Anatomy of the perineal membrane as seen in magnetic resonance images of nulliparous women

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OBJECTIVE: Recent cadaver research demonstrates the perineal membrane's ventral and dorsal portions and close relationship to the levator ani muscle. This study seeks to show these relationships in women by magnetic resonance (MR) images.

STUDY DESIGN: The subjects were 20 asymptomatic nulliparous women with normal pelvic examinations. MR images were acquired in multiple planes. Anatomical relationships from cadaver studies were examined in these planes.

RESULTS: In the coronal plane the ventral perineal membrane forms an interconnected complex with the compressor urethrae, vestibular bulb, and levator ani. The dorsal part connects the levator ani and vaginal side wall via a distinct band to the ischiopubic ramus. In the sagittal plane the parallel position of perineal membrane and levator ani are seen.

CONCLUSION: The perineal membrane's anatomical features can be seen in women with MR. The close relationship between the perineal membrane and levator ani is evident.

Key words: levator ani, MR imaging, pelvic floor, pelvic organ support, perineal membrane

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Pelvic organ prolapse and stress urinary incontinence are distressing and common conditions.[1-3] They are, in large part, caused by structural abnormalities in the muscles, ligaments, and nerves of the pelvic floor.[4,5] Modern cross-sectional imaging has recently demonstrated its ability to demonstrate specific defects present in the pelvic organ support system to determine the precise anatomical problem in individual women, especially in the case of the levator ani muscle.[6,7]

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The perineal membrane is an often discussed, yet rarely studied, pelvic organ support structure. Formerly known as the urogenital diaphragm, it spans the triangle between the anterior portions of the urogenital triangle and attaches the pelvic organs laterally to the bony outlet.[8,9] We have recently completed a study of the anatomy of this region as seen in cross sections of cadavers and dissection.[9] This study revealed perineal membrane in women to be a composite structure with 2 unequal regions: 1) the ventral or anterior component where the membrane is formed by the blending and fusion of tissue from adjacent structures, and 2) the more dorsal or posterior part which is a distinct fibrous sheet.

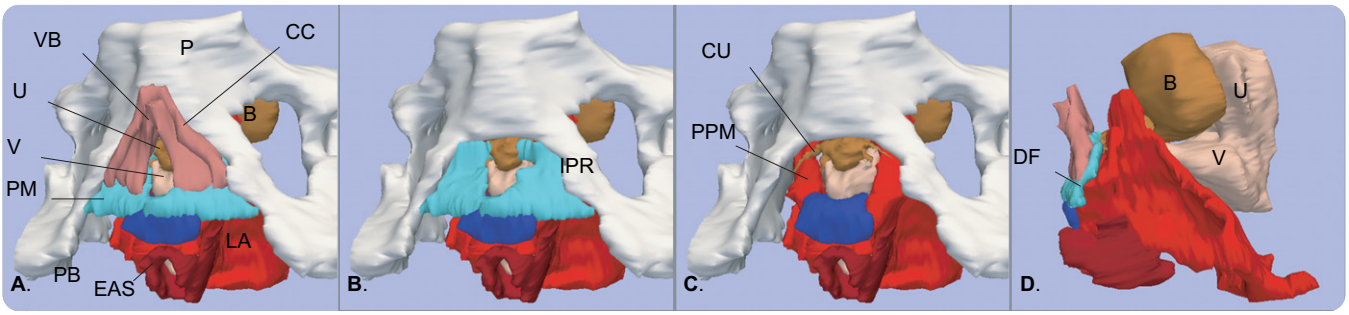
Previously this structure could only be evaluated in cadavers, but the advent of high resolution magnetic resonance (MR) imaging has allowed us to see the detailed nature of this important structure. There will be obvious importance to comparing this structure in women with and without pelvic floor disorders. This study seeks to evaluate MR imaging's ability to visualize these relationships in living women and to describe which structural relationships are visible with this technique.

Materials and Methods

MR images from 20 asymptomatic, nulliparous women were examined. All subjects (aged 23-55 years) denied incontinence or prolapse symptoms, and had full pelvic organ quantification (POP-Q) examinations confirming normal support. The women had been recruited as controls in case-control studies with MR for evaluation of prolapse and incontinence. All were asymptomatic, had not had prior pelvic floor surgery, and had demonstrably normal support and continence on pelvic floor evaluation. Scans were performed on a 1.5-Tesla 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. A 160×160 mm field of view and 256×256 imaging matrix were used (1.5 T, Signa). Supplemental images were made on a 3 T scanner (Achieva; Philips Medical Systems [Eindhoven, the Netherlands] using an 8 channel phased-array cardiac coil). Proton density sequences (TR 2107, TE 30) were obtained (4 mm slice, 1 mm gap, 256×256 matrix, NSA 2) in the coronal, axial, and sagittal planes through the pelvis. Additional higher resolution (2 mm slice 0.2 gap, 256×256 matrix, NSA 2) proton density sequences (TR 2107, TE 30) and proton density with fat saturation sequences (TR 2355, TE 30) were obtained in the axial and coronal planes of the anterior (ventral) pelvic floor in selected

FIGURE 1

The 3-dimensional relationships are best seen in the models generated from MR images of a 27-year-old nullipara



A, Oblique left inferolateral view showing structures related to perineal membrane. **B,** Same view with clitoral crus and vestibular bulb removed to show the perineal membrane cephalad to these structures, extending bilaterally to the ischiopubic rami. **C,** Same view with the perineal membrane removed to illustrate its relation to the compressor urethra and anterior portion of the levator ani. **D,** Left lateral supine view of structures with pubic bone removed to illustrate parallel nature of levator ani to the ventral perineal membrane and the dorsal fusion (DF) of these structures.

B, bladder, *brown*; *CC*, clitoral crus, *dark pink*; *CU*, compressor urethra; *EAS*, external anal sphincter, *dark red*; *LA*, levator ani, *red*; *P*, pubic bone, *white*; *PB*, perineal body, *dark blue*; *PM*, perineal membrane, *turquoise*; *PPM*, puboperineal muscle; *U*, uterus; *V*, vagina, *light pink*; *VB*, vestibular bulb, *dark pink*. ©DeLancey 2008.
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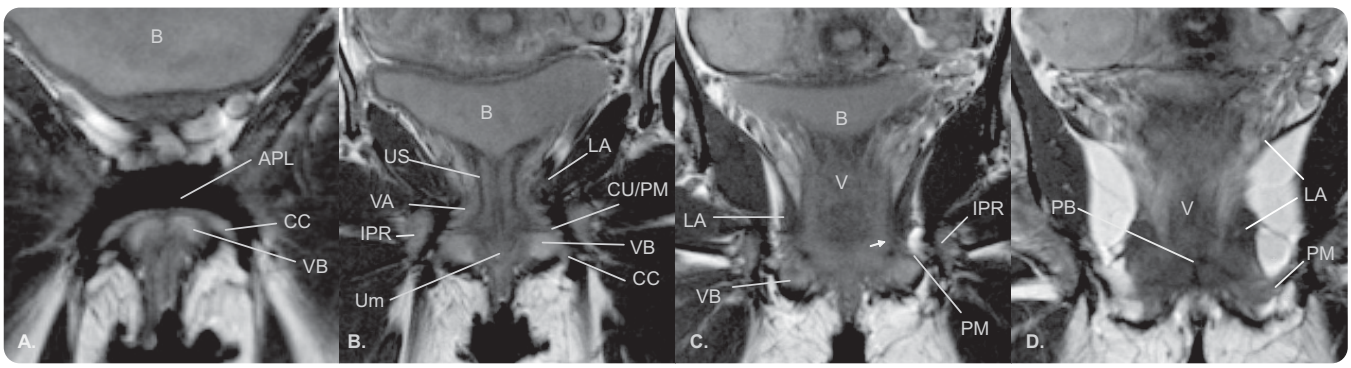
women. The imaging planes were angled in both the axial and coronal planes to better demonstrate the anatomy when necessary.

When plane adjustment was needed, the axial plane was along the pelvic floor from the inferior pubic symphysis to the external anus. The coronal plane was angled midway between the standard coronal and an orthogonal plane from the study axial plane. The sagittal was a straight sagittal plane through the midline. The location of known attachment points, structural connections, and anatomical relationships from previous cadaver studies were sought and qualitatively evaluated in each plane. The authors reviewed the images together and agreed on the planes best able to demonstrate the relationships seen at the cadaver studies.

A 3-D model was generated to better visualize the anatomical relationships of the perineal membrane utilizing a subject's original axial, sagittal, and coronal Digital Imaging and Communications in Medicine (DICOM) images. Using 3-D Slicer imaging software (v 2.1b1; Brigham and Women's Hospital, Boston, MA), the static images were aligned using bony landmarks. Anatomical structures bounding the perineal membrane were outlined in the best-visualized plane. These tracings were then combined to create the 3-D model. Structure tracings and 3-D models were reviewed by the senior author, and accuracy assured by confirming the fidelity of the model to previous experience with dissection and cross-sectional anatomical studies.

FIGURE 2



Proton density MR image in the coronal plane of a nullipara showing anatomic relationships from the level of the arcuate pubic ligament (APL) **A,** ventrally to the **D,** perineal body dorsally.

APL, arcuate pubic ligament; *B*, bladder; *CC*, clitoral crus; *CU*, compressor urethra; *IPR*, ischiopubic ramus; *LA*, levator ani muscles; *PB*, perineal body; *PM*, perineal membrane (*arrowhead*); *Um*, external urethral meatus; *US*, striated urogenital sphincter muscle; *V*, vagina; *VA*, vascular anastomosis between the pudendal and periurethral vessels; *VB*, vestibular bulbs. ©DeLancey 2008.
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