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REVIEW ARTICLE

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The role of puboprostatic and pubovesical ligaments in urinary incontinence: a systematic review

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ABSTRACT

The puboprostatic ligament (PPL) and pubovesical ligament (PVL) are critical anatomical structures that play a significant role in maintaining urinary continence by supporting the urethra and bladder neck. Despite their well-documented functions, the impact of preserving or reconstructing these ligaments during surgical procedures, particularly radical prostatectomy, on continence outcomes remains underexplored. This systematic review synthesizes current evidence on the anatomy, function, and clinical implications of the PPL and PVL. A comprehensive literature search was conducted in PubMed following PRISMA guidelines, selecting studies related to the anatomical characteristics, functional roles, and clinical management of these ligaments. Anatomical studies consistently highlight the structural

complexity and supportive roles of the PPL and PVL in maintaining urethral and bladder neck positioning, which are essential for continence. Functional studies on the other hand further explain their involvement in the urethral closure process while clinical evidence demonstrates that sparing or reconstructing these ligaments during radical prostatectomy significantly improves both early and long-term continence outcomes, suggesting that their preservation is crucial for enhancing postoperative continence recovery. The findings emphasize the importance of these ligaments in continence mechanisms and advocate for their consideration in future surgical innovations. Further research is needed to refine surgical techniques and to better understand the biomechanical properties of these ligaments to optimize patient outcomes.
Keywords: pubovesical ligament, puboprostatic ligament, urinary tract, urological surgical procedures

INTRODUCTION

The development of the puboprostatic ligament (PPL) or pubovesical ligament (PVL) begins early in fetal life, with significant implications for their structure and function in adult males and females [12]. In both male and female fetuses, a condensed mesenchyme layer forms around the bladder at nine weeks, which later develops into the puboprostatic or pubovesical ligaments. By 13–14 weeks this differentiates into dense connective tissue that becomes continuous with the earliest forms of the PVL or PPL [12]. In males, the connective tissue surrounding the prostate begins to condense, and the ventral part of the prostate capsule connects to the puboprostatic ligament, which then anchors to the superior ramus of the pubis [1]. In females, the mesenchyme surrounding the urethra starts differentiating into dense connective tissue around nine weeks before covering the bladder neck and urethra as the pubovesical ligament [21, 26].

The puboprostatic and pubovesical ligaments play a crucial role in the maintenance of urinary continence by providing support to the urethra and bladder neck in men and women, respectively. The pubovesical ligament in females extends from the neck of the bladder to the inferior aspect of the pubis, anchoring the bladder in position while maintaining urethral stability [7, 8, 35]. In males, the puboprostatic ligament connects the anterior part of the prostate to the pubic bone, providing similar structural support to the bladder neck and urethra [4]. The puboprostatic and pubovesical ligaments serve as critical stabilizing structures for pelvic organs, with their medial and lateral components providing robust support to the bladder and prostate.

These ligaments exhibit considerable anatomical variability, which poses unique challenges in surgical procedures. Given the structural complexity and variability of these ligaments, surgical procedures such as prostatectomy should carefully navigate these anatomical differences to minimize damage and preserve urinary continence. Understanding the precise role of these ligaments in continence mechanisms is crucial for optimizing surgical outcomes.

Clinically, the preservation or reconstruction of the puboprostatic and pubovesical ligaments during procedures like prostatectomy has been shown to significantly improve continence outcomes. Research shows that sparing these ligaments can improve urinary function recovery after surgery. Understanding their functional aspects requires exploring how these ligaments work with surrounding muscles and tissues to maintain continence under different physiological conditions

Functional analyses have revealed the role of these ligaments in the mechanism of urinary continence. For instance, Petros and Abendstein [30], and Roch et al. [36] described the involvement of the levator ani muscle and its interaction with the ligaments in maintaining urethral closure during periods of increased intra-abdominal pressure, such as during coughing or lifting. Anatomical studies such as those by Huri et al. [14], where an in-depth cadaveric study was conducted to map the distribution of nerve fibers and fascia surrounding the prostate, particularly in the prostatic and periprostatic regions. The study utilized fresh cadaveric specimens to explore the precise localization of neural pathways within the pelvic fascia, specifically targeting the puboprostatic ligament. Tissue samples taken from different clock positions around the prostate showed that nerve fibers were uniformly distributed across these regions, although the diameter of the nerve fibers varied significantly between different prostatic regions. This study emphasized that the puboprostatic ligaments not only serve a mechanical support function but are also closely related to the pelvic neural network, which is crucial for continence. The homogeneous distribution of nerves across the pelvic plexus, with a higher concentration at the caudal apex, implies that surgical intervention must consider these neural pathways to minimize postoperative incontinence. Additionally, Finley et al. [10] provided a detailed description of the dissection of the anterior prostatic fat pad, revealing its anatomical relationship with the puboprostatic ligaments. This study demonstrated that proper identification and preservation of the puboprostatic ligaments during prostate surgery is essential, as they contribute to the structural integrity of the urethra and bladder neck. The study also highlighted that damage to these ligaments could lead to the disruption of neural pathways associated with the pelvic plexus, potentially increasing the risk of urinary incontinence.

Anatomical studies have also highlighted the structural complexity and variability of these ligaments, further emphasizing their importance in surgical planning and execution [5, 41]. Petros and Abendstein [28, 29] detailed the biomechanical properties of the pubourethral ligaments, reinforcing their significance in the continence mechanism by aiding in stabilizing the urethra in its normal anatomic position in a horizontal position.

Clinically, the preservation or reconstruction of the puboprostatic and pubovesical ligaments during procedures such as prostatectomy has been shown to significantly enhance postoperative continence outcomes. Studies such as those by Poore et al. [31] and Ratanapornsompong et al. [33] demonstrate that techniques which spare these ligaments result in improved early and long-term continence rates, meaning that patients are less likely to experience urinary incontinence both shortly after surgery and in the longer term compared to those who undergo surgeries where these ligaments are not preserved. This is further supported by Deliveliotis et al. [9], who observed that sparing these ligaments during radical prostatectomy significantly reduces the incidence of postoperative incontinence. Similarly, novel surgical techniques aimed at reconstructing these ligaments have been developed to mitigate the adverse effects of prostatectomy on urinary continence, specifically targeting the prevention of post-surgical urinary leakage [40]. Both of these techniques have shown to reduce incontinence rates by significant margins, with studies reporting improvements in continence recovery time and overall continence rates postoperatively [15, 27, 40].

Despite their importance, there remains a lack of comprehensive understanding of the precise mechanisms by which these ligaments contribute to continence and how their preservation or reconstruction during surgical interventions impacts patient outcomes [5, 37]. Therefore, this paper aims to consolidate current evidence on the anatomical characteristics, functional significance, and clinical implications of these ligaments.

MATERIALS AND METHODS

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [22]. A comprehensive electronic literature search was performed using PubMed database. The search involved three independent searches on the database, after which the results were de-duplicated. The search terms used were “puboprostatic ligament”, “pubovesical ligament”, “puboprostatic ligament and urinary incontinence”, and “pubovesical ligament and urinary incontinence”. Additionally, backwards citation tracing of references within the retrieved articles was performed to identify additional relevant studies. There were no restrictions based on patient age, sex, or publication year in the search criteria.

Criteria for study selection

Studies were included if one of the publication conformed to one of the following criteria: (1) discussion of structure or function in the relevant anatomical locations, (2) anatomical description of “puboprostatic ligament” or “pubovesical ligament”, (3) urinary incontinence due to damage of “puboprostatic ligament” or “pubovesical ligament”, (4) discussion of the topic of preservation or dysfunction of “puboprostatic ligament” or “pubovesical ligament”, (5) discussion about “puboprostatic ligament” or “pubovesical ligament”. Studies were excluded if the publication met one of the following criteria: (1) search terms were only nominally discussed and did not provide relevant data, (2) not available in English, (3) not available in full text.

RESULTS

Study identification

A total of 144 articles were initially identified through the PubMed database search, including 4 articles found eligible for inclusion after manually searching citations within the gathered publications. Following the removal of duplicates and the application of the predefined inclusion and exclusion criteria, 48 articles remained for screening. Out of these, 43 publications met the eligibility criteria and were included in the final systematic review (Fig. 1).

Characteristics of included studies

The included studies varied in design and methodology, reflecting the multidisciplinary nature of research on the role of the puboprostatic and pubovesical ligaments in continence. The study types used for this review are as follows: cadaveric studies, randomized trials, case series, human specimen studies, finite element analysis, meta-analyses, observational trials. Further details can be found in Table 1.

Data were extracted from the included studies regarding the anatomical, histological, and clinical aspects of the puboprostatic and pubovesical ligaments. The extracted data were then synthesized to provide a comprehensive overview of the roles of these ligaments in urinary continence and their implications for surgical practice.

Prevalence of morphological types of puboprostatic ligament

The morphological variations of the puboprostatic ligament (PPL) were documented in two key studies, revealing distinct patterns categorized into λ-shape, I-shape, Y-shape, and other irregular shapes. Kim et al., 2014 [18] examined a total of 62 puboprostatic ligaments. Among these, 31% were classified as λ-shape, 27% as I-shape, 11% as Y-shape, and 28% fell under the "other" category. Choi et al.(4), 2019, with a larger sample size of 315 ligaments, reported 30% as λ-shape, 19% as I-shape, 11% as Y-shape, and 34% as other morphological variations. Figure 4 illustrates this classification. When aggregated across studies, the overall prevalence rates were approximately 29.98% for the λ-shape, 20.4% for the I-shape, 11.1% for the Y-shape, and 33.2% for other irregular shapes.

Ligament morphology

These findings illustrate a significant degree of variability in PPL morphology, emphasizing its complexity and potential clinical implications for urinary continence mechanisms.

Both the puboprostatic ligament (in males) and the pubo-vesical ligament (in females) exhibit notable morphological variations, with some specimens demonstrating what has been termed an “irregular” type. This irregular type is characterized by a heterogeneous arrangement of collagen fibers, variable thickness, and non-uniform insertions into the pubic symphysis and adjacent urogenital structures. Such variability in structure may contribute to differences in biomechanical properties and functional roles, particularly in maintaining urinary continence. Recognizing these morphological differences is essential for clinicians and researchers, as they provide insight into the anatomical underpinnings of urinary incontinence and related pelvic disorders [4, 18].

DISCUSSION

Puboprostatic ligament (PPL)

In males, the anterior prostate has the most secure attachments to the pubis, offering substantial support to the proximal urethra, which contains the external urethral sphincter for voluntary voiding of urine [1, 12]. The posterior support structures, including Denonvilliers' fascia, median fibrous raphe, and central tendon of the perineum, also contribute to a musculofascial suspension system capable of contraction [34]. The integration of these support structures, both posterior and anterior, forms a comprehensive system that maintains urinary continence. Considerable variability can be found with PPLs. Choi et al. [4] observed significant variability in the number of PPLs per hemipelvis, with most cadavers presenting a single PPL bilaterally (61.3%), while others exhibited double PPLs bilaterally (19.4%) or mixed configurations (19.4%). These PPLs were further categorized into four distinct shapes: I-shape, λ-shape, Y-shape, and irregular shape. The I-shape was the most prevalent, accounting for 53.8% of PPLs, followed by the λ-shape (36.2%), Y-shape (8.8%), and irregular shapes (1.2%). Kim et al. [18] also observed similar variability, with the Lambda shape accounting for 31% and the I-shape 27% of puboprostatic ligaments. This diversity in PPL shape and thickness highlights the significant anatomical variations that can exist between individuals and must be taken into consideration, particularly during pelvic surgeries aimed at preserving continence. Functionally, it is currently not clear whether the PPL shares the contractile qualities with the PVL. Predicated on extant literature findings, the current review was not able to determine whether puboprostatic ligaments contain any smooth muscle. More studies are needed to determine whether the PPL possesses contractile qualities like its female counterpart or whether its primary function is to fix the prostate to pubis [18]. Figure 2 illustrates the puboprostatic ligament and its attachments.

Pubovesical ligament (PVL)

Although thinner and appearing with less morphological variety than the puboprostatic ligaments in males, the pubovesical ligaments provide support to the bladder and urethra and therefore are crucial for maintaining the urethral stability during periods of increased intra-abdominal pressure [19]. The pubovesical ligaments have been identified as extensions of the detrusor muscle and its adventitia that attach to the pubic bone and arcus tendinous fascia pelvis. Positioned around the proximal urethra & vesical neck attaching to the pelvic walls, some authors suggest that the anatomical position of the PVL indicates that it contracts to assist in vesical neck opening during micturition while the pubourethral ligaments aid in urethral support [7, 8]. Figure 3 illustrates the pubovesical ligament and its attachments.

Although some studies have noted variations in the morphology of the pubovesical ligament (PVL), these findings are not widely documented or well represented in the current literature. Furthermore, unlike the puboprostatic ligament (PPL), no classification system has been established to categorize these variations. Further anatomical investigation is warranted to systematically characterize these differences, improving both understanding and representation in the literature

Although DeLancey [7] suggests that the PVLs contain smooth muscle fibers and are therefore distinct from the pubourethral ligaments, subsequent literature maintains that the pubovesical and puboprostatic ligaments (PVL and PPL) are primarily structural components that aid in continence by providing passive support, with no significant contractile abilities. Hudolin et al. [13] emphasize that post-surgical continence recovery relies on muscle strengthening rather than ligament function, highlighting their passive role. Similarly, Pacik et al. [28] and Muctar et al. [24] describe these ligaments as stabilizing structures for the urethra and bladder, drawing parallels between male and female anatomy without suggesting contractile functions Noguchi et al. [25] confirm that preserving the PPL aids in early continence recovery post-prostatectomy, emphasizing its structural role without evidence of contractile involvement. Together, these studies illustrate that the PVL and PPL are essential in maintaining continence through stabilization rather than active contraction.

However, some studies propose that the PVL and PPL, though primarily structural, may have a minor contractile component. For instance, Ito et al. [16] suggests that the PVL could contribute to dynamic urethral positioning during micturition. Similarly, studies like Hudolin et al. [13] highlight the importance of preserving ligamentous structures for optimal continence, indirectly implying their active role in the continence mechanism.

Clinical implications

Preserving the puboprostatic and pubovesical ligaments during surgical procedures has profound clinical implications, particularly in the context of improving continence outcomes post-prostatectomy. Katz et al. [12] emphasized the importance of ligament sparing during radical prostatectomy, as it was found to significantly reduce the incidence of urinary incontinence.

Their study demonstrated that patients who underwent surgeries with ligament preservation had higher rates of continence recovery.

Similarly, another study showed that sparing or reconstructing the puboprostatic ligaments during surgery resulted in better long-term continence outcomes [3]. In their randomized controlled trial, patients who had ligament-sparing prostatectomies were less likely to experience both early and late urinary incontinence, demonstrating the importance of these ligaments in maintaining pelvic floor function. Some studies took this a step further by presenting a new pubovesical complex-sparing technique during robotic-assisted laparoscopic prostatectomies [2, 40]. This technique not only preserved the ligaments but also focused on maintaining neurovascular integrity, further improving continence outcomes. These findings suggest that reconstructive and ligament-sparing approaches should be prioritized to optimize postoperative recovery.

Other researchers added to these findings by advocating for the use of posterior musculofascial plate reconstruction to enhance continence recovery [16]. They demonstrated that reconstructing these ligaments provided additional support to the bladder neck and urethra, leading to improved continence outcomes in patients undergoing prostate surgery.

Urinary continence mechanism and clinical applications

Urinary continence is maintained through complex, multifactorial mechanisms that involve both structural support and dynamic contractile elements [39, 40]. Any disruption to these elements, whether through surgical procedures, trauma, or degenerative changes, can lead to incontinence [37]. Therefore, understanding the intricate relationships between these structures and their roles in continence is essential for developing effective surgical techniques and interventions aimed at preserving or restoring continence. As seen in the study by Huri et al. [14], where the pelvic plexus was mapped in fresh cadaveric settings, essential information was provided on the neural distribution in relation to puboprostatic ligaments, highlighting the importance of preserving these structures during prostate surgery to prevent incontinence.

Clinically, the preservation or reconstruction of the puboprostatic and pubovesical ligaments during procedures such as prostatectomy has been shown to significantly enhance postoperative continence outcomes [33]. Kaggwa and Galukande [17] observed that sparing the puboprostatic ligament during open retropubic radical prostatectomy resulted in faster continence recovery in

79% of patients within three months post-surgery. Similarly, Daouacher and Waldén [6] reported that reconstructing the posterior aspect of the rhabdo-sphincter and preserving the puboprostatic collar led to improved continence outcomes after laparoscopic radical prostatectomy.

Knowing the morphology of the puboprostatic ligament (PPL) is critical before conducting interventional procedures [43]. Due to PPL's intimate relationship with the prostate and urethra, post-operative side effects from retropubic radical prostatectomy may include urinary incontinence and erectile dysfunction [26]. As far back as 1905, Hugh Young described the function and importance of the PPL in relation to conserving urinary continence after radical retropubic prostatectomy [43]. More recent puboprostatic-sparing prostatectomies preserve the maximum available urethral length and the anterior support structures, which can lead to an earlier return of continence [4, 32].

CONCLUSIONS

The clinical evidence presented in this study highlights the importance of both preserving and reconstructing the puboprostatic and pubovesical ligaments to improve urinary continence outcomes post-surgery. These ligaments are essential for maintaining the anatomical and functional integrity of the pelvic floor, and surgical techniques that take their variability into account result in better postoperative recovery. As future research continues to explore the biomechanics and reconstructive possibilities of these ligaments, their role in improving continence outcomes will remain a critical focus of urological surgical practice. Preserving these ligaments enhances postoperative continence recovery, and future surgical innovations should focus on their functional importance. The anatomical integrity and functional preservation of these ligaments should be prioritized in surgical interventions to mitigate the risk of postoperative incontinence and improve overall patient quality of life.

ARTICLE INFORMATION AND DECLARATIONS

Author contributions

Writing — original draft preparation: SC, YS. Writing — reviewing and editing: SC, YS, MJM, ML.

Ethics statement

Figures presented in this article were created by Courtney Brendal for the authors. Figures were created and rendered in Adobe Photoshop and Adobe Illustrator [© CC-BY-ND 2025 Courtney Brendal MA]. Adobe Photoshop and Adobe Illustrator are either registered trademarks or trademarks of Adobe in the United States and/or other countries.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Table 1. Categorization of articles included in the systematic review.

Category	Number of articles included
Cadaveric studies	17
Case series	2
Randomized trials	3
Observational trials	5
Nonrandomized trials	1
Human specimens	8
Meta-analysis	2
Finite element analysis	5

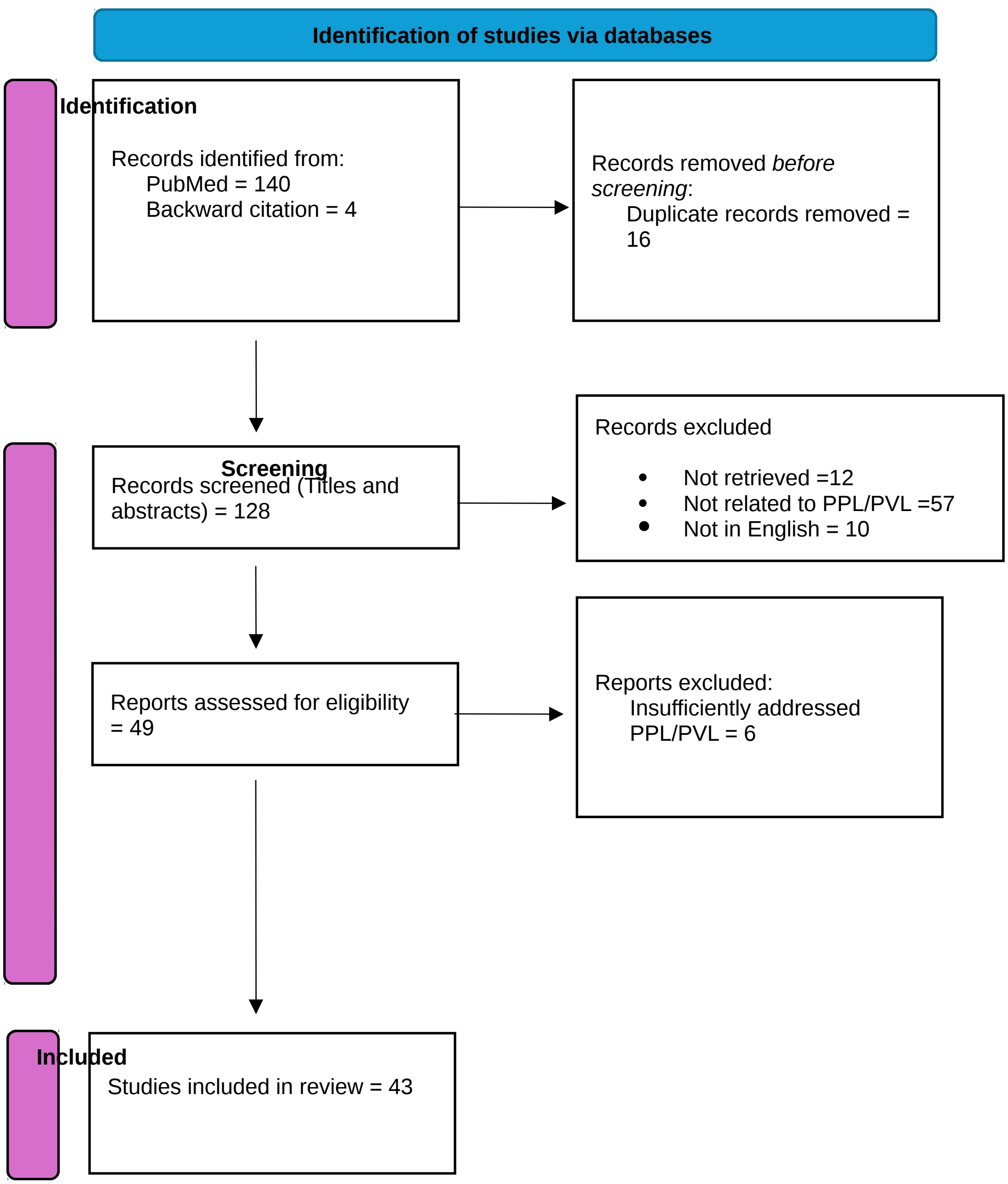

Figure 1. PRISMA flowchart showing the breakdown of the identification and screening process during the literature search. The chart illustrates the number of records identified, screened, excluded, and included in the systematic review, providing a clear overview of the study selection process. This original illustration was created by Courtney Brendal for the authors. This image was created and rendered in Adobe Photoshop and Adobe Illustrator [© CC-BY-ND 2025 Courtney Brendal MA].

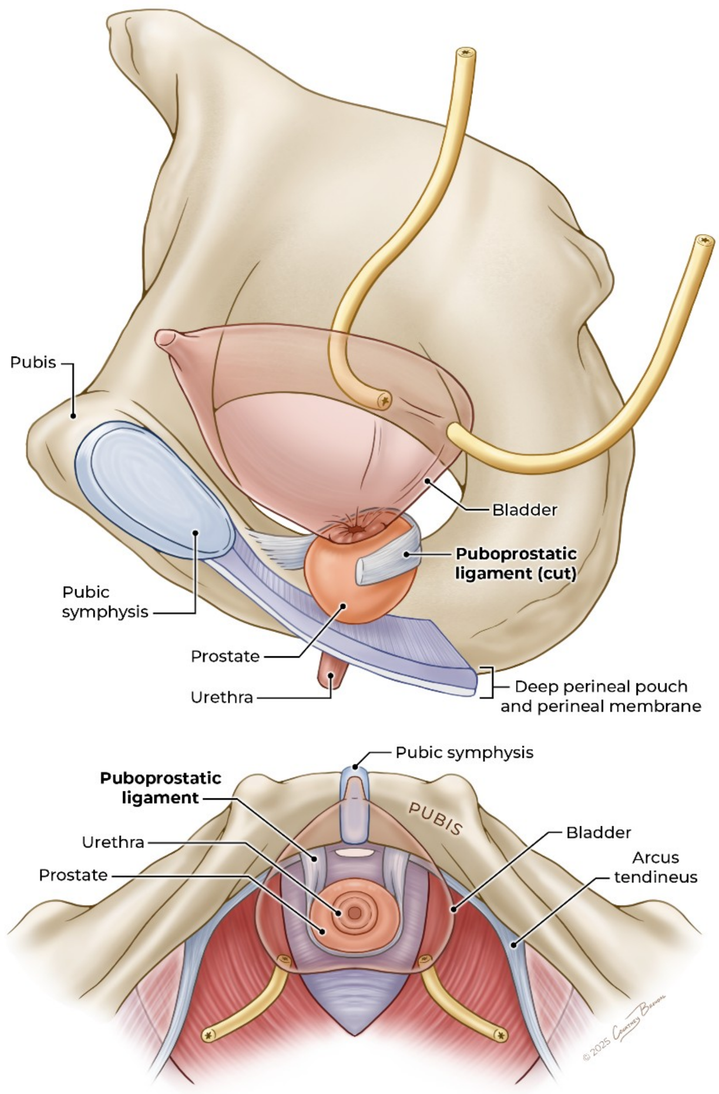

Figure 2. Illustration of the puboprostatic ligament. This figure depicts the anatomical structure and positioning of the puboprostatic ligament, highlighting its supportive role in maintaining the position of the prostate and urethra. The illustration demonstrates how the ligament anchors the prostate to the pubic bone, contributing to the stability and function of the pelvic floor. This original illustration was created by Courtney Brendal for the authors. This image was created and rendered in Adobe Photoshop and Adobe Illustrator [© CC-BY-ND 2025 Courtney Brendal MA].

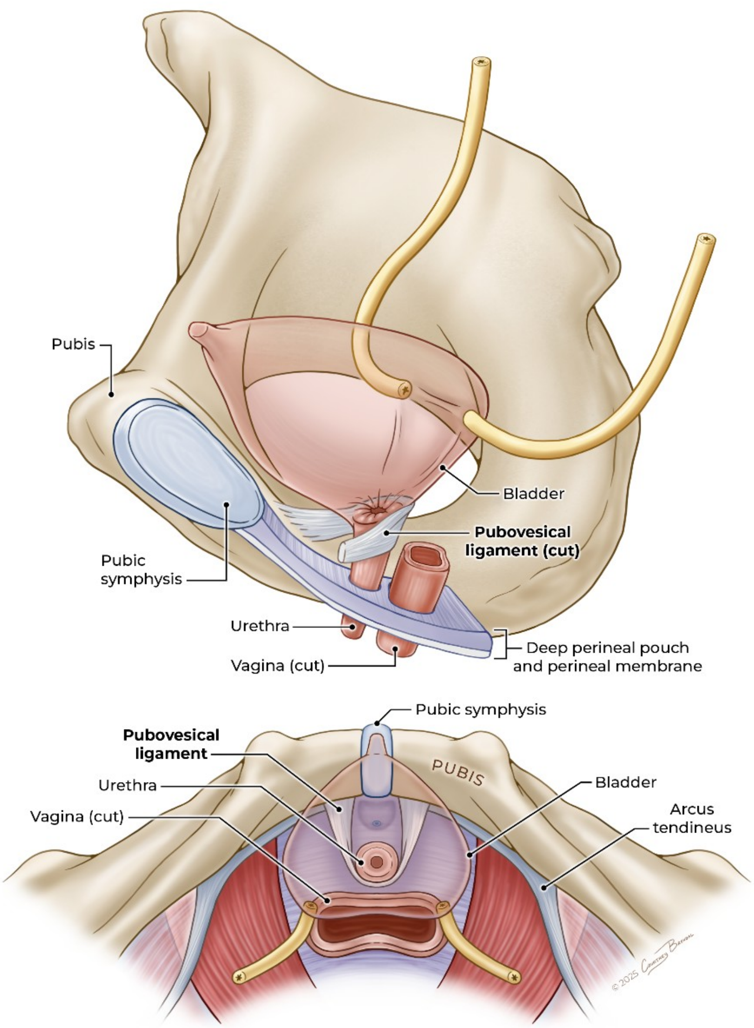

Figure 3. Illustration of the pubovesical ligament. This figure illustrates the pubovesical ligament, emphasizing its anatomical structure and its role in supporting the bladder and urethra. The ligament's connection between the bladder neck and the pubic bone is shown, emphasizing its importance in maintaining bladder positioning and contributing to urinary continence mechanisms.

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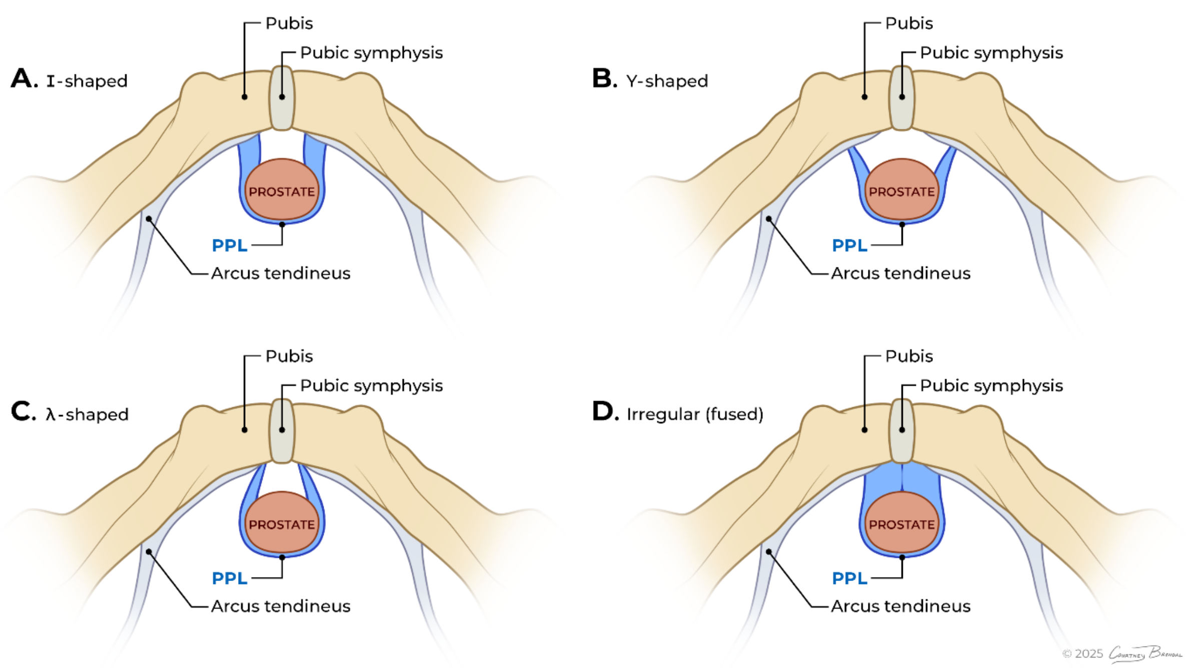

Figure 4. Illustration of morphological variations of the puboprostatic ligament (PPL): This figure depicts the four primary morphological variations of the PPL as identified in anatomical studies. **A.** I-shaped: a straight, midline configuration. **B.** Y-shaped: bifurcating superiorly. **C.** λ-shaped: diverging at an angle resembling the Greek letter lambda. **D.** Irregular (fused): an atypical variant with fused or asymmetric features. This original illustration was created by Courtney Brendal for the authors. This image was created and rendered in Adobe Photoshop and Adobe Illustrator [© CC-BY-ND 2025 Courtney Brendal MA].