evaluation of the uterosacral ligaments. Third, the MRI technique used in this study has shortcomings. We cannot determine fiber direction within connective tissues and cannot be certain that the uterosacral ligaments directly connect to the pelvic sidewall structures. In addition, among the 9 scans with adequate image quality in which the uterosacral ligaments could not be identified, we could not determine if they were attenuated, absent, or simply obscured by other tissues.

The contribution of different disease mechanisms to pelvic organ prolapse need to be better understood. While there is evidence associating muscular, neurologic, and connective tissue injury with prolapse, the relative contributions of these processes are not appreciated. New imaging modalities provide the means to quantitatively assess changes in connective tissues. This study establishes normative data of uterosacral ligament morphology with MRI scanning and will allow us to explore and understand the connective tissue differences in women with and without prolapse. By understanding the pathomechanisms leading to pelvic organ prolapse we can then improve treatment.

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Figure 1.

Axial scan at the level of the cervix. This image demonstrates the uterosacral ligament origins and insertions, and the measuring strategy. The origin of the uterosacral ligaments from the cervix (white arrowheads) and their insertions (black arrowheads) on the pelvic sidewall are seen. The location of the insertion point (b) on a line (ac) between the body midline and the ischium (I) was measured as described in Materials and Methods. The location of the bladder (B), cervix (C), rectum (R), coccyx (X), and coccygeus muscle (CM) are shown. © 2004 DeLancey.

Umek. Uterosacral Ligament Anatomy on MRI. *Obstet Gynecol* 2004.

Figure 2.

Examples of common uterosacral origins and insertions. Points of origins (white arrowheads) are the cervix (C) in panel a, cervix/vagina (C, V) in panels b and c, and vagina (V) in panel d. Points of insertion (black arrowheads) are the sacrum in panel a, the coccygeus muscle in panel b, the piriformis muscle in panel c, and the ischial spine (IS) in panel d. R = rectum. © 2004 DeLancey.

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Figure 3.

Variation in uterosacral ligament anatomy in 2 healthy women. Top row (a–d) shows images of a 57- year-old woman, bottom row (e–h) shows images of a 58-year-old woman. Numbers in the right lower corner indicate in millimeters the distance of the picture plane relative to the ischial spine. White arrowheads point to origins from the genital tract, and black arrowheads point to insertions on the pelvic sidewall. Uterosacral origins are from the cervix in panels a and e, from cervix and vagina in panels b–d and f–h. Uterosacral insertions are on the coccygeus muscle/sacrospinous ligament complex in panels a–c and f–h, near the ischial spine in panel d, and on the sacrum in panel e. Note that the uterosacral ligaments of the woman on the top row (panel c) are thicker than those of the woman on the bottom row (panel g). © 2004 DeLancey.

Umek. Uterosacral Ligament Anatomy on MRI. Obstet Gynecol 2004.

Table 1
Distribution of Uterosacral Ligament Insertion Points on the Pelvic Side Wall

Levels relative to the ischial spine, 0 (mm)	Insertion location		
	SSL/CM	Sacrum	Others
+40 and above	1	2	5 P
+35	5	0	3 P
+30	11	5	2 P
+25	20	7	2 P 1 SF
+20	37	5	3 P 1 SF
+15	56	0	1 SF
+10	46	0	1 IS
+5	26	0	3 IS 1 SF
0	9	0	3 IS
-5	2	0	1 IS
All levels	213 (82%)	19 (7%)	27 (11%)

SSL/CM = sacrospinous ligament/coccygeus muscle complex; P = piriformis muscle; SF = sciatic foramen; IS = ischial spine.

Table 2
Position of the Uterosacral Ligament Insertion Points, Relative to the Body Midline

Levels relative to the ischial spine, 0 (mm)	Number at this level	Insertion position	
		Distance from the body midline to the point of insertion (mean $\pm$ standard deviation mm)	Distance from the body midline to the medial border of the ischium (mean $\pm$ standard deviation mm)
+40	4	53 $\pm$ 18	118 $\pm$ 6
+35	7	58 $\pm$ 15	118 $\pm$ 7
+30	16	48 $\pm$ 18	113 $\pm$ 9
+25	26	53 $\pm$ 15	108 $\pm$ 8
+20	40	58 $\pm$ 10	105 $\pm$ 8
+15	51	60 $\pm$ 10	100 $\pm$ 8
+10	40	60 $\pm$ 13	95 $\pm$ 11
+5	27	63 $\pm$ 15	90 $\pm$ 10
0 (ischial spine)	8	63 $\pm$ 13	90 $\pm$ 11