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Pelvic floor anatomy and imaging

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A B S T R A C T

The pelvic floor is a complex, three-dimensional mechanical apparatus that consists of several components: the pelvic organs and endopelvic fascia, the ligament and perineal membrane, the levator ani muscles and superficial perineal muscles, and the pelvic nerves. The support for the pelvic organs comes from connections to the bony pelvis and its attached muscles. Any damage to the structural and functional interactions of the pelvic floor elements can potentially cause multicompartmental dysfunction. Surgical management of pelvic floor disorders depends on a comprehensive understanding of the structural integrity and function of the pelvic floor. As a result of technological progress, dedicated imaging modalities including static and dynamic 3D and 4D transvaginal, endoanal and transperineal ultrasound, dynamic Magnetic Resonance, and evacuation proctography have been introduced. The "integrated" use of these techniques provides outstanding visualization of the anatomy of the pelvic floor, allowing for accurate assessment of the major disorders—urinary and fecal incontinence, pelvic organ prolapse, and obstructed defecation syndrome.

Introduction

The pelvic floor is a complex, three-dimensional (3D) mechanical apparatus that has been artificially divided into three different regions (anterior, middle, and posterior compartments). In this article, the term "pelvic floor" is used broadly to include all the structures supporting the pelvic cavity rather than the restricted use of this term to refer to the levator ani group of muscles.

The pelvic floor consists of several components lying between the peritoneum and the vulvar skin. From above downwards, these are the peritoneum, pelvic viscera and endopelvic fascia, levator ani muscles, perineal membrane, and superficial genital muscles. The support for all these structures comes from connections to the bony pelvis and its attached muscles. The pelvic organs are often thought of as being supported by the pelvic floor, but in reality form part of it. The pelvic viscera play an important role in forming the pelvic floor through their connections with structures, such as the cardinal and uterosacral ligaments and are attached to the levator ani muscles when they pass through the urogenital hiatus. As a consequence, any dysfunction of the structural and functional interactions of the pelvic floor elements can potentially cause a multicompartmental disorder.[1] Although patients may present with symptoms (urinary incontinence, voiding dysfuntion, fecal incontinence, obstructed defecation, and dyssynergy) that involve only one compartment, 95% of these have abnormalities in all three compartments.[2] Therefore, the specialist (urologist, gynecologist, gastroenterologist, colorectal surgeon, or physical therapist) needs to appreciate that as pelvic floor disorders rarely occur in isolation, evaluation and surgery can impact on the function of the neighboring compartment.[3,4]

Diagnostic evaluation has a fundamental role to identify all pelvic floor disorders and to provide comprehensive information for a management that encompasses the consequences of therapy on adjacent organs and avoid sequential surgery. The increasing availability of ultrasound equipment in the clinical setting, and the recent development of 3D and 4D ultrasound, have renewed interest in using this modality to image pelvic floor anatomy as a key to understanding dysfunction.[5] The "integrated approach," by using a combination of different modalities (endovaginal ultrasound—EVUS, endoanal ultrasound—EAUS, and transperineal ultrasound—TPUS) provides a comprehensive evaluation of this region.[5] In this article, we will also present the advantages and limitations of other imaging modalities such as evacuation proctography and dynamic magnetic resonance imaging (MRI).

Pelvic floor anatomy

The pelvic organ support system includes the endopelvic fascia, the perineal membrane, and the levator ani muscles that are controlled by the central and peripheral nervous system. The supports of the uterus and vagina are different in different regions.

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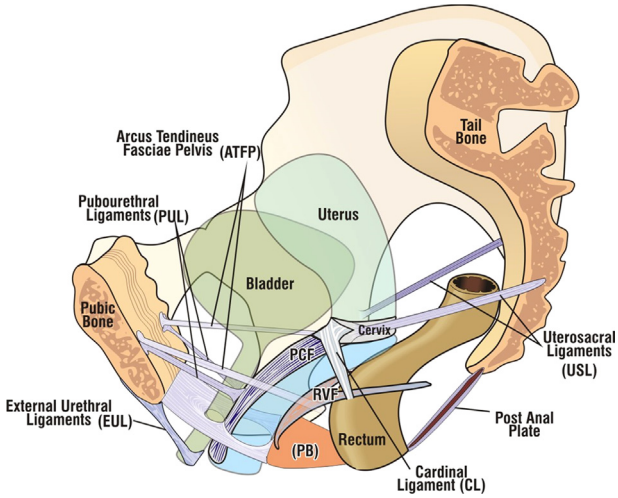

Fig. 1. Levels of vaginal support according to DeLancey. In level I (suspension) the uterosacral and cardinal ligaments suspend the vagina from the lateral pelvic walls. In level II (attachment) the vagina is attached to the arcus tendineus fasciae pelvis and the superior fascia of levator ani by the pubocervical (PCF) and rectovaginal fascia (RVF). In level III (distal support) the vagina is attached directly to the perineal body (PB) and the perineal mambrane.

According to DeLancey,[6] the cervix and the upper one-third of the vagina (level I) have relatively long suspensory fibers (uterosacral and cardinal ligaments) that are vertically oriented in the standing position, while the mid portion of the vagina (level II) has a more direct attachment (pubocervical and rectovaginal fascia) laterally to the pelvic wall. In the most caudal region (level III), the vagina is attached directly to the structures that surround it (Fig. 1). At this level, the levator ani muscles and the perineal membrane have important supportive functions.

In the upper part of the genital tract, a connective tissue complex attaches all the pelvic viscera to the pelvic sidewall. This endopelvic fascia forms a continuous sheet-like mesentery, extending from the uterine artery at its cephalic margin to the point at which the vagina fuses with the levator ani muscles below. The uterosacral and cardinal ligaments together support the uterus and upper one-third of the vagina.[6] At level II, the pubocervical and rectovaginal fascia form more direct lateral attachments of the mid portion of the vagina to the pelvic walls. These lateral attachments stretch the vagina transversely between the bladder and the rectum.[6] In the distal vagina (level III), the vaginal wall is directly attached to surrounding structures. Anteriorly, the vagina fuses with the urethra, posteriorly with the perineal body, and laterally with the levator ani muscles.[6] Damage to level I support can result in uterine or vaginal prolapse of the apical segment. Damage to the level II and III portions of vaginal support results in anterior and posterior vaginal wall prolapse.[3,4] The varying combinations of these defects are responsible for the diversity of clinically encountered problems and will be discussed in the following sections.

Apical segment

In level I, the cardinal and uterosacral ligaments attach the cervix and the upper one-third of the vagina to the pelvic walls (Fig. 2). The uterosacral ligaments are bands of tissue running under the rectovaginal peritoneum composed of smooth muscle, loose and dense connective tissue, blood vessels, nerves, and lymphatics.[6] They originate from the posterolateral aspect of the cervix at the level of the internal cervical os and from the lateral vaginal fornix. The cardinal ligament is a mass of retroperitoneal areolar connective tissue in which blood vessels predominate; it also contains nerves and lymphatic channels. When placed under tension, it assumes the appearance of a strong cable as the fibers align along the lines of tension. It originates from the pelvic sidewall and inserts on the uterus, cervix, and upper one-third of the vagina. Both the uterosacral and cardinal ligaments are critical components of level I support and provide support for the vaginal apex following hysterectomy[6] (Fig. 2). The cardinal ligaments are oriented in a relatively vertical axis (in the standing posture) while the uterosacral ligaments are more dorsal in their orientation.

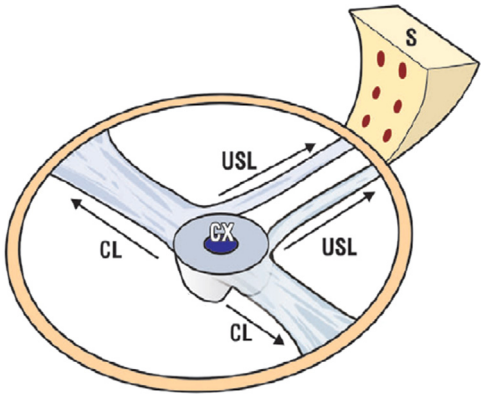

Fig. 2. Uterosacral ligaments (USL) extend both vertically and also posteriorly toward the sacrum (S). Cardinal ligaments (CL) suspend the cervix (CX) from the lateral pelvic walls.

The suspensory ligaments hold the uterus in position over the levator muscles that in turn reduce the tension on the ligaments and protect them from excessive tension.[7] After a certain amount of descent, the level I supports become taut and arrest further cervical descent. Damage to the upper suspensory fibers allows uterine or apical segment to prolapse.[8]

Anterior compartment

Anterior compartment support depends on the connections of the vagina and periurethral tissues to the muscles and fascia of the pelvic wall via the arcus tendineus fascia pelvis. On both sides of the pelvis, the arcus tendineus fascia pelvis is a band of connective tissue attached at one end to the pubic bone and at the other end to the ischium, just above the spine.

The anterior wall fascial attachments to the arcus tendineus fascia pelvis is also defined as paravaginal fascial attachments. Anterior vaginal wall prolapse (cystocele) can occur either because of “lateral detachment” of the anterior vaginal wall at the pelvic sidewall or as a “central failure” of the vaginal wall itself[9] (Fig. 3). However, if the cardinal and uterosacral ligaments fail, the upper vaginal wall prolapses downward while the lower vagina (levels II and III) remains supported.

Perineal membrane (urogenital diaphragm)

The “perineal membrane” is a dense connective tissue that surround the urethra and close the anterior part of the pelvic outlet. It lies at the level of the hymen and attaches the urethra, vagina, and perineal body to the ischiopubic rami.[10] The compressor urethrae and urethrovaginal sphincter muscles are associated with the cranial surface of the perineal membrane.

Posterior compartment and anal sphincters

The posterior vagina is supported by connections between the vagina, the bony pelvis, and the levator ani muscles. The lower one-third of the vagina is fused with the perineal body (level III)