5. MALE TRIGONE - development

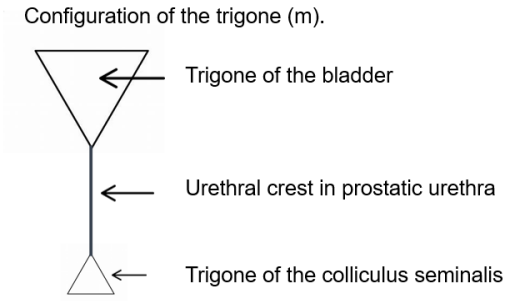
TERMINOLOGY:

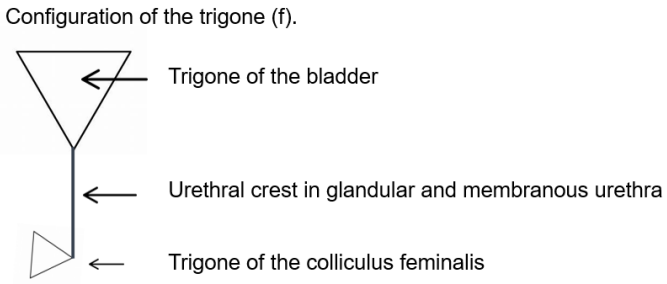
SEGMENTS OF THE VESICOURETHRAL CANAL (m):
Cranial segment: future urachal remnant, (median umbilical ligament)
Middle segment: future urinary bladder
Caudal segment: future prostatic urethra, colliculus seminalis, and the membranous urethra

Notes:
The vesicourethral canal is continuous with the definitive urogenital sinus (vestibule/urethra). Since the colliculus seminalis develops at the upper border of the membranous urethra, the membranous urethra functions as the pelvic part of the definitive urogenital sinus/vestibule/urethra.

PARTS OF THE TRIGONE: (m), (f).

a) Trigone of the bladder:
   base between ureteral orifices, (m), (f).
   a*pex* at upper end of urethral crest in the prostatic urethra. (m).
   apex at upper end of urethral crest in the glandular urethra (f).
b) Urethral crest:
   posterior wall of the prostatic urethra (m).
   posterior wall of the glandular urethra and membranous urethra (f).
c) Trigone of colliculus seminalis: (m). Trigone of colliculus feminalis (f).
   apex at lower end of urethral crest in the prostatic urethra (m).
   apex at lower end of urethral crest in the membranous urethra (f).
   base between openings of ejaculatory ducts (m).
   base between openings of Gartner's ducts (f).





Development of the male trigone:
The male trigone develops from *panels of mesoderm*, *anterior to the mesonephric ducts* and *posterior to the*
a) *trigonal section of the bladder segment of the vesicourethral canal.*
b) *prostatic urethral segment of the vesicourethral canal*.
c) *trigonal section of the sinus bulb (colliculus seminalis).*

The mesodermal panels that form the trigone:
The *mesodermal panels* can be divided into *three sections.*
a) The *bladder section* will form the *trigone of the bladder*.
b) The *prostatic section* will form the *urethral crest*.
c) The *collicular section* will form the *trigone of the colliculus seminalis.*

Incorporation of the mesodermal panels in the posterior wall of the vesicourethral canal, to form the trigone:
The mesodermal panels, form *vertical narrow rectangles*, *aligned side by side*, on either side of the midline.
The panels of mesoderm, insert into and become incorporated into, and become part of, the *posterior wall of the tubular vesicourethral canal, and posterior wall of the sinus bulb.*

The *sinus bulb* develops at the *upper border of the membranous urethral*, segment of the *vesicourethral canal.*

a) In the *middle or bladder segment of the vesicourethral canal*, the mesodermal panels insert in the *trigonal section of the bladder* and will form the *trigone of the bladder*.
b) In the *prostatic urethral segment of the vesicourethral canal*, the mesodermal panels insert in the *posterior wall of the prostatic urethra*, to form the *urethral crest of the prostatic urethra.*
c) In the *trigonal part of the sinus bulb*, the urethral plates, insert in the posterior wall of the sinus bulb and will form the trigone of the colliculus seminalis.

Ureteric buds attach to the lateral ends of the upper borders of the trigonal section of the mesodermal plates:
On each side, at the level of the upper border of the trigonal section of the mesodermal panels, the *mesonephric duct*, generates a ureteric bud. The ureteric bud is formed above the level of the opening of the ducts of the seminal vesicle.
The ureteric buds detach from the anteromedial aspect of the mesonephric ducts.
The ureteric buds are close to, or contact, the upper ends of the mesodermal plates.
The ureteric buds detach from the mesonephric ducts and attach to the lateral ends of the upper border, of the trigonal section of the mesodermal plates.
The *posterior walls of the ureteric buds* and the mesodermal plate to which they are attached, *insert into, and are incorporated in, the posterior wall of the trigone area of the bladder* section of the vesicourethral canal.
The ureteric buds develop a lumen which open in the bladder at the lateral ends of the upper borders of the mesodermal plates. The ureteric buds elongate in a cephalad direction, to form ureteric diverticula, the anlages of the ureters and collecting systems (pelvis, infundibula, and

minor calyces) of the ipsilateral kidney. The openings of the ureteric diverticula, become the *openings of the ureters*, (ureteral orifices), at both ends of the *upper borders of the mesodermal plates* in the trigone segment of the vesicourethral canal.

Development of the interureteric ridge and trigone of the bladder.

The *bladder segment of the vesicourethral canal* enlarges to become the *urinary bladder*. As the bladder expands, the upper borders of the mesodermal panels, widen, and the ureteral orifices move laterally.

The upper borders of the mesodermal panels, and openings of the ureteral orifices at both ends of the upper borders, form the *interureteric ridge*, which forms the base of the bladder trigone.

The posterior walls of the intravesical segments of the ureters and the trigone.

In development, the posterior walls of the ureteric buds, are in continuity with the upper borders of the mesoderm panels, in the trigone section of the vesicourethral canal.

The ureteric buds lengthen to form the *transmural and intravesical segments of the ureter*s.

The *posterior walls of the intravesical segments of the ureters*, rest on a *sheath of mesoderm, in continuity with trigone of the bladder.*

The posterior walls of the intravesical ureters, are incorporated and become an integral part of the posterior wall of the bladder, in continuity with the trigone of the bladder.

The lateral borders of the mesodermal plates in the bladder, merge caudally, to form the *apex of the trigone*. At the posterior border of the internal urethral orifice, the *apex of the trigone is continuous* with the upper ends of the narrow mesodermal plates in the posterior wall of the prostatic urethral segment of the vesicourethral canal.

Development of the urethral crest in the prostatic urethra:

The *narrow mesodermal panels* posterior to the prostatic urethral section of the vesicourethral canal, straddle the midline, anterior to the mesonephric (ejaculatory) ducts.

The mesodermal panels insert into and form a narrow vertical strip in the posterior wall of the prostatic urethra.

The mesodermal panels covered by epithelium differentiated from underlying mesoderm, form a raised fold called the *urethral crest* (verumontanum), in posterior midline of the prostatic urethra. The upper end of the urethral crest is continuous with the apex of the trigone in the bladder. The lower end of the urethral crest is continuous with the apex of the trigone of the colliculus seminalis.

Relation of mesonephric (ejaculatory) ducts to the urethral crest:

Caudal to ureteric buds, thin *ducts of the seminal vesicles* arise from the lateral aspects of the mesonephric ducts. At the junction of the ducts of the seminal vesicles, the *mesonephric ducts become the ejaculatory ducts.* The short ejaculatory ducts immediately enter the base of the prostate.

The ejaculatory ducts descend on either side of the midline, posterior to the urethral crest.

The course of the ejaculatory ducts in the prostate, may be distorted by proliferation of the prostatic glands at puberty, or benign prostatic hyperplasia (BPH) in older adults.

Development of the trigone of the colliculus seminalis:

Mesodermal panels:

Mesodermal panels develop anterior the mesonephric ducts and trigone section of the vesicourethral canal (trigone of the bladder), the prostatic urethral segment of the vesicourethral canal (urethral crest), and the trigone section of the sinus bulb (trigone of the colliculus seminalis.

The lower ends of the *mesodermal plates* insert and are incorporated into the *trigone part of the sinus bulb*, destined to become the *trigone of the colliculus seminalis*.

Sinus bulb:

The *sinus bulb* develops as a mesodermal projection in the *posterior wall of the primitive uro-genital sinus (UGS)*. It divides the UGS into the vesicourethral canal above and the definitive UGS/vestibule/urethra, below.

In males, the sinus bulb develops at the *upper border of the membranous* urethral segment of the vesicourethral canal. Therefore, the membranous urethra functions as the pelvic part of the definitive UGS/vestibule/urethra. The sinus bulb is covered by *epithelium (endoderm)* of the *vesicourethral canal.*

Mesonephric ducts:

The mesonephric (ejaculatory) ducts descend posterior to the mesodermal panels in the prostatic urethral segment of the vesicourethral canal. At the lower end of the prostatic urethral segment of the vesicourethral canal, the ejaculatory ducts enter the sinus tubercle. They travel through the sinus tubercle and develop tiny *openings at the lateral ends of the lower borders of the mesonephric panels*.

In the sinus tubercle, the mesonephric ducts diverge slightly from the midline, widening the inferior borders of the mesodermal panels, between the openings of the ejaculatory ducts.

The *ascending lateral borders* of the trigonal section of the sinus tubercle, converge towards the midline, where they are continuous with the lower end of the mesodermal panels in the posterior wall of the prostatic urethral segment of the vesicourethral canal.

Vagina masculinus:

The vagina masculinus develops by *cavitation of a cylindrical condensation of mesenchyme*, in the lower part of the sinus tubercle. The lower end of the vagina masculinus is closed by a diaphanous *double layered membrane* (hymen of the vagina masculinus). The inner layer is derived from mesoderm and the outer layer is derived from endoderm. A perforation forms the introitus of the vagina masculinus.

The sinus bulb is now the colliculus seminalis (CS).

The openings of the *ejaculatory ducts* are *superolateral to the* introitus of the vagina masculinus. The colliculus seminalis, arises from the upper border of the membranous urethra, and projects into the lower end of the prostatic urethra.

Trigone of the colliculus seminalis (CS):
The *base of the trigone of the CS*, is border between the openings of the ejaculatory ducts.
The *apex of the trigone of the CS* is continuous with the *lower end of the urethral crest in the lower end of the prostatic urethra.*
Epithelium covering the trigone of the CS, is differentiated from underlying *mesoderm.*
Epithelium of the remainder of the CS is epithelium (endoderm) of the definitive urogenital sinus/membranous urethral segment of the vestibule/urethra.

FORMATION OF THE TRIGONE IS COMPLETE:
The male trigone consists of the trigone of the bladder, the urethral crest in the prostatic urethra, and the trigone of the colliculus seminalis.
The *ureteral orifices* open at the *upper end of the trigone*.
The *ejaculatory ducts* open at *lower end of the trigone*.
Origin: Mesonephric panels anterior to the mesonephric ducts and posterior to vesicourethral canal and posterior to the sinus bulb.

Trigone of the bladder:
The *base* is formed by the interureteric ridge. The *apex* joins the urethral crest of the prostatic urethra, at the internal urethral orifice.

Trigone in the prostate:
Is the urethral crest. The upper end joins the apex of the trigone of the bladder. The lower end joins the apex of the trigone of the colliculus seminalis.

Trigone of the colliculus seminalis:
The base is mesoderm between the openings of the ejaculatory ducts. The apex joins the lower end of the urethral crest at the lower end of the prostatic urethra.

Mucosa of the trigone:
Epithelium of the trigone of the bladder, urethral crest, and trigone of the colliculus seminalis, differentiates from underlying *mesoderm*. Trigone epithelium may resemble urothelium, but may be stratified squamous.

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