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RETROSPECTIVE COMPARATIVE STUDY BETWEEN DUPLAY AND KOFF METHODS IN REPAIR OF ANTERIOR HYPOSPADIAS

(About 90 cases)

THESIS

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By

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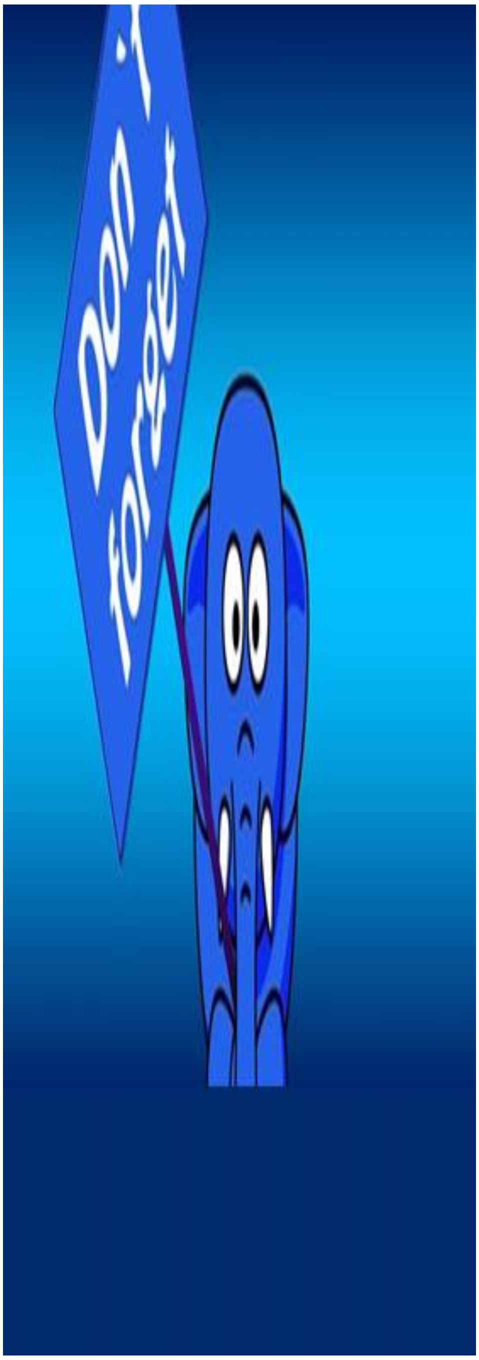
TABLE OF CONTENT

"A man who carries a cat by the tail learns something he can learn in no other way"

— ***Mark Twain***



LIST OF ABBREVIATIONS

"Being ignorant is not so much a shame, as being unwilling to learn"

– Benjamin Franklin

AT : Anesthesia Technique

AUA : Anterior Urethral Advancement

BF : Buck's Fascia

BS : Bulbo-Spongiosus muscle

CB : Caudal Block

CC : Corpora Cavernosa

CM : Cloacal Membrane

CS : Corpus Spongiosum

CSF : Cerebro-Spinal Fluid

DDV : Deep Dorsal Vein

DHT : Dihydrotestosterone

DN : Dorsal Nerves of the penis

DT : Dressing Type

EML : Ectopic Meatal Location

ETT : Endo-Tracheal Tube

GA : General Anesthesia

GD : Glans Dehiscence

GT : Genital Tubercle

HOSE : Hypospadias Objective Scoring Evaluation

HR : Hypospadias Repair

IC : Ischio-Cavernosus muscle

MEG : Male External Genitalia

MIP : Mega meatus Intact Prepuce

MS : Meatal Stenosis

OR : Operation Room

PB : Penile Block

PDD : Penile Developmental Disorder

PDS : Polydioxanone

PHS : Pre-operative Hormonal Stimulation

PN : Perineal Nerves

PO : Post-Operative

POA : Prophylactic Oral Antibiotics

PPPS : Pediatric Penile Perception Score

PR : Preputial Reconstruction

PT : Penile Torsion

PU : Penile Urethra

RCT : Randomized Clinical Trial

SB : Spinal Block

SD : Suture Disunion

SM : Suture Materials

SP : Surgical Procedure

SPD : SupraPubic Diversion

SPF : Superficial Perineal Fascia

SQ : Surgeons qualification

ST : Suturing Technique

TA : Tunica Albuginea

TIPU/TIP : Tubularized Incised Plate Urethroplasty

UCF : Urethro-Cutaneous Fistula

UD : NeoUrethral Dehiscence

UF : Urethral Folds

UG : Urethral Groove

UMA : Urethral Mobilization and Advancement

UP : Urethral Plate

UR : Urogenital Ridges

US : Urinary Stream

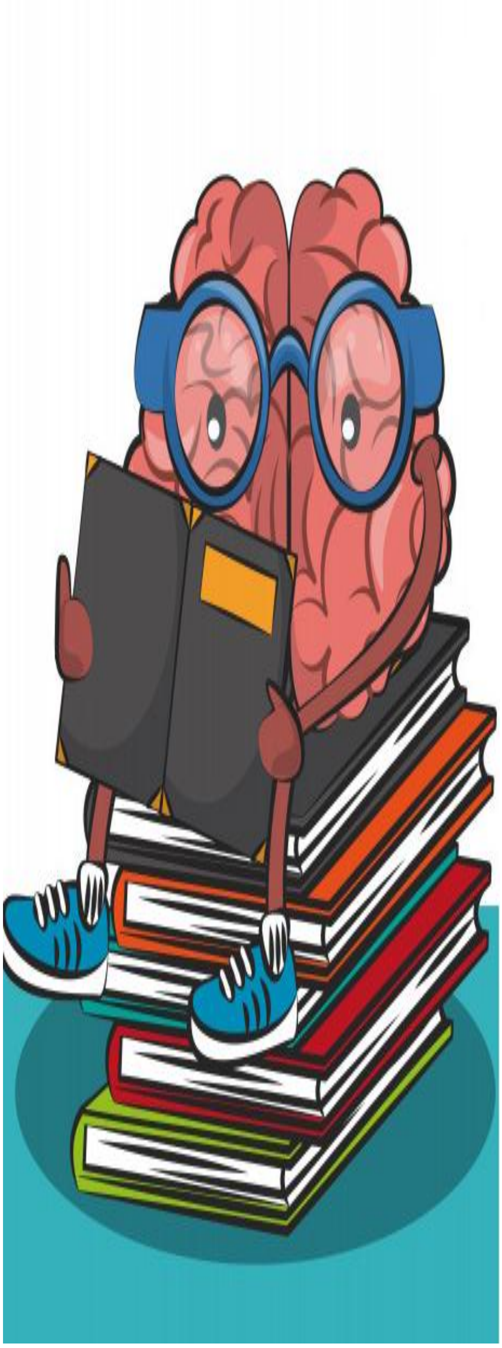
VPC : Ventral Penile Curvature

WD : Wound Dehiscence

ILLUSTRATIONS

"Learning is not attained by chance, it must be sought for with ardor and attended to with diligence"

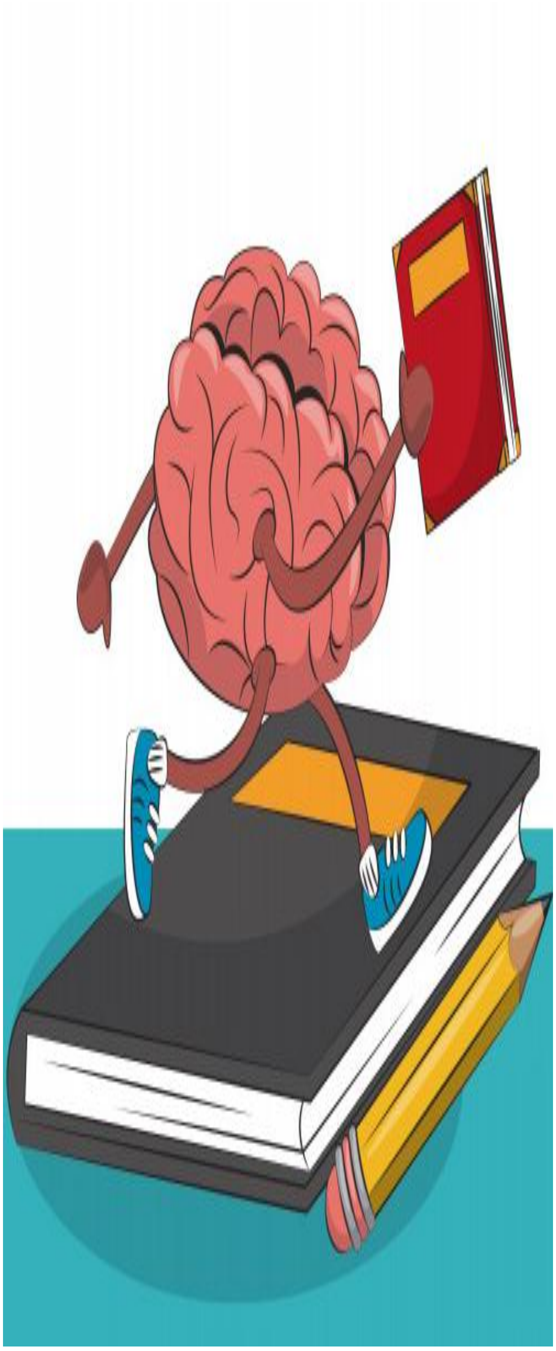
— *Abigail Adams*



LIST OF FIGURES

"Man's mind, once stretched by a new idea, never regains its original dimensions"

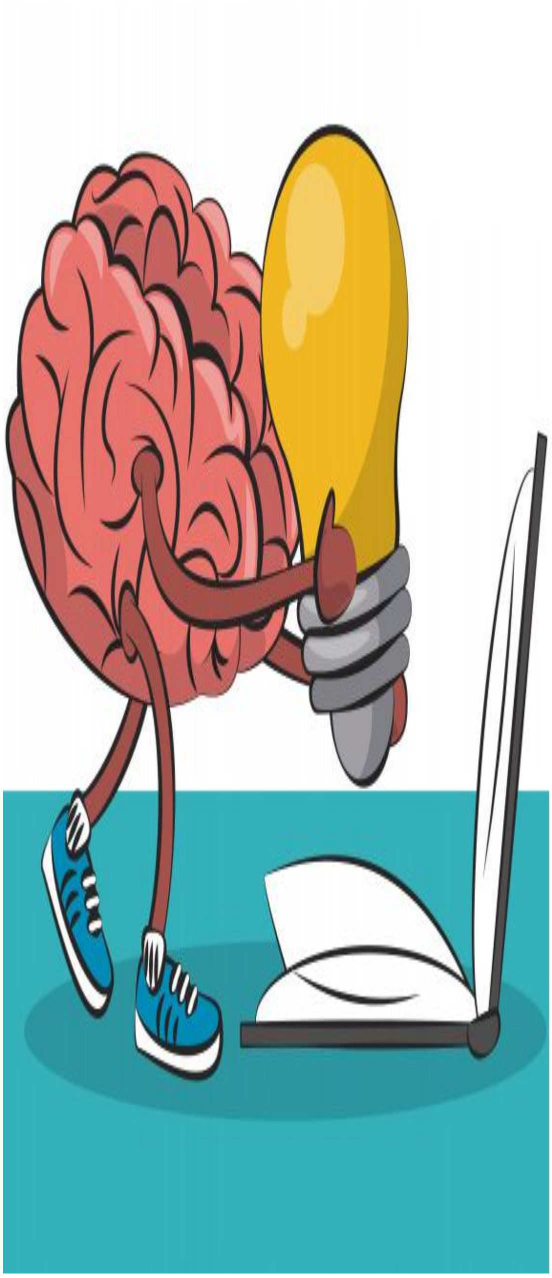
— Oliver Wendell Holmes



LIST OF TABLES

"An investment in knowledge pays the best interest"

— Benjamin Franklin



LIST OF CHARTS

"Always walk through life as if you have something new to learn and you will"

— Vernon Howard

INTRODUCTION

"A man is his penis"

-William Granzig

Hypospadias is the most common congenital malformation of the penis. Its prevalence has been estimated to range between **one per 200 to 300** live male births.

Hypospadias is a **penile developmental disorder** (**PDD**) in which the urethral meatus is in an abnormal position: at the penial **ventral surface**, mostly **distally** and mostly on the **glans** in **70% to 80%** of cases, as it may be on the **scrotum**, or even on the **perineum**, with or without the presence of **ventral penile curvature (VPC)**, or a **hoody prepuce.**[1]

Unfortunately, its surgical management remains controversial with **over 200** reported **surgical methods** for urethral reconstruction, some being merely modifications of modifications of original techniques. Justified with hopes of **minimizing complications** and improving functional and cosmetic results.

From a practical surgical perspective, experienced surgeons and after correcting the **VPC**, they classify the position of the ectopic urethral meatus and establish the most appropriate surgical technique. [2]

The surgical correction aims t

o **restore the penis** to the best possible **function** and **appearance**, by leaving the urethral meatus as close to the **normal position** as possible, with the supreme goal of enabling a **single and straight forward urinary flow** and **normal sexual intercourse**.

However, of the many surgical techniques that have been developed to correct **distal hypospadias** through a **single procedure** (one-step techniques or one-stage procedures), two main methods have particularly attracted our attention: the **Thiersch-Duplay** procedure and the **Koff** procedure.

The **Tubularized Plate Urethroplasty** (Thiersch-Duplay technique) is used in individuals with an appropriately **wide urethral plate (UP)** and a **deep glanular groove**.

It allows a terminal and vertically oriented slit-like meatus, associated with an appropriate diameter of the **neourethra**, obtained by simple **tubularization** of the urethral plate.[3]

The **Urethral Mobilization and Advancement** (Koff technique) is used in the presence of a **shallow glanular groove** or **flat** and relatively **narrow urethral plate** that cannot be primarily tubularized, in coronal, sub-coronal, and distal penile hypospadias.[4]

Inopportunely, the question about which of the two techniques is **more safe** and **effective** remains **controversial** and **unanswered**, although the Duplay appears to be more popular among pediatric surgeons in our department.

This thesis aims to **compare** the **efficacy** of the two surgical procedures in terms of **success** and related **complications** commonly encountered, in order to recommend the **best surgical treatment** to repair primary distal hypospadias, which can then be more practiced and taught to future surgeons. This will go a long way in improving the **quality of life** of many affected hypospadiac children.

HISTORICAL BACKGROUND

"Those who cannot remember the past are condemned to repeat it"

-The philosopher Santayana

The term hypospadias is derived from **Greek** and consists of "**hypo,**" which stands for **under** and "**spadon**" for **rent** or **fissure**. [5] To advance the field of "hypospadiology," one must acknowledge the contributors whose work has helped evolve older techniques into modern hypospadias repair.

One of the earliest descriptions of hypospadias dates back to the **1st and 2nd centuries AD**. It was the work of the **Alexandrian** surgeons ***Antyllus*** and ***Heliodorus***. [6] They were the 1st to describe, classify and define the pathophysiology and treatment of hypospadias.

Galen [130-199 A.D.], [7] the physician of the Gladiators in **Rome** and one of the hypospadias **pioneers,** was the 1st to use the term "hypospadias" and emphasize the major significance of **chordee** during intercourse.

A thousand years later, the fall of the Roman Empire heralded the arrival of the Middle Ages, in which the majority of medical texts originated from **Islamic physicians**. The next major medical text referring to hypospadias was a medical encyclopedia called **Al Tasreef**, written by ***Albucasis of Cordoba*** (963-1013), [8] a well-known **Arab** surgeon who made enormous contributions to pediatric surgery. In this book, *Albucasis* described how he used a scalpel to treat an **imperforate urethra** during the newborn period.

I. TUBULARIZATION

In **1556**, the 1st real scientific developmental step was taken when a 2-year-old boy with penoscrotal hypospadias was treated by ***Amatus Lusitanus*** [6] from **Portugal**, with a **canal** being created from the proximal ectopic urinary meatus up to the penile shaft using a **silver cannula** (**canalization technique**).

Ambrois Paré, [9] the famous surgeon to the **French** royalty of the **16th century**, was one of the 1st in medical history to describe the details of accompanying **chordee**

malformation; he advised cutting off all **fibrotic tissue** to make the penis more straight as surgical treatment.

The great surgical writer and anatomist ***Pierre Dionis***, [10] the founder of modem **French** surgical education, described the hypospadias repair in his book titled *"Cours d'opérations."* This text included details regarding the placement of a tunneled leaden pipe to bridge the distance between the hypospadiac meatus and the newly created glanular meatus.

Dupuytren [11] described a modification of the **canalization** canal. The formed canal was cauterized with a red-hot wire, and after the severe inflammation had passed, he kept the new canal open with **flexible catheters**.

In **1874**, the **French** surgeon ***Theophil Anger***, [12] the real initiator of the **modern urethroplasty** technique, reported on the successful treatment of penoscrotal hypospadias by using two lateral skin flaps to create a **tubularized neourethra** with the 1st flap, and the 2nd flap used for **ventral skin coverage**.

In **1874,** other surgeons began refining these techniques, including ***Simon Duplay*** [13] from **France*,*** who first actually **tubularized the skin**, although ***Karl Thiersch*** [3] had performed this procedure for **epispadias** repair in **1869**.

Duplay clearly delineated **3 separate steps** in the hypospadias repair: correction of the **ventral chordee** with a horizontal ventral penile incision that was closed vertically, using penile skin flaps to **create a neourethra**, and **connection** of the neourethra to the proximal **meatus**.

In **1880** ***Duplay*** [14] described a 2nd remarkable procedure. He made the urethral strip much narrower and sutured it over a catheter, but not as a completely secure tube. In other words, it was a "**buried strip of skin**" that would subsequently complete its own tubularization. That concept was the forerunner of the ***Denis Browne*** (**1949**) [15] technique **69 years later**.

In 1989, *Rich et al.*[16] described a midline longitudinal **incision** in the glanular urethral **plate** (hinging) to obtain a cosmetically acceptable **vertical slit-like meatus** for Mathieu repair. This dorsal midline incision was subsequently adopted for the entire length of the urethral plate (from the meatus to the distal margin) as a complement **to the** *Thiersch-Duplay* urethroplasty for distal hypospadias by *Snodgrass* [17] in 1994.

II. URETHRAL MOBILIZATION AND ADVANCEMENT

Beck and Hacker (1898) [18] were the 1st to mobilize the urethra and draw it distally along a trocar track. They presented a special technique for the distal type of hypospadias without chordee. They undermined and mobilized the urethra and advanced it into the glans. **Tunnelization** of the glans was performed with the help of a trocar-like instrument. For deeper grooves, they advised **cutting the glans** medially and reapproximating it over the advanced urethra. The idea is to make use of the **elasticity** of the urethra.

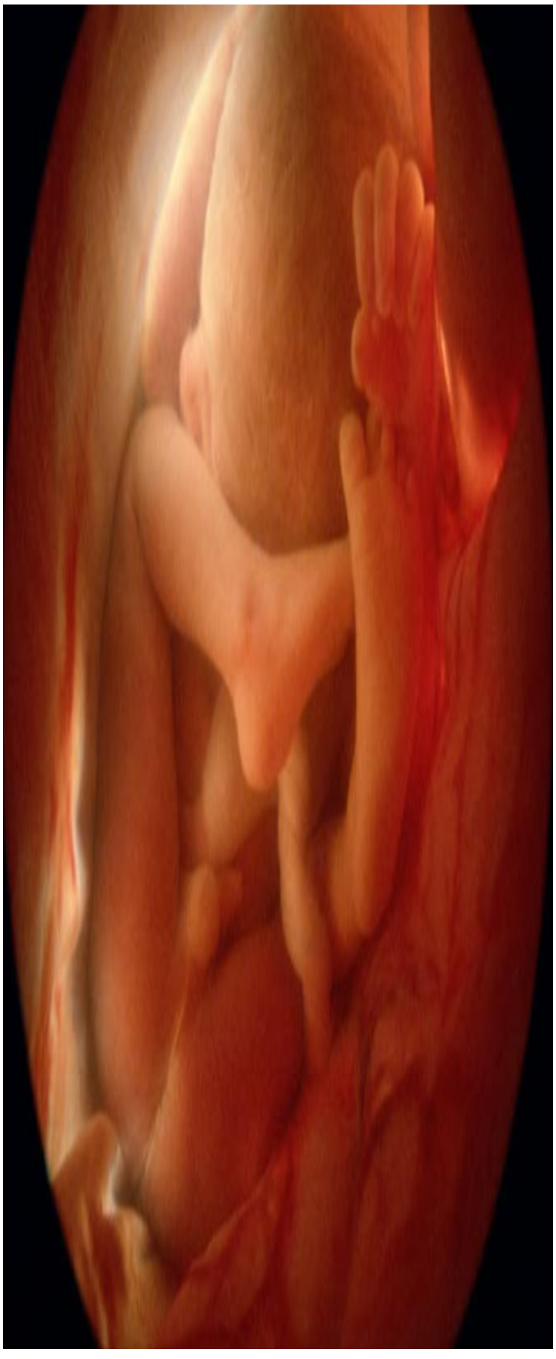
Stephen A. Koff (1981) [4] suggested a technique in which the **whole urethra** is **detached** from the anterior aspect of the **corpora cavernosa** and then **moved** forward to bring its opening to the **tip of the glans**.

Duckett, in1981 [19], described the meatal advancement and glanuloplasty incorporated" (**MAGPI**) technique for **sub-coronal** and **glanular** hypospadias cases without chordee. The tenet of this procedure is a combination of the **Heineke-Mikulicz** technique with urethral mobilization.

In 1982, *Baran* [20] used a modification of the **Beck and Hacker** technique by **elongating** the distal urethra to the **tip of the penis** through a surgically created tunnel. A glanular **triangular flap** was used in the meatal anastomosis in order to prevent

stricture formation. This was an operation especially advised for circumcised hypospadias patients.

Finally, we can try as much as we can to give credit to the great pioneers who first described main concepts, but we can’t by no means be exhaustive, nor capture all the techniques described for hypospadias repair.



EMBRYOLOGY

"The longer you look back,

the further you can look forward"

-Winston Churchill

I. MALE SEX DEVELOPMENT [21]

In normal foetal development, the 1st determinant of sex differentiation (**the chromosomal sex (XX/XY)**), is established at **fertilization**, when the **ovum** with its **X** chromosome fuses with a **sperm** carrying an additional sex chromosome, either **X** or **Y**. Thereafter, the embryo stays anatomically undifferentiated until **fetal week seven**, when the gonadal tissues begin to differentiate to **testes** or **ovaries** (**the gonadal sex**), depending on which sex chromosomes are present. The type of gonad then dictates the development of the **phenotypic sex**, **male** or **female**, which is defined by the **internal** and **external** genitalia and **secondary sex characteristics**.

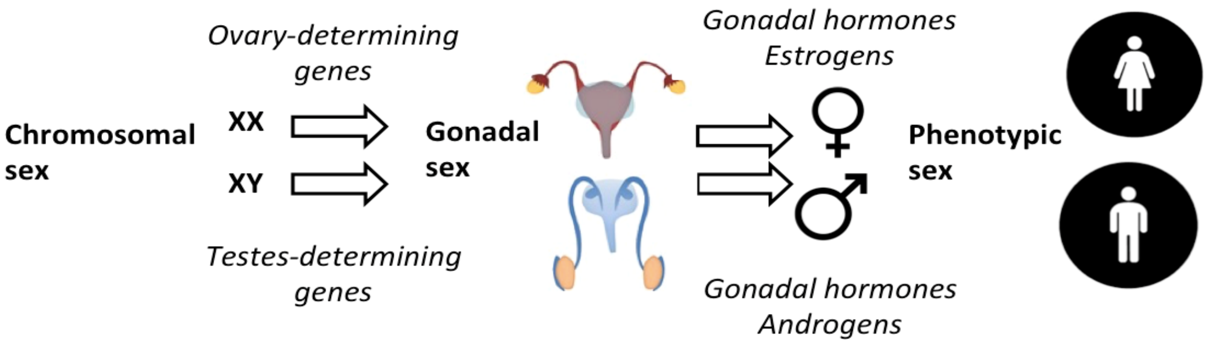


Figure 1. *Simplified sex differentiation* [21]

1. The Undifferentiated Stage

The initial development is **independent** of the chromosomal sex and is **identical** in both sexes. The **primitive** gonadal structures are derived from the **urogenital ridges (UR)** at approximately **4 weeks** after fertilization.

The **UR** are the **common precursors** of the urogenital system, develop in the still sexually undifferentiated embryo.[21] it gives rise to **2 duct systems**, the **Wollfian** (**mesonephric**) and **Müllerian** (**paramesonephric**) **ducts**, which are the primordial parts of the **inner genitalia** in **males** and **females**, respectively. [10]

During **gastrulation** the **bi-layered** embryo (**ectoderm, endoderm**) acquires a **3rd layer** through the migration of **mesoderm** cells through the primitive streak, resulting in the **tri-laminar** embryo. However, **2** areas remain **bi-layered**: the **oropharyngeal** membrane **cranially** and the **cloacal** membrane **caudally**.

Both membranes consist of ectoderm in intimate contact with the underlying endoderm without an intervening layer of mesoderm. [22]

The **cloacal membrane (CM)** is the future site of **urogenital ostium** and the **anus.**

During the **4th week** of development, the **flattened tri-laminar** embryo is converted through a series of complicated **morphogenetic movements** into a **tubular embryo** containing a **primitive tubular gastrointestinal system** subdivided into **3** zones: **foregut**, **midgut** and **hindgut.** [23]

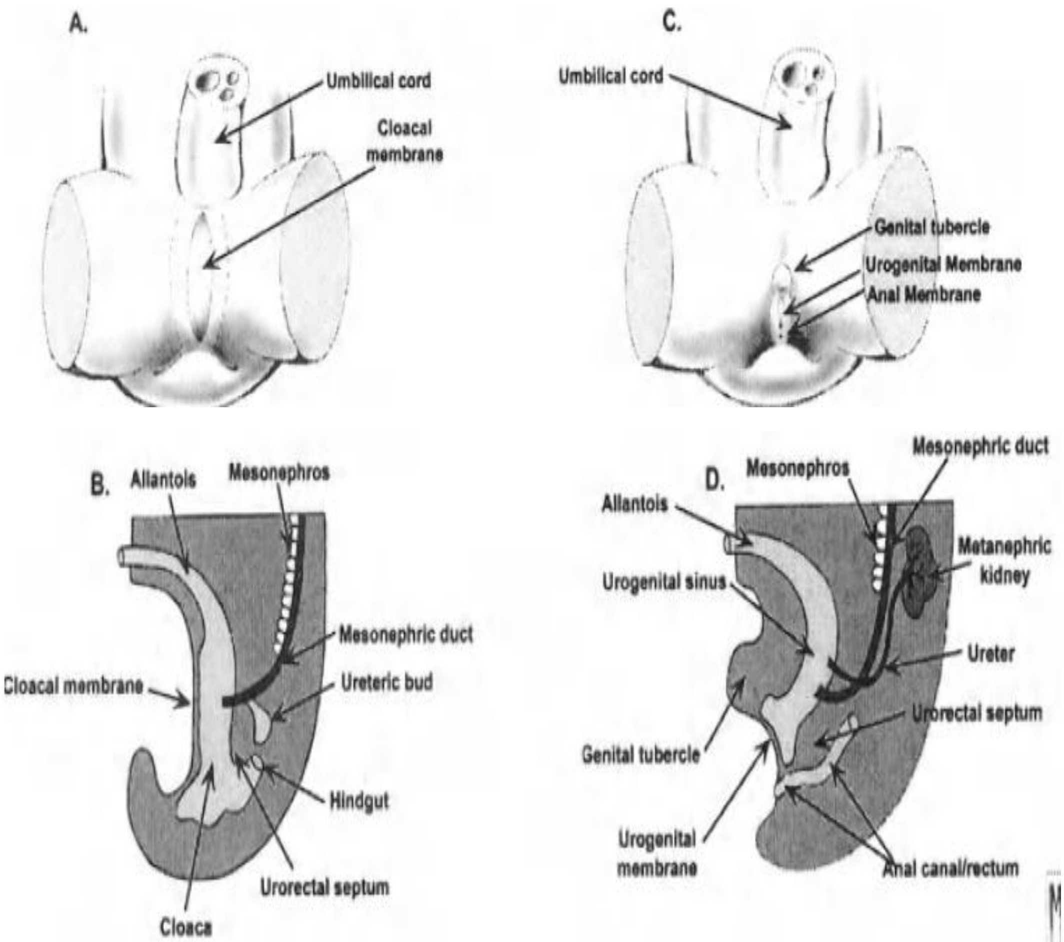


Figure 2. Development of the external genitalia-undifferentiated stage [23]

(A) Surface view of the perineum of **4-week** fetus. Note that the **CM** extends from the perineum up the anterior body wall to the **umbilicus** base.

(B) Mid-sagittal view through the pelvis of a **4-week** fetus. The **cloaca** is the blind **caudal terminus** of the **hindgut** and has a **ventral diverticulum**, the **allantois**, extending up the **anterior body wall** and terminating blindly in the **umbilical cord**. The **urorectal septum** is growing **caudally** towards the **CM** to subdivide the **cloaca**.

(C) Surface view of the perineum and anterior body wall of a **7-week** fetus. The **CM** has "**retracted**" into the perineum and has been divided into the **urogenital membrane** and **anal membrane**, Note the **genital tubercle** immediately cranial to the urogenital membrane.

(D) Mid-sagittal view through the pelvis of a **7-week** fetus. Showing division of the **cloaca** into the **urogenital sinus** and **rectum/anal canal**.

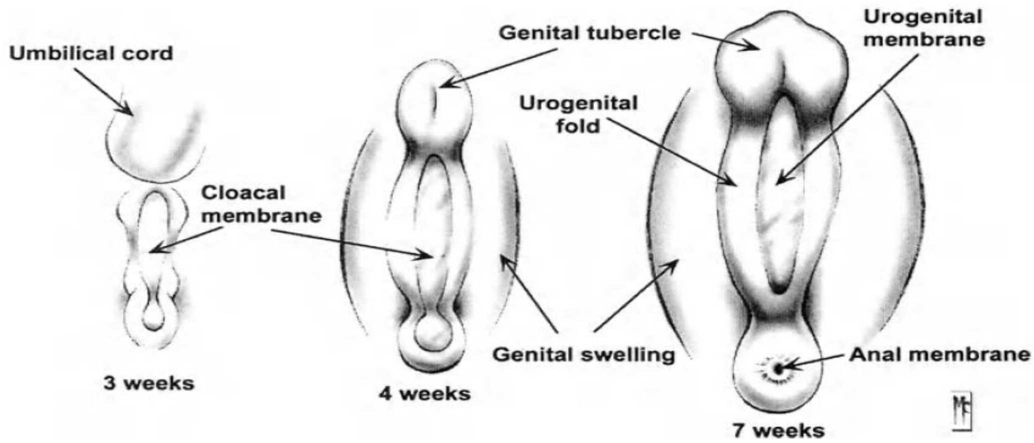


Figure 3. Detail of the cloacal membrane transformation [23]

The **CM** separates the **cavity of the cloaca** from the **amniotic cavity**.

At 3 weeks: [24]-[28]

Initially, the **CM** is an extensive elongated **midline structure** whose **cranial extremity** approaches the **umbilical cord's** root. Whereas the **caudal extremity** is located in the future **perineum** and is the site of the **anus**.

During development, the **bi-layered CM** "**retracts**" into the **perineum** as a result of **cranial** and **medial migration** of **mesodermal** cells into the **anterior body wall** between the **ectoderm** and **endoderm** of the **CM**.

This mesenchymal migration brings about the **closure** of the **inferior part** of the **anterior abdominal wall** and causes the **CM** to "retract" caudally into the perineal region.

These migrating mesodermal cells give rise to the **musculature** of the medial portion of the **anterior abdominal wall**, the **anterior wall of the bladder**, the **pubic symphysis**, and to the **rudiments of the external genitalia**.

Failure of migration results in **exstrophy** of the **bladder** and associated malformations: defect in the anterior abdominal wall, **absence** of the **anterior wall of the bladder**, defect in the pubic symphysis and **epispadias**, a severe **malformation** of the **external genitalia**.

At 4 weeks: [24], [25], [29]

The migrating mesenchymal cells spread around the **CM** and pile up to form **3 swellings**. One swelling, the **genital tubercle**, appears in the midline between the **CM** and the umbilicus.

Bi-lateral **genital swellings** appear on each side of the **CM**. These external features are related **internally** to the caudal terminus of the **gastrointestinal tract**, the **cloaca** and its diverticulum the **allantois**.

At 7 weeks: [21], [30]

The **cloaca** becomes divided **coronally** by the **urorectal septum** into the **urogenital sinus ventrally** and the **rectum** and **anal canal dorsally**.

Accordingly, the **CM** becomes subdivided into the **urogenital membrane** and the **anal membrane**. When this occurs, the **urogenital membrane** is bounded **cranially** by the **genital tubercle** and demarcated **laterally** by the **urogenital folds** and the **genital**

swellings. Subsequently, the **urogenital membrane** (and **anal membrane**) breaks down to establish continuity between **internal** structures (**urogenital sinus** and **anus**) and the **amnionic cavity**.

The **urogenital sinus** forms the bladder and prostate and caudally the pelvic and phallic parts of the urogenital sinus will form the **prostatic** and **membranous** segments of the **urethra**.

2. Differentiation Of Male External Genitalia (MEG) [21], [23]

In the primordial parts of the **MEG**, **testosterone** is converted to **DHT** by steroid **5 alfa-reductase** type **2** enzyme (encoded by the *SRD5A2* gene).

DHT binds to the androgen receptor in the target tissues and thereby drives the differentiation towards male development of the external genitalia.

Disturbance in the expression of 5ARI-2, despite normal levels of testosterone, results in a disturbance of the development of the normal **MEG**.

Through the regulation of human chorionic gonadotropin (hCG) and luteinizing hormone (LH), the **Leydig cells** produce **INSL3**, which acts in the steering of the **descent of the testicles** into the scrotum. Unilateral or bilateral undescended testis in the presence of hypospadias should lead to further investigation, as it may indicate an underlying disorder of sexual differentiation (DSD).

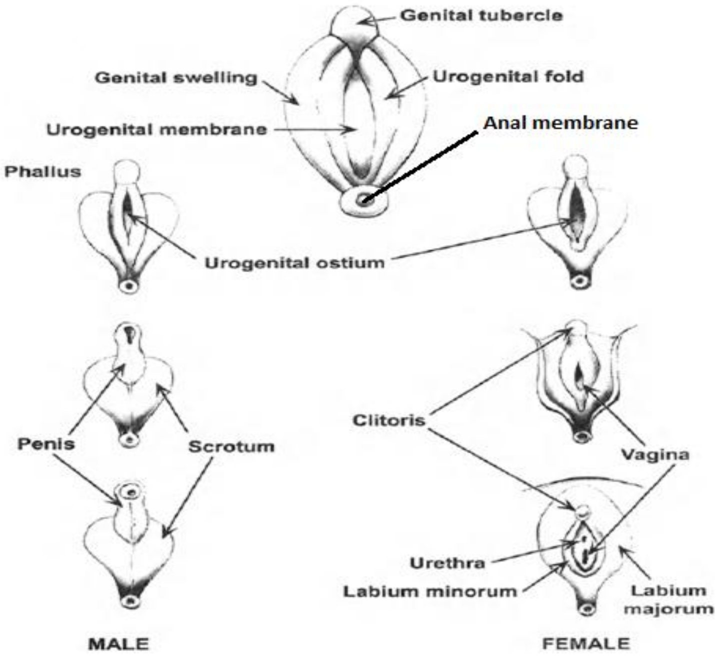


Figure 4. Sex differentiation of the external genitalia [23]

Before **12 weeks** of gestation, the **external genitalia** of both **male** and **female** fetuses are **identical** (the **ambisexual stage**) and consist of **undifferentiated** structures: the **genital tubercle (GT)**, the **urogenital folds** bounding the **urogenital ostium,** and the more **laterally** placed **genital swellings**. (top center illustration)

-During **female** development (right illustration in the figure next page), only minor changes occur from the original ambisexual stage. The **GT** undergoes minimal growth to form the **clitoris**. The **urogenital folds** and **genital swellings** remain unfused to form the **labia minora** and **majora**, respectively. The urogenital folds define the **vestibule** of the **vagina** into which open the **urethra** and **vagina**.

-During **male** development (left illustration), the **genital tubercle** elongates to form the **penis**, while the **genital swellings migrate** caudally and **fuse** in the midline to form the **scrotum**. As the phallus elongates, the **urethral groove (UG)** forms on the **ventral aspect** of the **GT**. The **UG** extends distally as a result of **canalization** of the solid **urethral plate (UP)**. Finally, the **urethral folds (UF)** bounding the urethral groove grow to the midline and **fuse** with each other, thus forming a **tubular urethra**.

A. Embryology Of The Penile Urethra

There are **two theories** concerning the development of the **distal-most segment** of the **urethra** within the glans.

1st theory [30]-[34]

The **UG**, which is defined laterally by **UF**, which are continuations of the **urogenital folds** surrounding the **urogenital ostium**, is thought to be lined by **endoderm** based upon histological observations.

Likewise, the solid **UP**, the distal precursor of the **UG**, is believed to be derived from **endoderm**. This idea implies that almost **all of the urethra** may be **endodermal** in **origin**.

The urethra is lined by **urothelium**. Urothelium is a **unique epithelium** found **only** in the **ureters**, **bladder,** and **urethra**. In the **ureter**, urothelium is derived from **mesodermal epithelium** arising from the **Wolffian duct**. In the **bladder** and **pelvic segments** of the urethra, the urothelium is derived from **endoderm**.

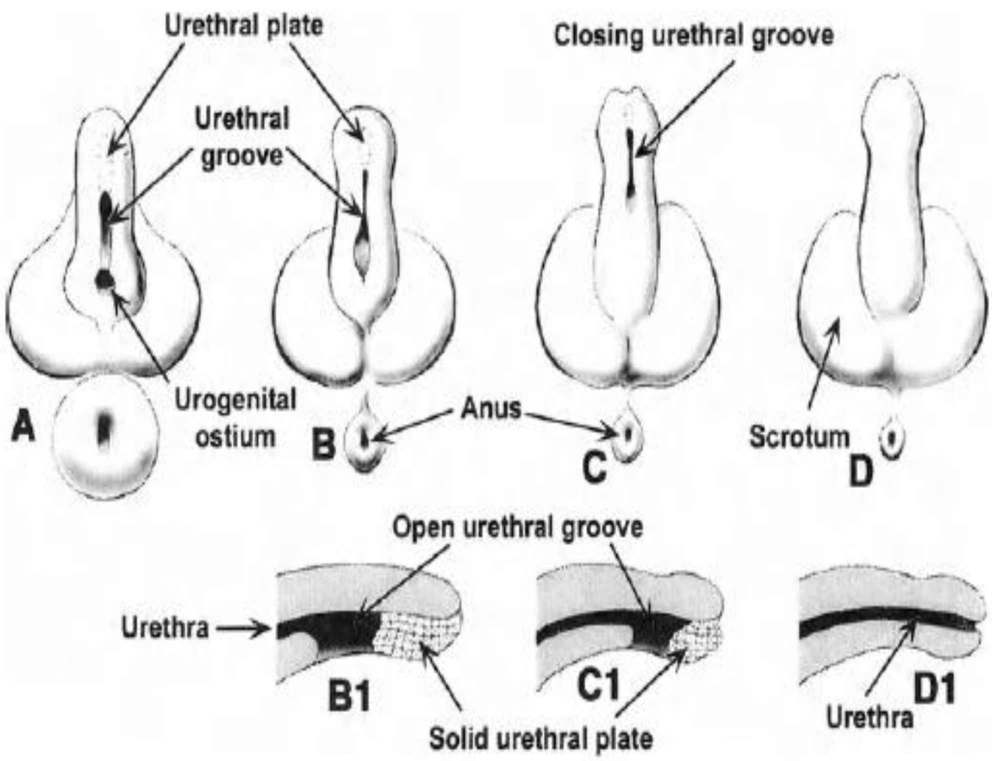


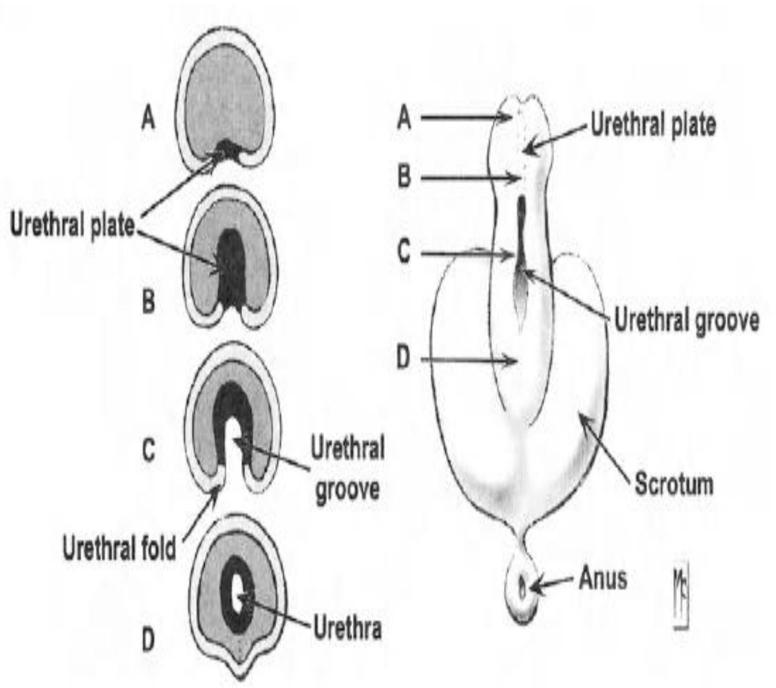
Figure 5. Detail of the urethral groove, urethral folds and urethral plate [23]

(**A**) At the ambisexual stage's beginning, the **UG** bounded by the **UF extends** about **halfway distally** along the elongating **GT's** ventral aspect. At the distal aspect of the **UG** is a solid **endodermal** plate called the **UP** (dotted lines) that extends to the glans of the developing penis.

(**B-C**) The **UG** extends distally to the glans by **canalization** of the **UP**.

(**B-D**) The **UF** grow towards each other in the midline, where they **fuse** to extend the tubular **penile urethra** distally to the glans.

(B1, C1, D1) are mid-sagittal sections showing **canalization** of the **UP** and formation of the penile urethra.



(**A-B**) The UP in the distal part of the phallus.

(**C**) UP canalization forms the UG bounded by UF, which grow to the midline and fuse to form the tubular urethra.

(**D**) After fusion, the resultant epithelial seam is removed.

<u>**Figure 6.**</u> Detail in transverse section of the UG, UF and UP [23]

2nd theory [35]-[38]

Since the **UF epithelium** is precisely at the **ectoderm** and **endoderm** interface, it is conceivable that the **UG** and thus the **penile urethra** could be derived from either **ectoderm** or **endoderm**. The hypothesis is that most (if not all) of the penile urethra is endodermal in origin, with the possible exception of the distal urethra within the glans whose epithelium may be ectodermal in origin.

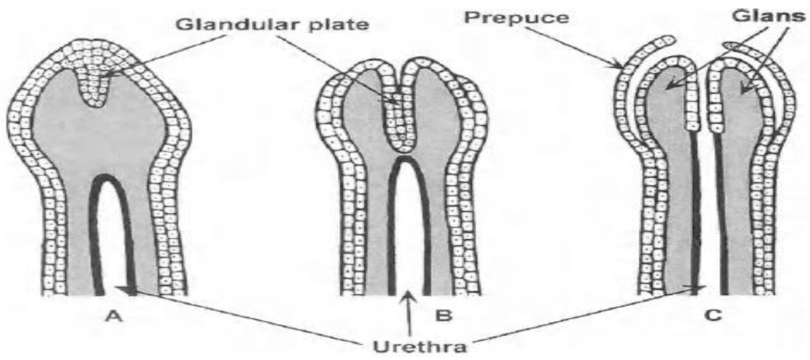


Figure 7. An alternate theory of urethral development in the glans [23]

(**A**) The **penile urethra** forms as a result of **UF fusion** throughout the shaft of the penis, but penile urethral formation **stops in the glans**.

(**A-B**) The last segment of urethra develops from a **solid ingrowth of ectoderm** (the **glanular plate**) into the glans, which makes contact with the **endodermally derived** tubular **urethra**.

(**C**) After **canalization** of the **glanular plate,** the urethra's continuity to the exterior is established.

During the development, the penile **mesoderm** segregates into derivatives:

Corporal tissue is 1st recognized as distinct dense mesenchymal condensations within the shaft of the developing penis.

The **outer aspect** of the **corporal bodies** differentiates into thick investing connective tissue **capsules** called the **tunica albuginea**.

Surrounding the tubular urethra the mesenchyme differentiates into **smooth muscle** contributing to the **mucosa** and **sub-mucosa** of the **urethra**, which is in tum surrounded by **erectile tissue** of the **corpus spongiosum**.

The elongating phallus is **covered externally** by **ectoderm** that gives rise to **penile skin**.

B. Development Of The Prepuce [39]-[41]

Formation of the prepuce begins at **the same time** as that of the **urethra** and is **dependent** on **normal urethral development** for completion.

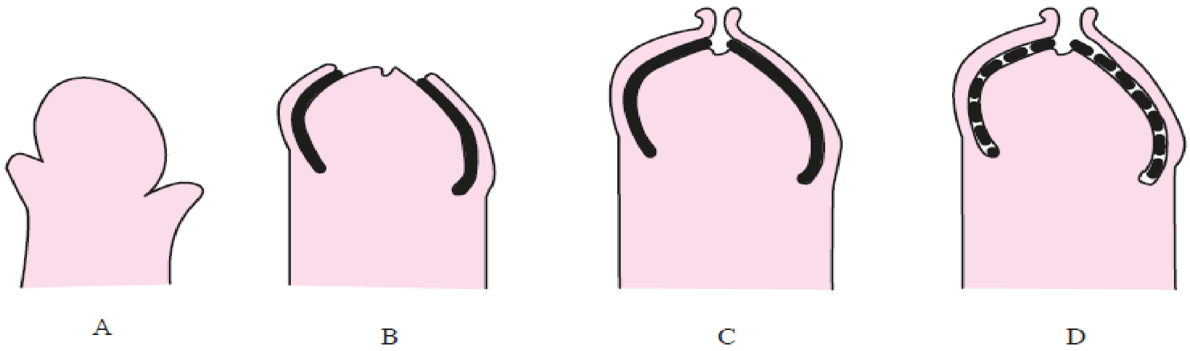


Figure 8. Development of the prepuce [39]

A) Formation of the preputial fold in the 10^{th} **week** of gestation

B-C) Weeks **10-28**: proliferation to the tip of the glans

D) Separation of the epithelial layers (**week 30**)

At about **8 weeks'** gestation, low **preputial folds** appear on both sides of the penile shaft, which **join dorsally** to form a flat ridge just proximal to the **coronal sulcus**.

The ridge entirely **encircles** the **glans** if not blocked on the ventral side by the incomplete development of the urethra.

The prepuce then rolls over the base of the glans, leaving a **groove** between it and the coronal sulcus, which becomes filled by active proliferation of cells that carry the prepuce forward along with the proliferation of the epithelial cells in the prepuce.

The **outer** and inner **layers** of the prepuce are separated at about **30 weeks**, starting at the **distal preputial ridge**.

Remnants of the attachment between the glans and the inner preputial layer can be seen as adhesions in the grown child.

II. ABNORMAL DEVELOPMENT IN HYPOSPADIAS [42], [43]

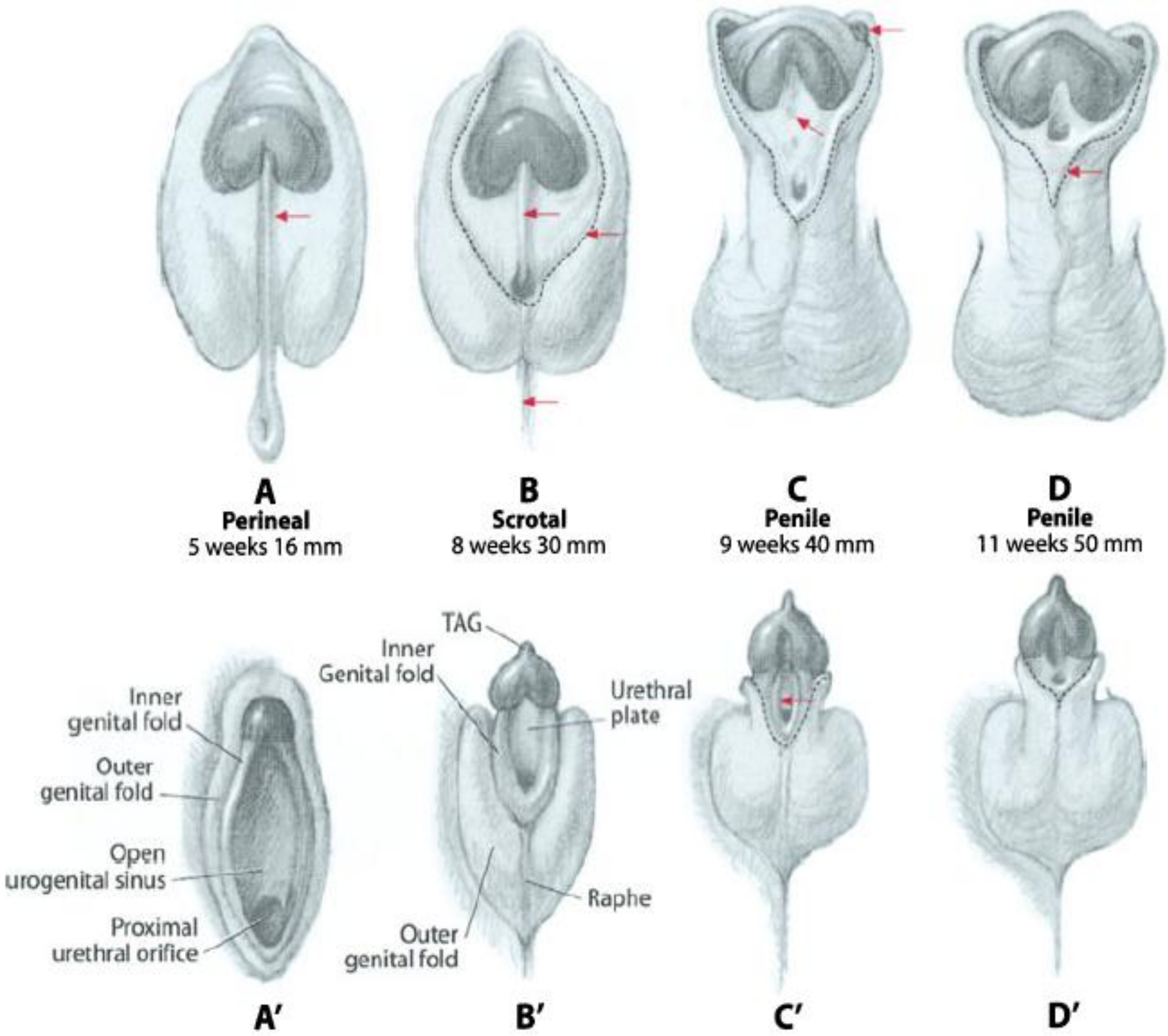
Most commonly, the development of chromosomal, gonadal, and phenotypic sex follows the textbook example described above, yet **atypicality** exists and collected under the name of: Disorders of Sex Development (**DSD**).

Hypospadias is an inborn error in the male **external genitalia's** development affecting **3** main **anatomical** features resulting in:

(I) The **ectopic** urethral **meatus** located somewhere alongside the **ventral** part of the penis,

(2) The abnormal **prepuce**, including irregular **penile raphe** and **dorsal hood**,

(3) The ventral **curvature,** clearly observed during erection.



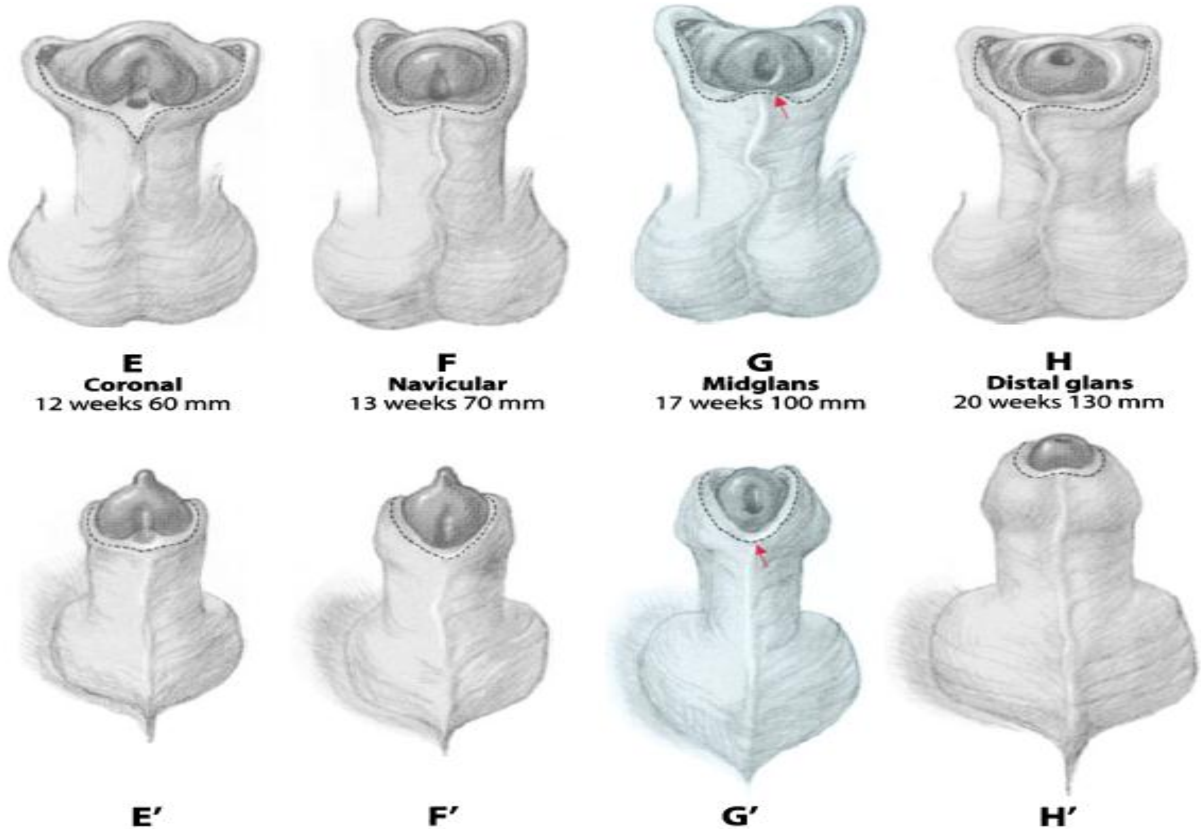


Figure 9. Diagrams of hypospadias clinical forms with corresponding crown-rump length & embryological gestation time stages. A ->H A' -> H' [43]

A) Perineal, UP *(arrow).*

A') Open urogenital sinus, inner and outer genital folds, proximal urethral orifice.

B) Scrotal, perineal raphe *(bottom arrow),* bifurcated raphe *(middle arrow),* distal urethral plate *(top arrow).*

B') Partly covered UP with scrotal raphe.

C) Mid-penile orifice, Littre gland orifice *(lower arrow),* dog-ear *(upper arrow).*

C') UP *(arrow)* in UG.

D) Distal penile orifice, bifurcation of raphe, hypoplastic triangle of skin *(arrow).*

D') UP open on glans.

E, E') Coronal orifice, deficient ventral prepuce.

F, F') Navicular orifice.

G) Mid-glanular orifice. G') Frenular attachment to glans (arrow).

H, H') Sub-apical orifice (stenotic), deviated raphe.

1. Ectopic Urethral Meatus [44], [45]

Hypospadias results from **failure of formation or fusion** of the **UF**. The site of fusion failure will dictate the opening of the urethra's position, from **perineal** positions **proximally** to more **distal** openings along the shaft of the penis.

A prerequisite of **UF** fusion is the formation of the **UG** bounded by the **UF**. Clearly, if the **UG** and the **UF** do not form properly, the possibility of **UF fusion** will be impaired.

Assuming normal development of the UF, the process of development of penile urethra involves the **movement or growth** of UF towards the midline so that they make contact. When it happens, the opposing **epithelial surfaces** must **adhere** to one another resulting in the formation of a **midline epithelial seam**.

Finally, the **midline epithelial seam** must be **removed** so that **mesenchymal continuity** is established across the midline.

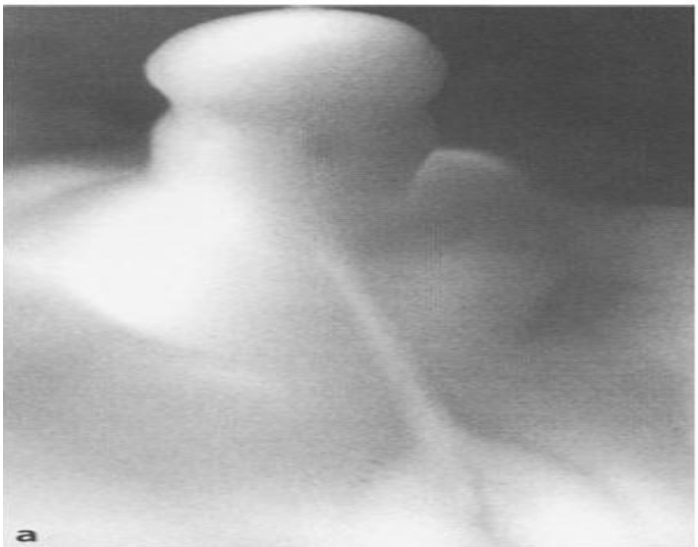


Figure 10. Development of the MEG in week 10 embryo [46]

*Showing the enlarging **genital tubercle** with the urogenital **opening** near the site of the **coronal groove**. The **median raphe** and anus are also visible.

Figure 11. Hypospadias with coronal groove opening [46]

*Note that the **UP** has broken down distally to form a **groove**, but the urethral **orifice** remains **proximal.**

More **proximal** is the ectopic opening, more **severe** is the anomaly.

The original opening of the **urogenital sinus** is located more proximally in the **perineum,** and it represents the **usual** site of the urethra in **females**.

At the same time, in **males,** it refers to a complex anatomical defect of perineal morphogenesis (often with imperforate anus) or **intersex** state.

Failure of the **UP** to be coated by **mesenchyme** (and **skin**) results in separated **outer genital folds** as 2 hemi-scrota.

An open midline gutter with pin-point orifices of presumed **Littre's glands** distal to the ectopic orifice indicates the **persisting UP**.

2. Ventral Penile Curvature Or Chordee [45]

The **degree** of **VPC** varies and is often related to the **severity** of the underlying anomaly.

The **distal** variant of hypospadias often shows **none** or **superficial VPC**, while the **proximal** one is usually associated with **severe VPC**.

Just proximal to the **aberrant meatus,** the **spongiosal body**, naturally surrounding the penile urethra in entirety, is **split** into **2** diverging branches; at this part, the **VPC** occurs.

In more **distal** hypospadias, the **VPC** results primarily from **deficient periurethral growth** or **skin length**, while in more **proximal** hypospadias, it is due to **apoptosis** of the **UP** and **corpus spongiosum** in **lack** of sufficient **androgen action.** To note that once it's **released**, the **VPC** may reveal a much **more proximal** meatal position than first expected.

An **impaired quality** of the **skin** and **supportive tissue** on the penile ventral side and a **lack of corpus spongiosum** proximal to the meatus may be present in addition to the **development arrest**.

3. Dorsal Hood and Raphe

A. Dorsal Hood [43]

This characteristic feature of hypospadias may be attributed to the **failure of androgen-dependent growth** of the **mesenchyme** on the ventral penile aspect, which marks a **wedge-shaped** defect in the **ventral prepuce**, with an **absent frenulum**.

In contrast, on the **dorsal hood,** the bifurcated **penile raphe** ends in the so-called **"dog-ears."** They represent the most distal **corners** of **external preputial skin** that would join each other in normal cases.

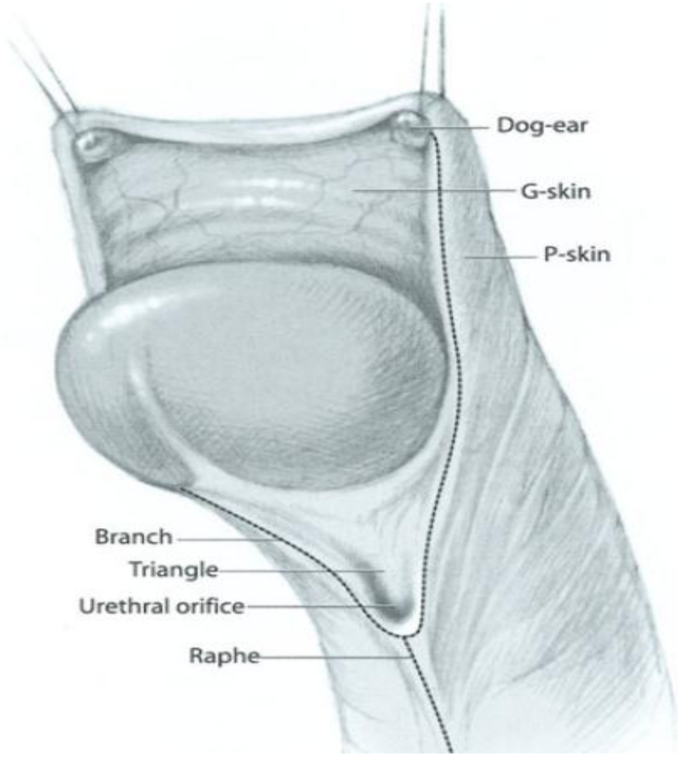


Figure 12. Features of hypospadias with chordee [43]

*Showing ectopic meatus triangle between branches of raphe and glans

P-skin: penile skin of outer genital folds

G-skin: inner skin of prepuce

>>The two skin tufts (dog-ears of the prepuce)

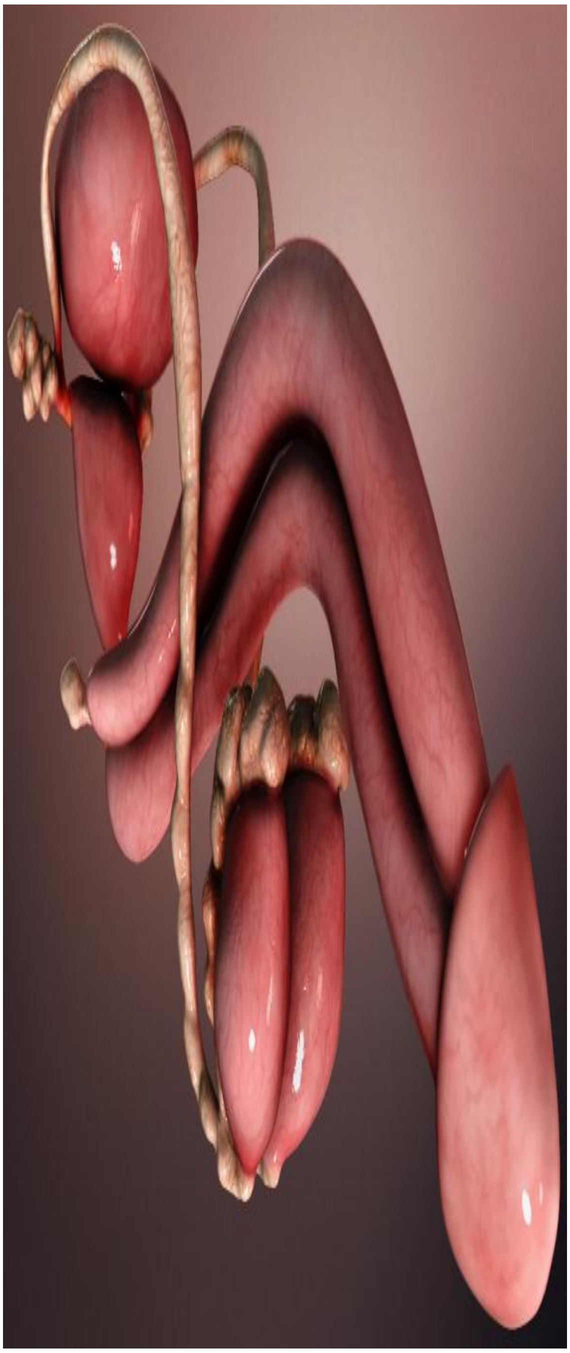
B. Penile Raphe [43]

In hypospadias, a **zigzag** course of the median raphe may be noted due to a deficiency of **mesenchymal growth** along the shaft.

The raphe **bifurcates** just proximal to the ectopic meatus, and each branch continues distally to reach the **dog-ears** on the foreskin.

Both branches indicate the distal edge of **migration** of the mesenchyme that forms **Buck's fascia** and **subcutaneous tissue**, **lacking** in the **triangular area** delimited by the branches.

In these cases, the urethra is very **superficial** and lacks adequate **supporting tissue** and **corpus spongiosum**.



ANATOMY

"Man should not strive to eliminate his complexes, but to get in accord with them: they are legitimately what directs his contact in the world"

–Sigmund Freud

I. PENILE ANATOMY [47]

Knowledge of penile anatomy and pathology is of paramount importance as the hypospadias diagnosis could be missed.

The penis is the male **copulatory organ** and carries the **spongiose urethra** in entirety {bulbar, penile and glanular (fossa navicularis and meatus) segments}.

The **flaccid** penis hangs in front of the **scrotum** over the median scrotal **raphe** below the **pubic symphysis**. In this state, the penile **dorsal** surface faces anteriorly, and the **ventral surface** faces posteriorly. Thus, when the penis is erect, the **dorsal surface** faces the anterior abdominal wall.

The penis comprises **3 parts**: The **root (radix),** The **shaft (body or corpus)** and The **glans.**

1. The Root Of The Penis [48]

It's the proximal end of the penis that lies in the perineum between the inferior fascia of the urogenital diaphragm and the fascia of Colles.

It is cemented to the inferior surface of the perineal membrane as well as to the ischiopubic rami's inner aspects.

It is **triradiate** in form, consisting of **3** elongated masses of **erectile tissue**: the diverging **crura**, one on either side, and the **centrally** located urethral **bulb**.

In front of the ischial tuberosity, each crus is attached to the **inner** surface of the ipsilateral **ischiopubic ramus** and partially to the **inferior** surface of the adjacent **perineal membrane**. In contrast, the **entirety** of the **bulb** is attached to the **lower** surface of the **perineal membrane**.

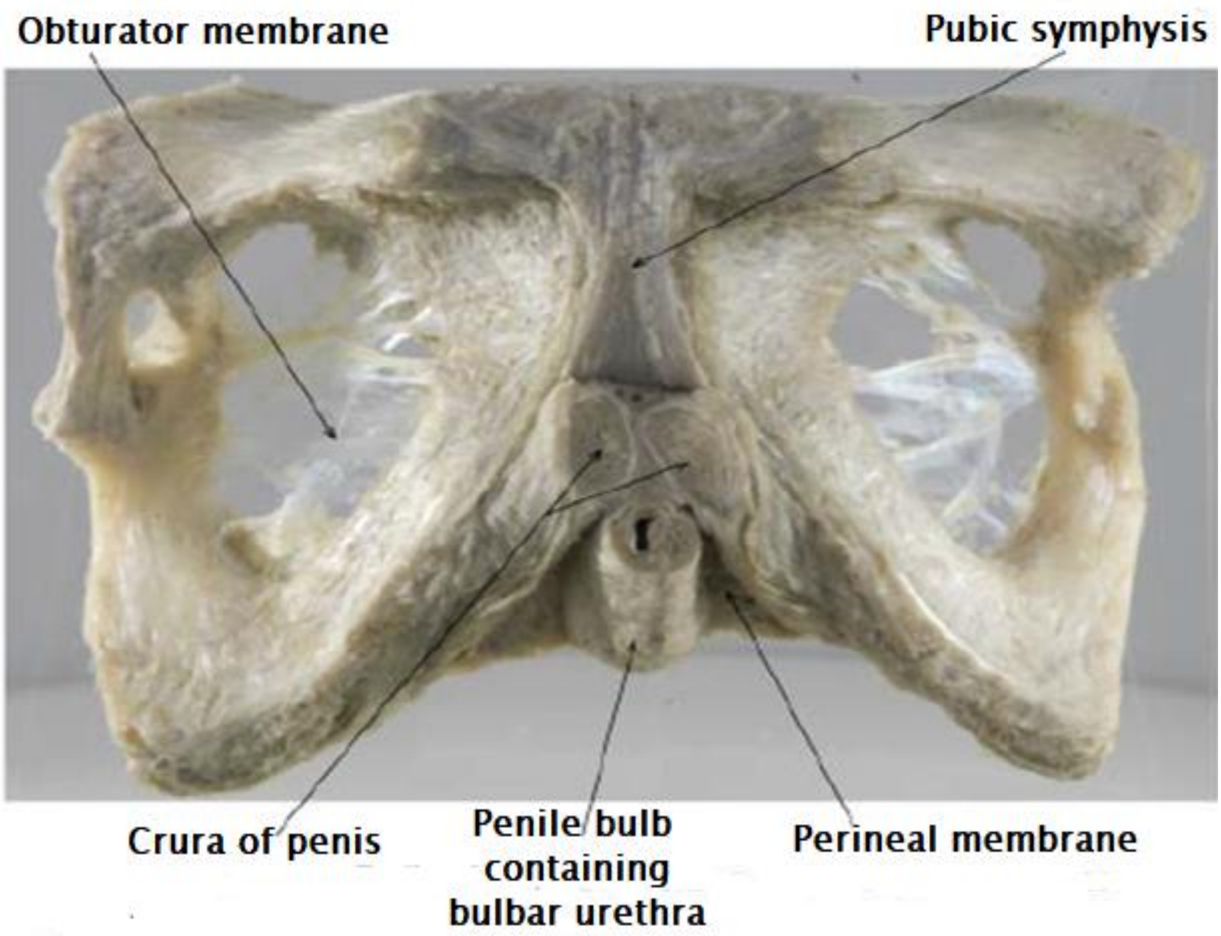


Figure 13. Cadaveric dissection of the male perineal urogenital triangle showing the 3 components of the penile root [48]

Each **crus** is surrounded by the corresponding **ischiocavernosus muscle** (IC) while the **bulb** is covered by the **bulbospongiosus muscle** (BS). The latter refers to the **midline fusion** of the IC muscles.

Distally, the **3** elements of **the penile root** (the two crura and the bulb) converge towards each other at the proximal end of the **penile shaft**, whence the **2 crura** are prolonged within the penile shaft as the **corpora cavernosa (CC)** and the **bulb** is continued as **the corpus spongiosum (CS)**. The **muscles** (IC and BS) are not prolonged into the penile shaft.

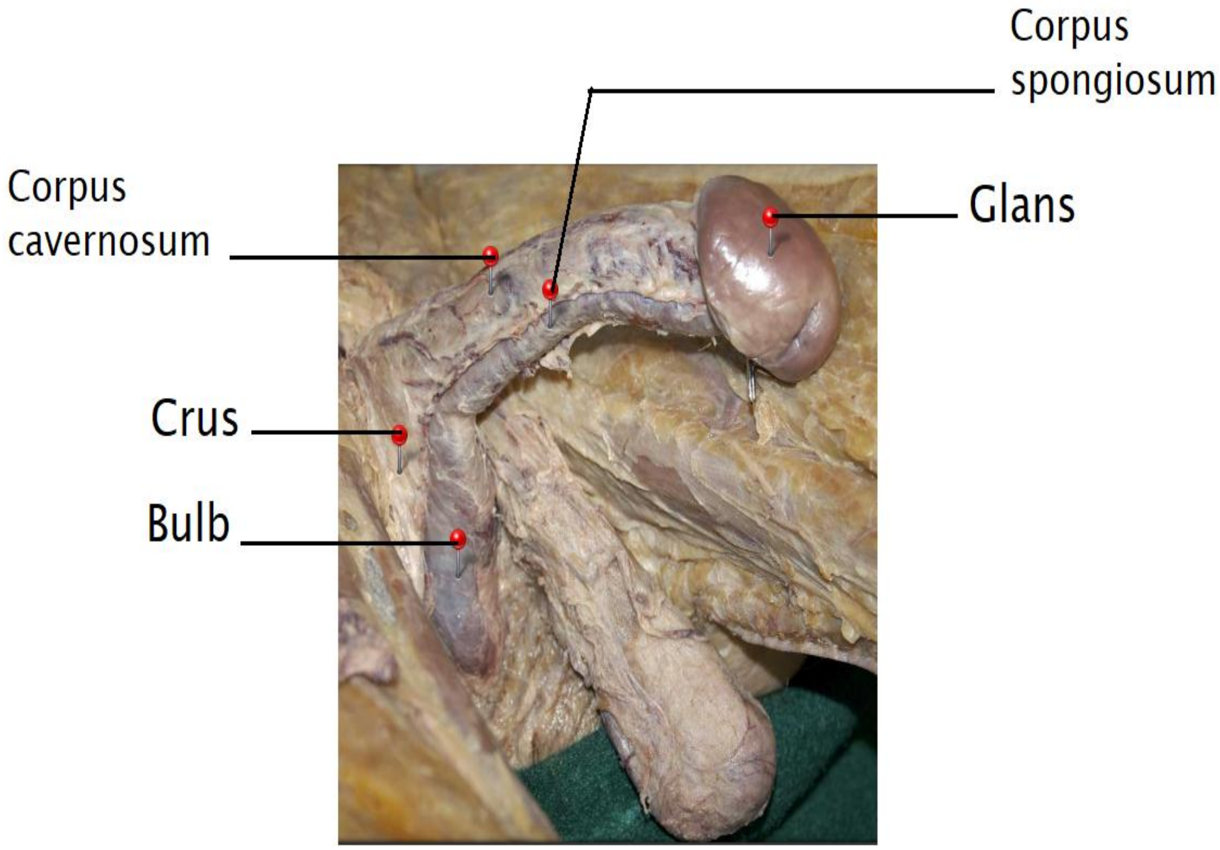


Figure 14. Lower lateral view of the penis [49]

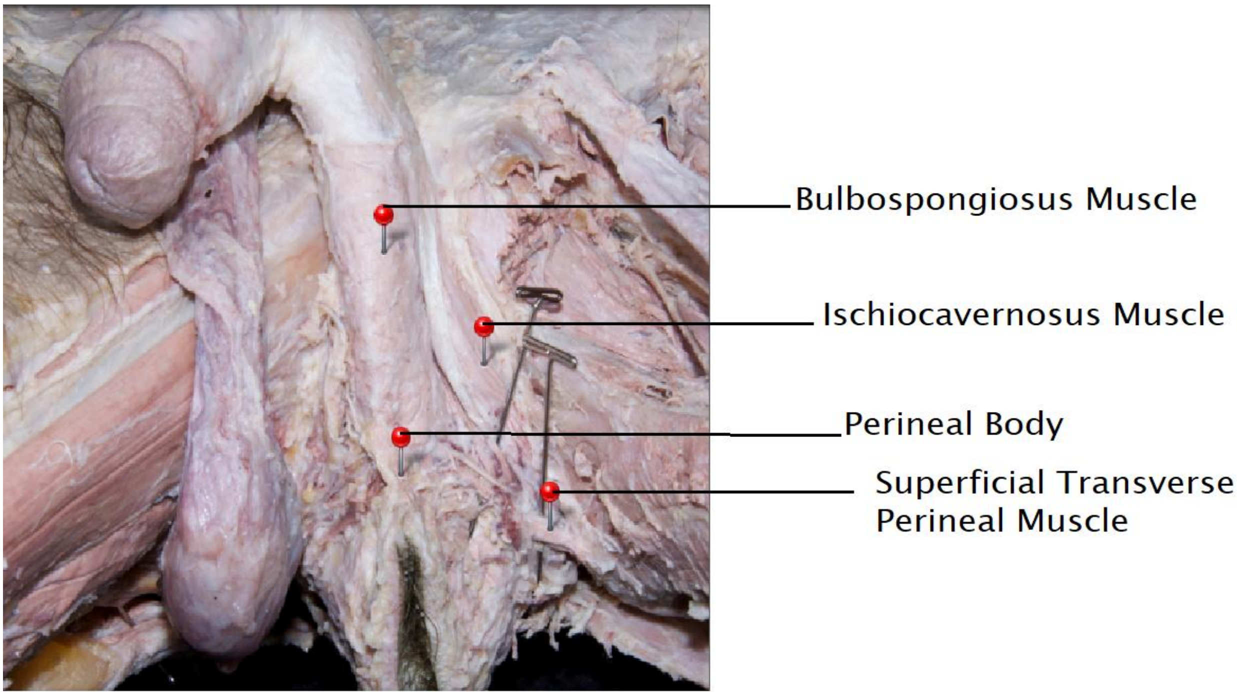


Figure 15. Dissection of the male perineum showing BS & IC muscles [49]

2. The Shaft Of The Penis [48], [50]

It comprises **3 columns** of **erectile tissue**: right and left **CC**, centered by the **CS**. Dorsal to the midline **CS,** the **2 CC** are lying side by side to form a longitudinal groove where the **CS** is lying.

The **crura**, **bulb,** and respective **corpora** are made up of **spongy connective tissue** comprising an interconnected network of highly vascular sinusoids.

The **CS** and the **2 CC** are each encountered by a dense **fibrous** sheath called the **tunica albuginea (TA)**, which is covered by the **deep penile fascia (Buck's fascia). TA** of the **2 CC** merge to make the **penile median septum,** and on the **ventral** aspect, the fusion is made with **TA** of the **CS**.

The penile **median septum** is incomplete in places, allowing the two sides' cavernous erectile tissue to communicate.

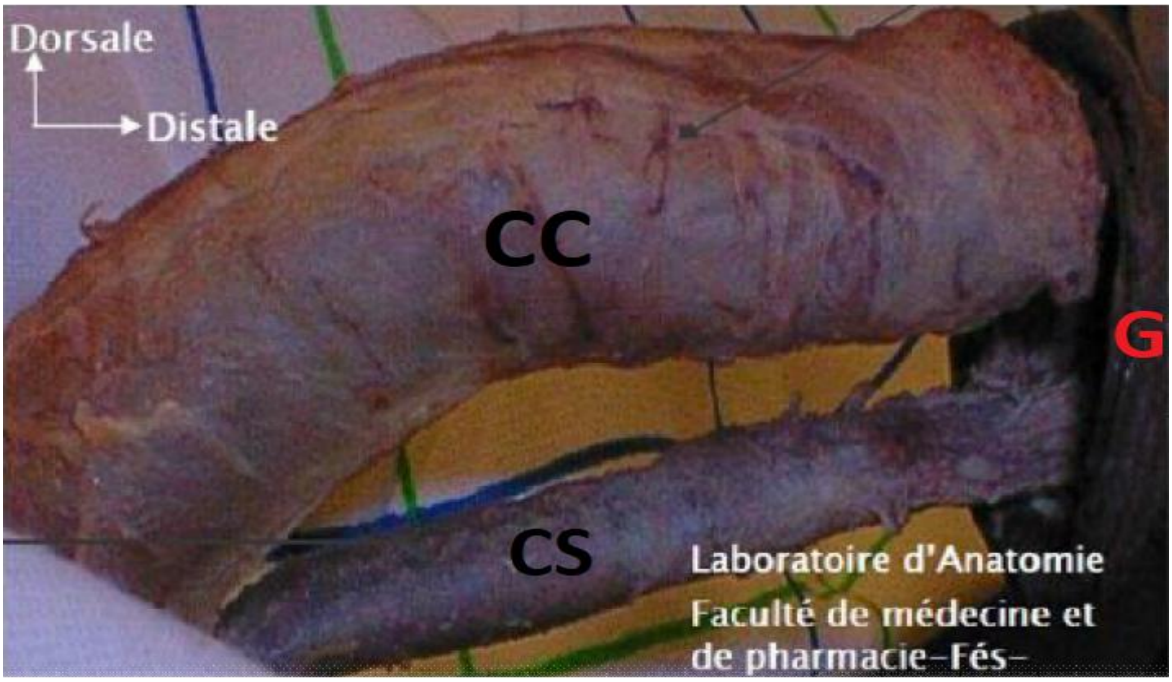


Figure 16. Lateral penile view after CS was dissected off the underlying CC [51]

*G:Glans

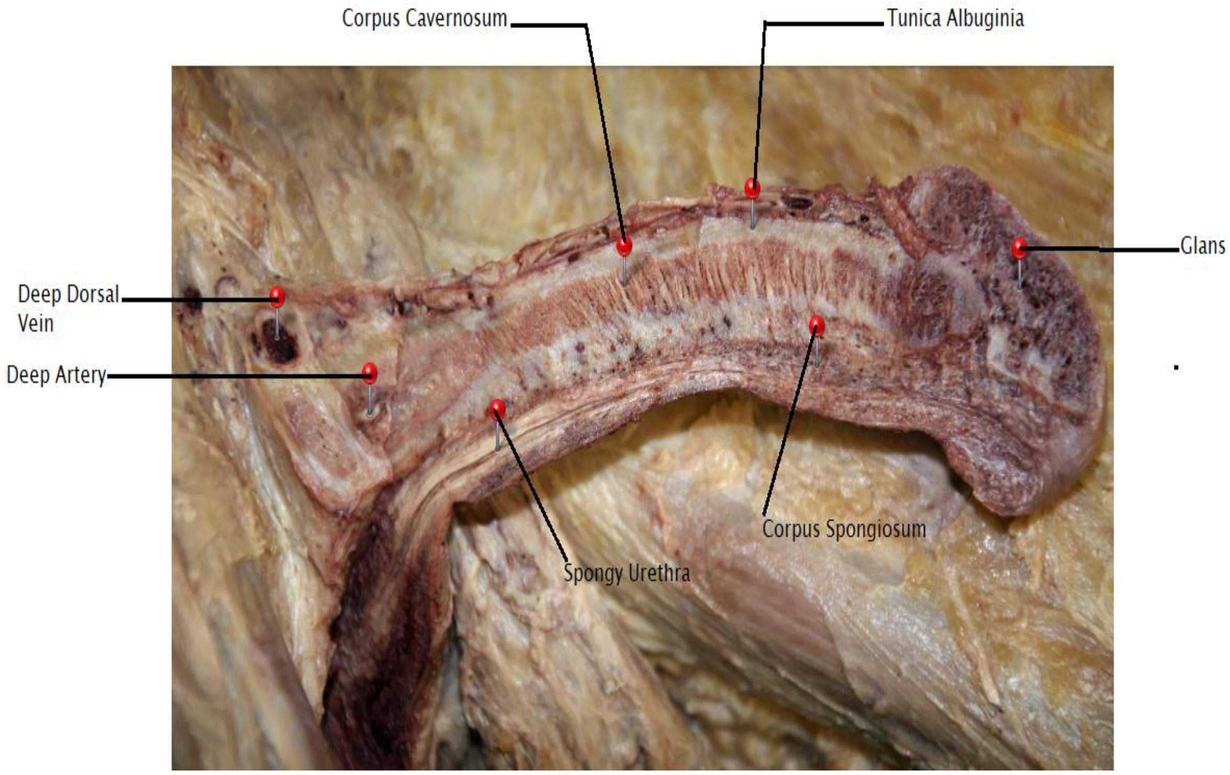


Figure 17. Sagittal section of the penis [49]

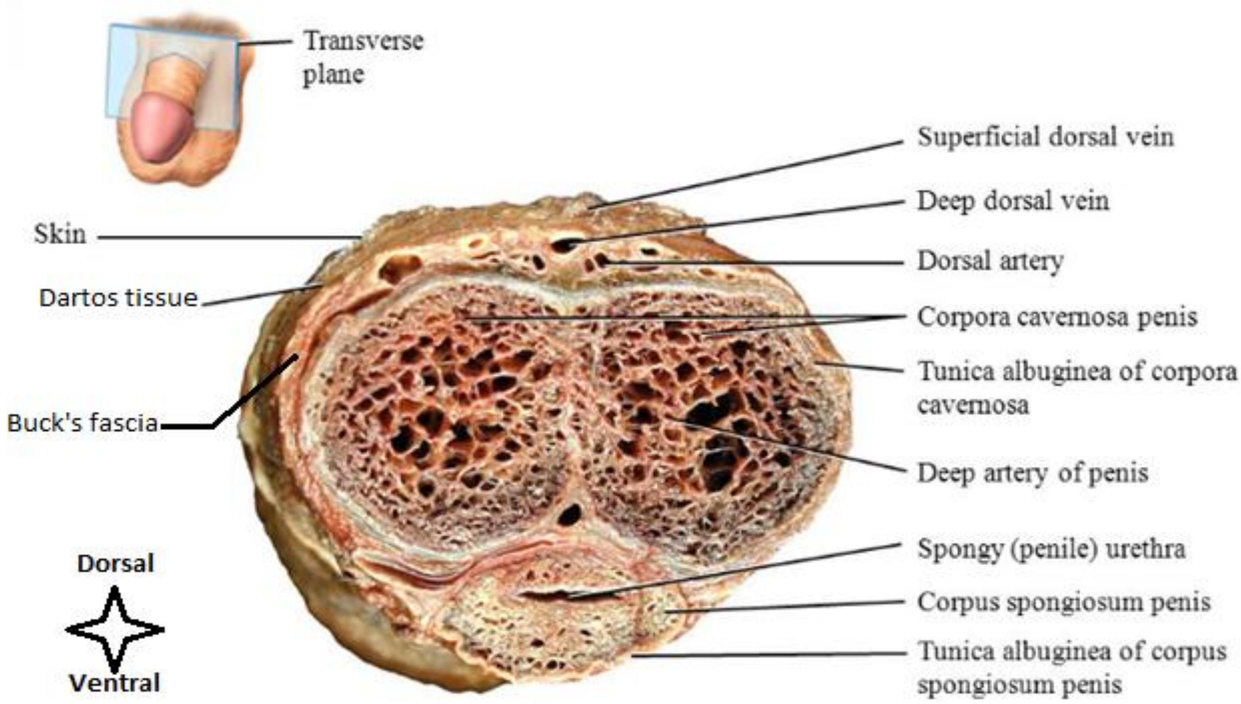


Figure 18. Transverse section of the penis. [52]

3. Fascial Layers In The Urogenital Region Of The Perineum [53]

Scarpa's fascia which is the **membranous** layer of anterior abdominal wall's superficial fascia is continued into the **urogenital triangle** of the perineum as the **superficial perineal fascia** (**SPF**), that is prolonged furtherly over the:

-**Scrotum**, and contains smooth muscle on its surface.

-**Penile shaft** and it's termed the **superficial penile fascia**,

Whereas we call the remainder of the **SPF** the **Colles' fascia**. It's attached to the outer margins of the everted **ischiopubic rami** and to the posterior edge of the **perineal membrane,** which demarcates a space with the overlying **SPF** termed the **superficial perineal pouch**.

The **pouch** comprises the **root** of the **penis** and the associated **muscles**, but also the **scrotal contents** and the **penile shaft** as the **SPF** continues into the scrotum and around the penile shaft.

Buck's fascia or the **deep fascia of the penis**, is a distinct fascial layer located deeply to the **superficial penile fascia** and encircles the **erectile** columns in the penile shaft.

Proximally, **Buck's fascia** continues with **Gallaudet's fascia,** defined as the deep fascia that covers the **muscles** that overlie the **root** of the penis.

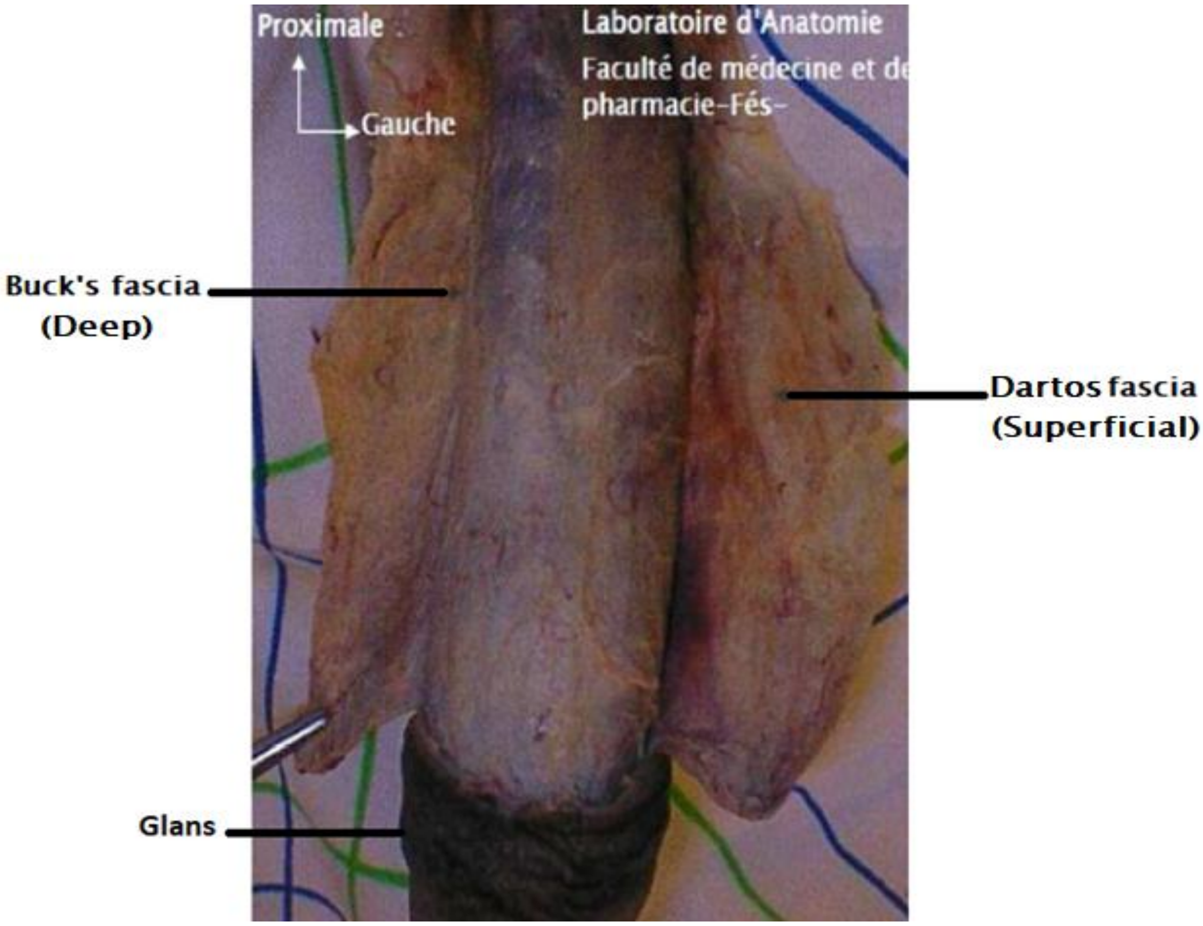


Figure 19. Ventral penile view showing different fascial layers [51]

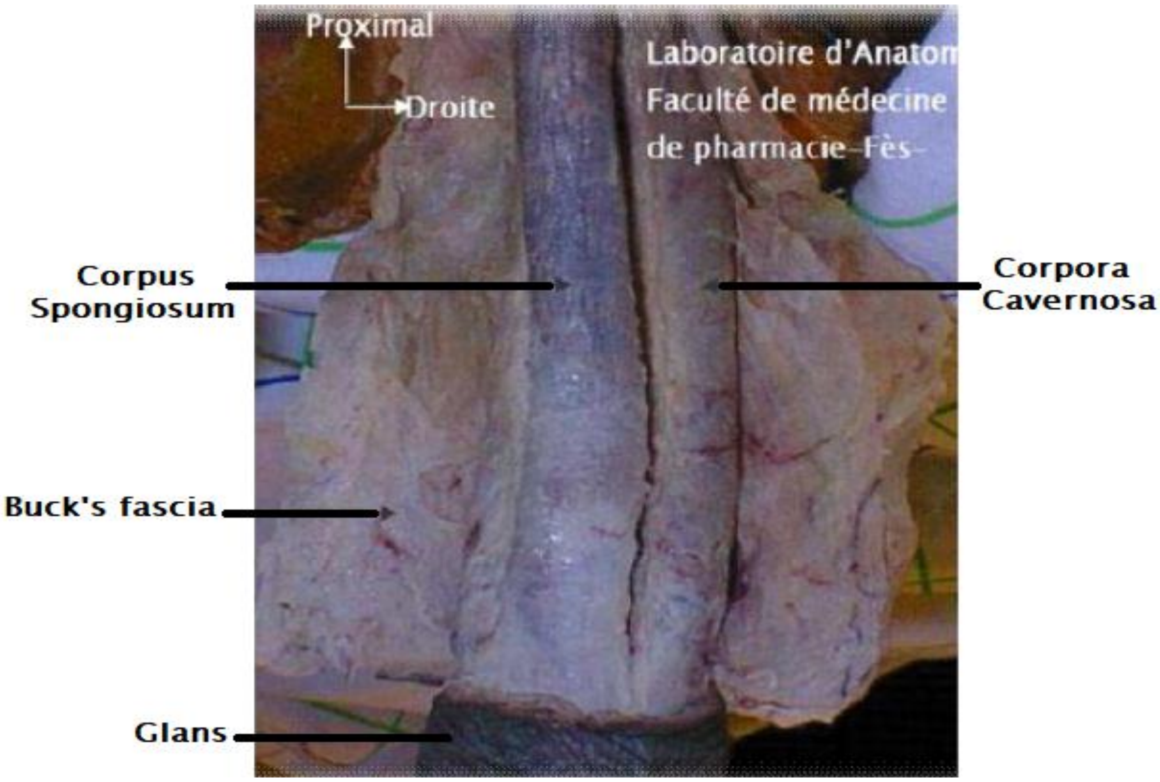


Figure 20. Ventral penile view after Buck's fascia dissection [51]

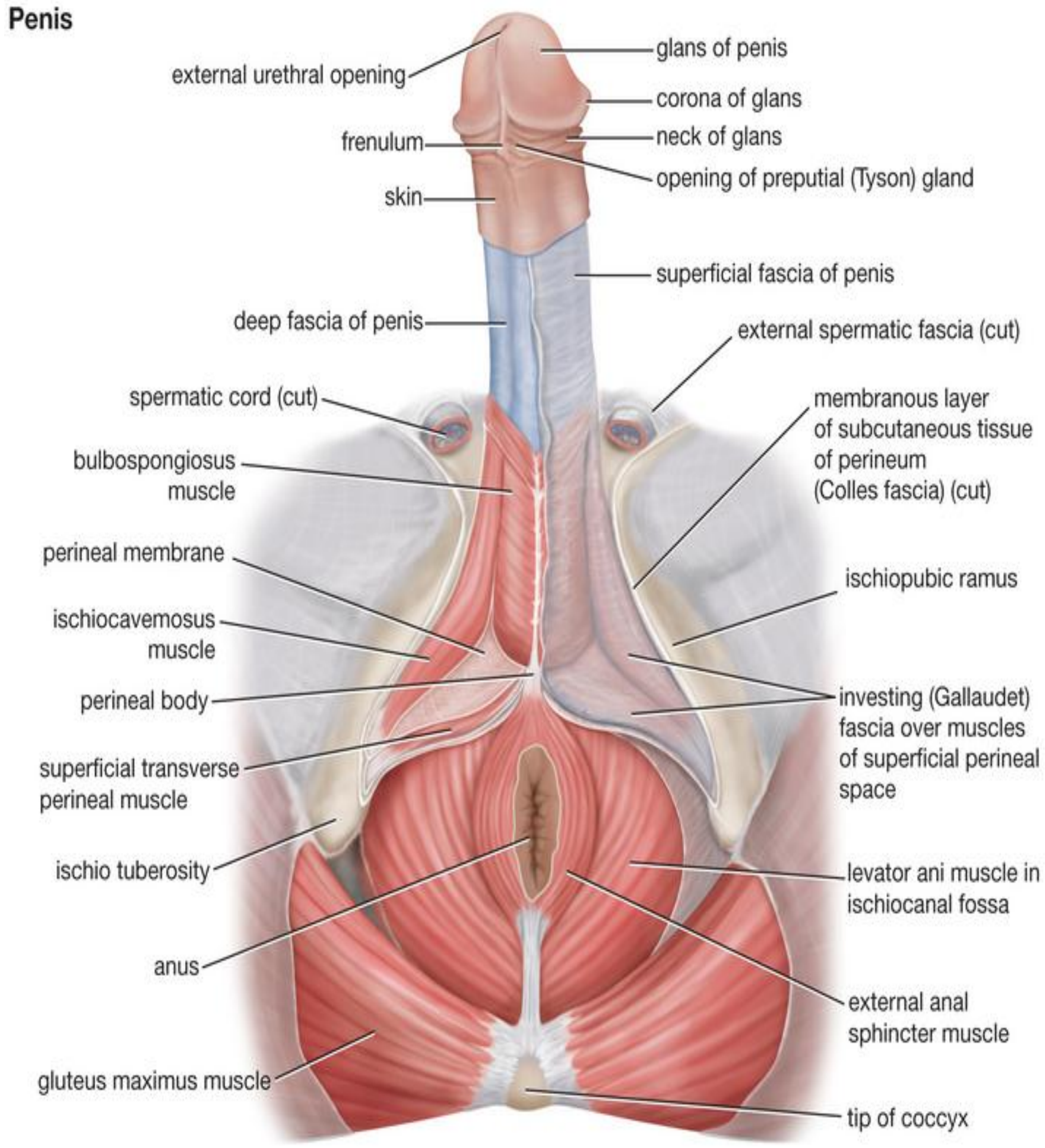


Figure 21. The penile underside showing different fascial layers [54]

4. The Glans Penis [48]

The **CS** continues to form the **distal end** of the penis described to be of a **conical** (a corn-like) shape. It is distinguished from the penile shaft by the so-called **neck of the penis**, a shallow, obliquely orientated circumferential groove.

The neck is partially overhung by the rounded edge of the **glans' base**, termed the **corona of the glans**.

The **collagen bundles** of the **tunica's outer longitudinal layer** in the **CC** aggregate to form a strong trunk within the glans called the **distal ligament.**

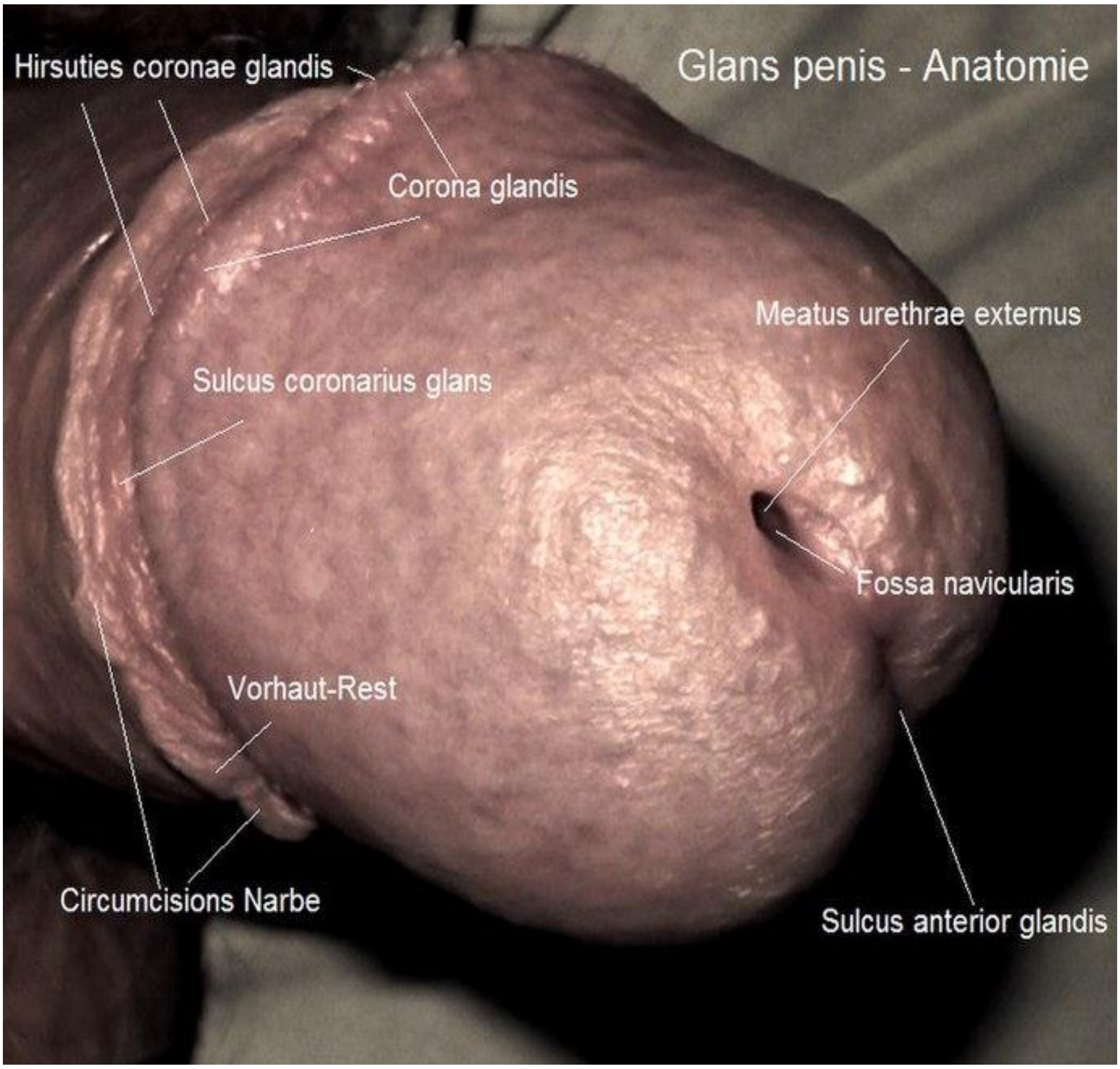


Figure 22. Anatomy of the glans penis [55]

5. The Penile Skin & Prepuce

The Penile Skin [48], [50]

It is characterized by being **thin**, **darker**, **hairless** (excluding the proximal end), and adequately **mobile**.

The distal extension of the skin from the **neck** of the penis over the **glans** is labelled the **prepuce** or **foreskin**, a **circumferential**, **mobile, double-layered**, **retractable** hood. With a variable extent of **glans** coverage between individuals.

The Prepuce [56]

The prepuce's **external layer** coating the glans is directly **continuous** with the **skin** overlying the whole shaft, along the **neck** line.

At the **neck** level, the region slightly bulging -because of the underlying **corona**- leaves the surface and becomes **folded upon itself** to form the prepuce.

It forms this small secondary **reduplication** directly behind the urethral **meatus,** and from this point, **the inner layer** continues proximally.

Note that the **integument** covering the glans is continuous with the **urethral mucous** membrane at the orifice.

On the **ventral** aspect, only the **inner prepuce** attaches along the bottom of a depressed **median raphe** forming **'frenulum'**, which extends on the ventral surface of the glans adjacent to the external urethral orifice.

The prepuce usually covers the complete length of the glans and is separated from it by the **'preputial sac,'** which presents a shallow **fossa** on either side of the **frenulum**.

At the neck, the **preputial sac's proximal border** is formed by the attachment of the **inner prepuce** proximal to the **corona** connecting to the shaft.

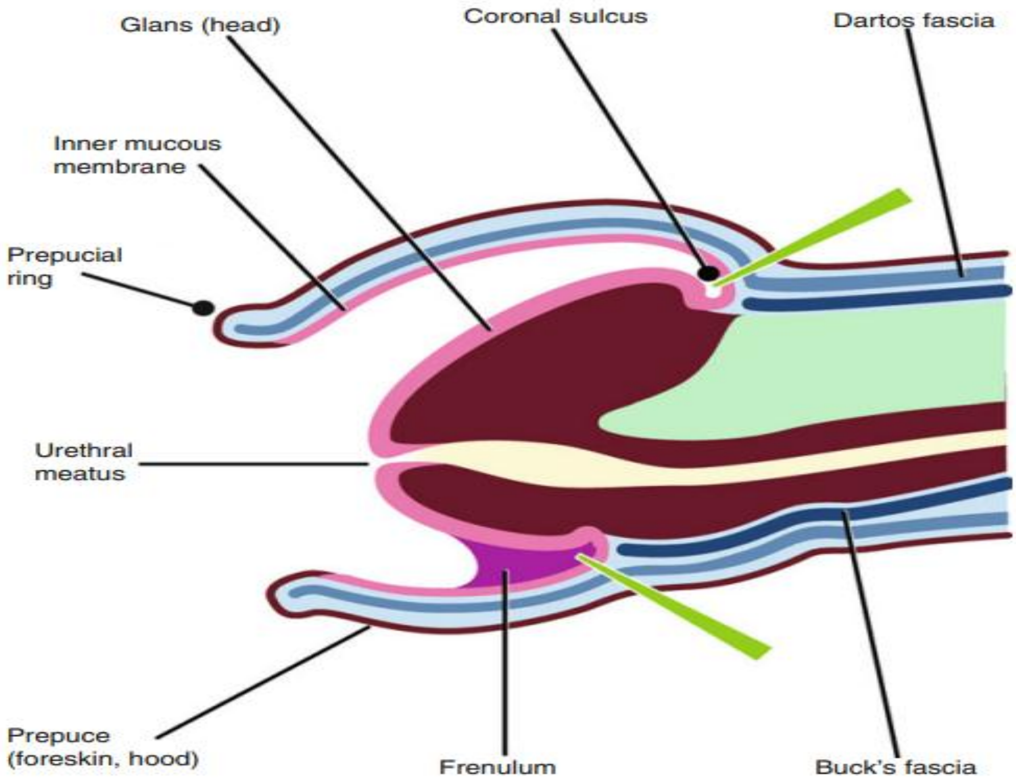


Figure 23. *Glans and prepuce illustration* [57]

Green wedges: site of circumcision.

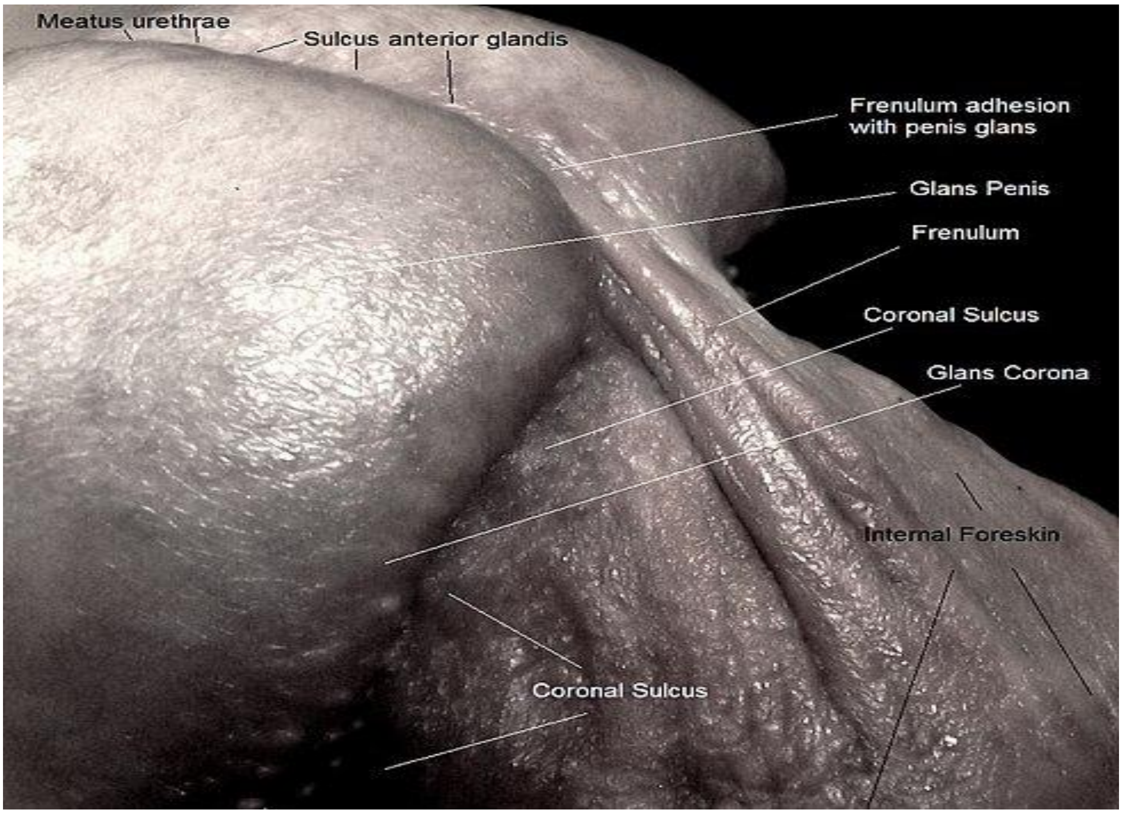


Figure 24. Ventral view of the glans showing the preputial frenulum [55]

Precise dissection of the prepuce showed that the **inner prepuce diverges** upon approaching the penile shaft **proximal to the corona**:

-The **innermost layer** labelled the **'inner aspect'** of the **inner prepuce**: curves under the corona to form the **coronal sulcus**; this is the 1st area of **attachment** of the **inner prepuce** to the most distal and extreme aspect of the **shaft.**

-The **outermost layer** labelled the **'outer aspect'** of the **inner prepuce:** is continuous along the **shaft axis** towards the root and **merges** with its **dartos** tunic, subsequently appearing as a single uninterrupted sheath.

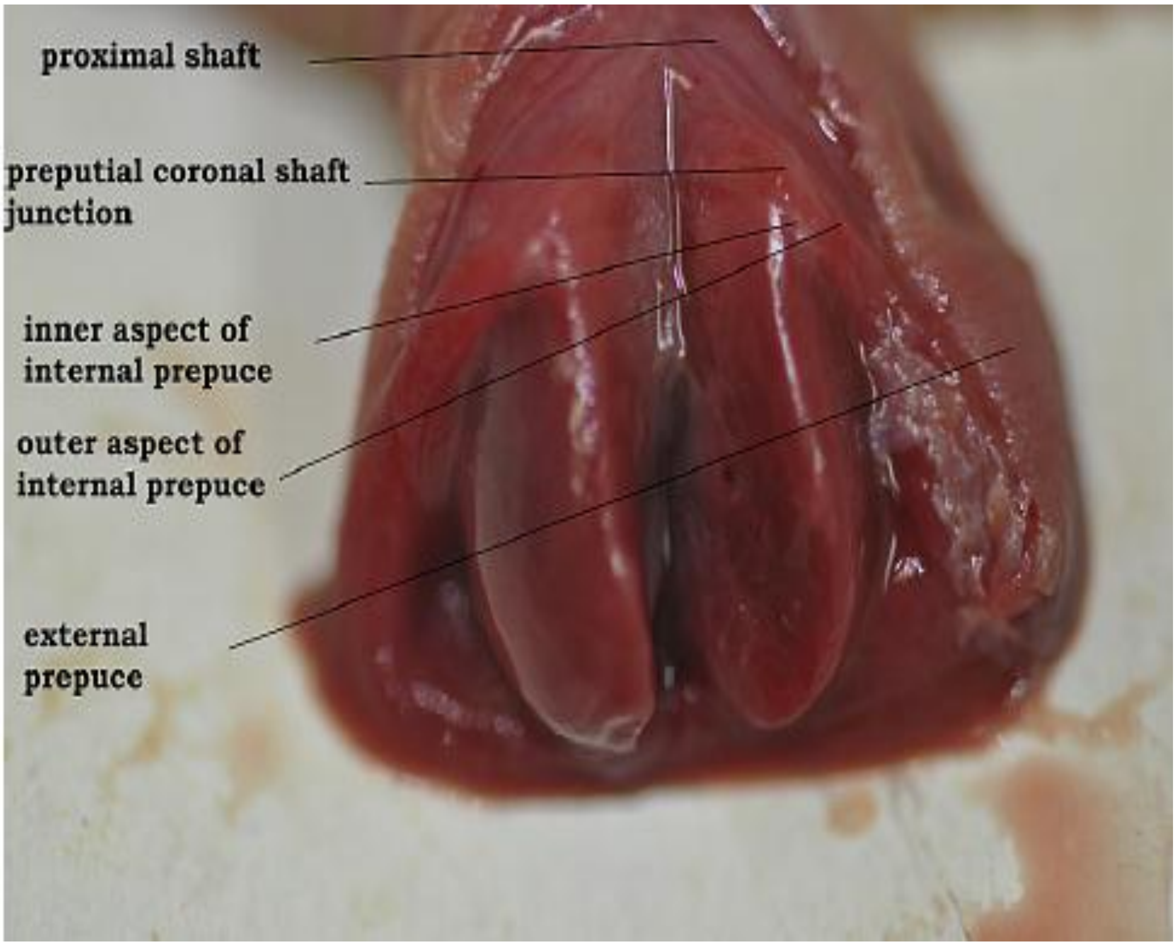


Figure 25. A sagittal section of the glans-shaft region through all layers [56]

*Showing the **dual** orientation of the **inner prepuce**: **Inner folding** of **internal** aspect & **Proximal merging** of **outer** aspect.

II. BLOOD SUPPLY, LYMPHATIC DRAINAGE AND INNERVATION OF THE PENIS

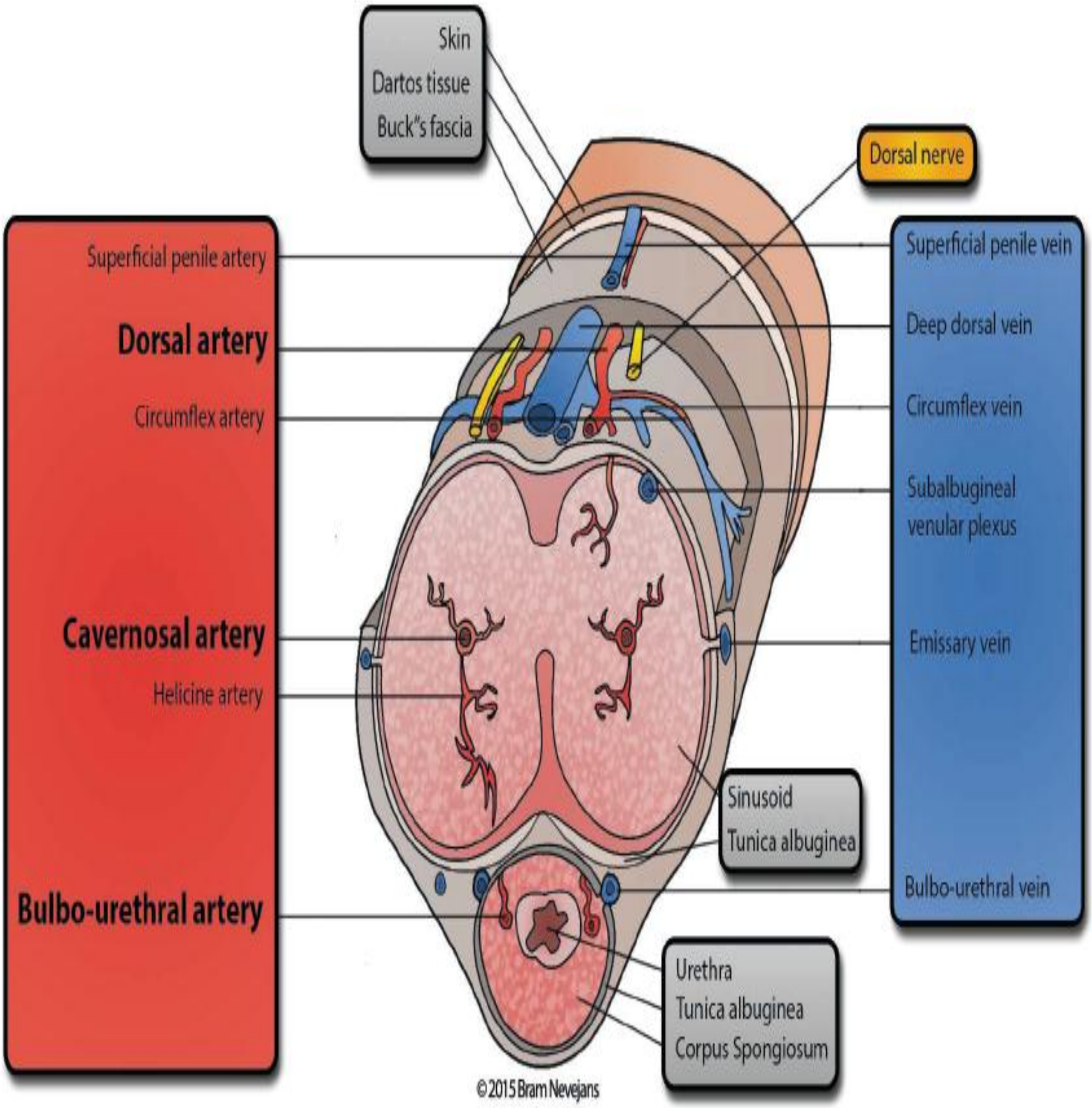


Figure 26. Cross-section of the penile shaft showing the blood supply [58]

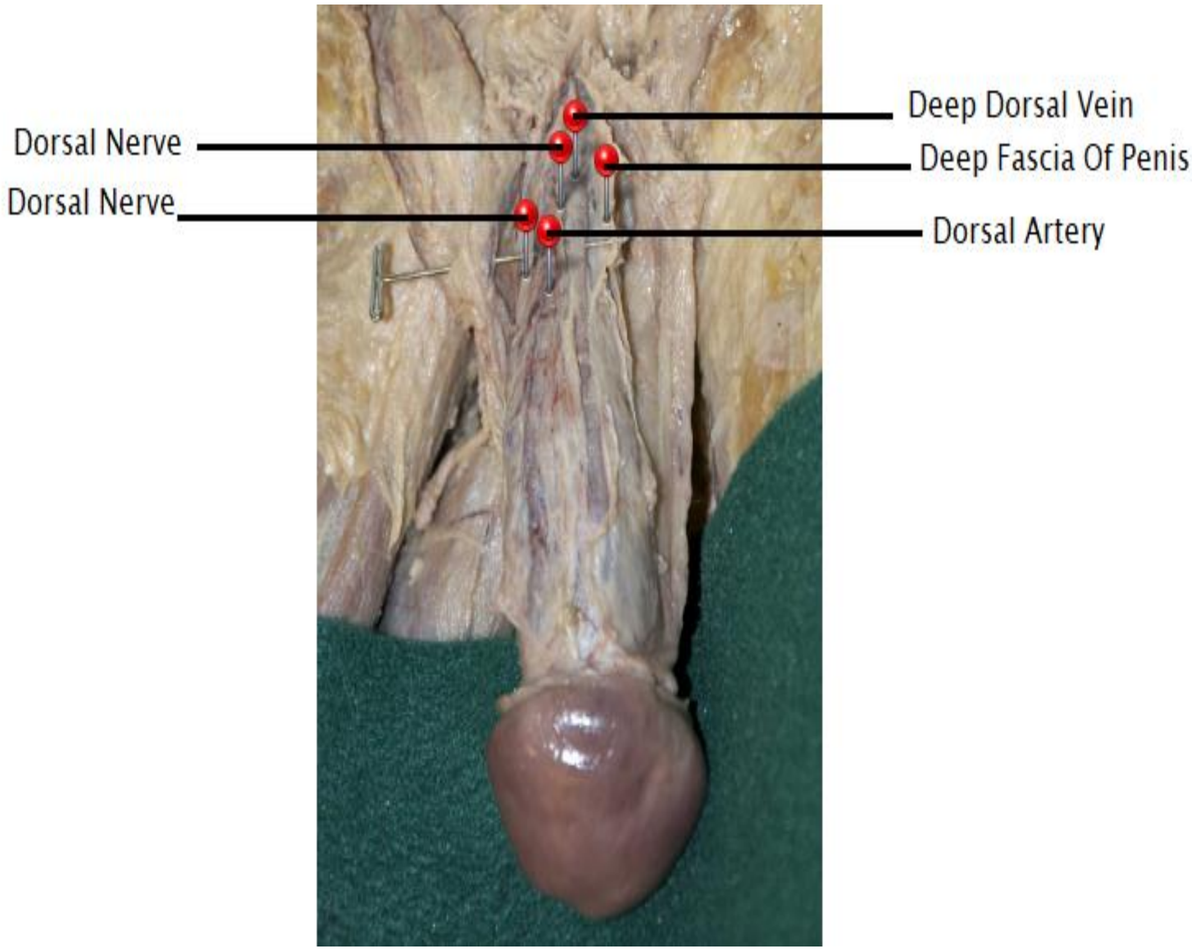


Figure 27. *Cadaveric dorsal penile view showing different vessels* [49]

1. Arterial Supply [47]

The penis is exclusively supplied by **the right and left deep internal pudendal arteries**, each giving rise to the **common penile artery** which then divides into an **artery to the bulb**, a **deep artery of the penis** (mentioned also as the **cavernosal artery**) and a **dorsal artery of the penis.**

>> The **bulb**, **corpus spongiosum**, **glans** and the entire **spongiose urethra** are supplied by the **artery to the bulb**.

>> The ipsilateral **crus** of the penis and the corresponding **corpus cavernosum** are supplied by the **deep artery**.

It enters the crus where it breaks up into multiple **helicine branches** that supply the **erectile tissue** of the corpus.

>>The **dorsal artery** irrigates the **penile skin**, the **dartos layer** and the **deeper fascial layers**.

The **deep artery** and the **dorsal artery** of the penis arborize distally in the erectile tissue of the **glans** and therefore provide retrograde blood flow into the **corpus spongiosum**.

Figure 28. Cadaveric dissection of cavernosal arteries [59]

***DAl**: Left dorsal artery;

***DAr**: right dorsal artery.

Figure 29. *Dorsal view of the penis showing the dorsal artery* [60]

2. Venous Drainage [47]

The venous drainage of the **penile skin** and **superficial structures** is via the **superficial external pudendal veins** bilaterally, that drain into the **right and left great saphenous veins**.

Venous drainage of the **deeper structures** including the **erectile tissue** is via the **deep dorsal vein of the penis (DDV)** that runs posteriorly under the pubic symphysis to join the **periprostatic venous plexus (of Santorini).**

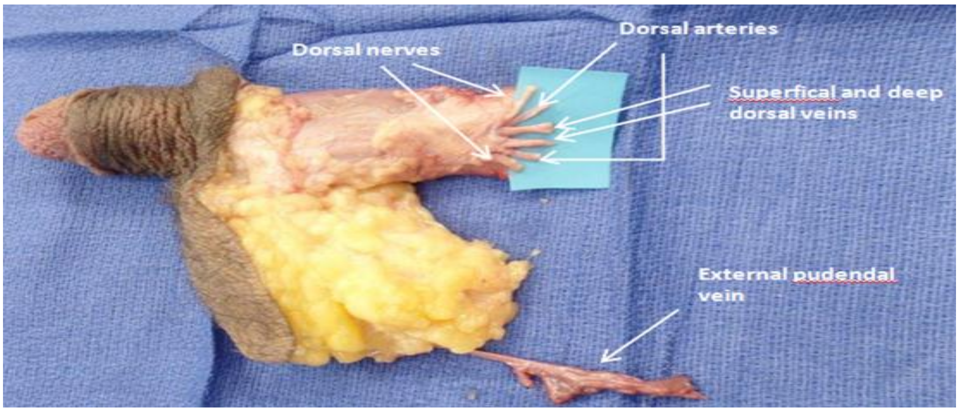


Figure 30. Cadaveric dissection of penile veins, arteries, and nerves [59]

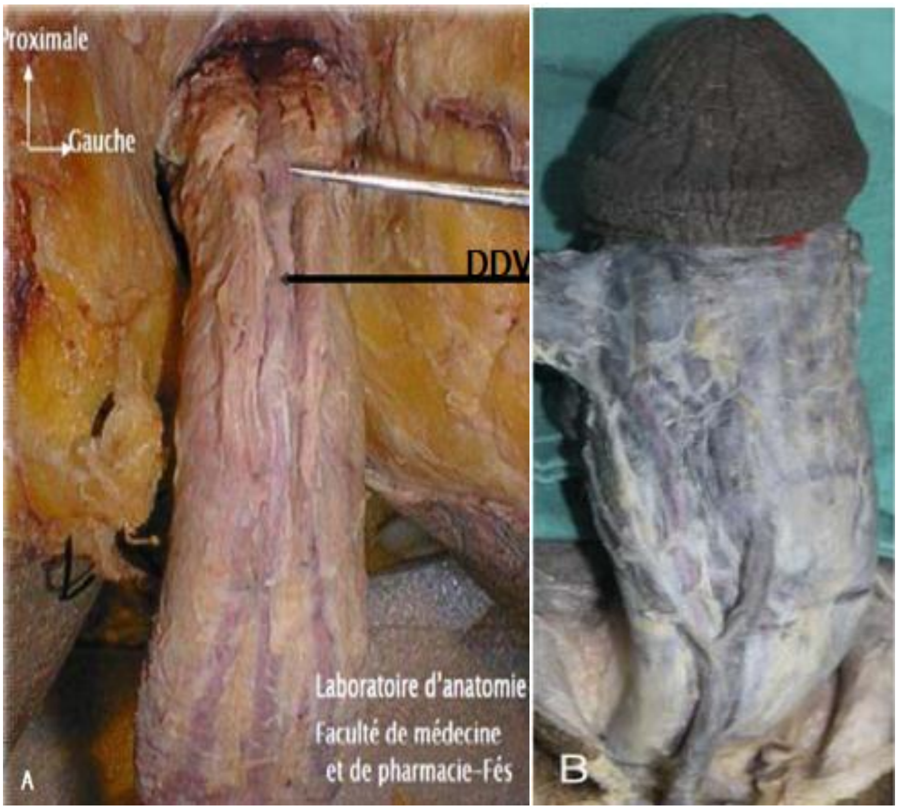


Figure 31. Dorsal view of the penis showing **A:** the DDV and [51] **B:** the SDV [60]

***SDV**: Superficial dorsal vein of the penis

A: **DDV** has a midline course on the shaft without a significant decline in its diameter.

B: **SDV** receives blood from its branches on the same plane and makes connections with DDV.

3. Lymphatic Drainage [47]

The lymphatic drainage of the penis is as follows:

- The **superficial inguinal lymph nodes** receive the lymph from the **penile skin** bilaterally.
- The **deep inguinal lymph nodes** receive the lymph from the **glans** and the **distal parts** of the **corpus spongiosum** and **corpora cavernosa**, and thence drains into the **external iliac lymph nodes**.
- The **internal iliac lymph nodes** receive the lymph from the **proximal parts** of the **erectile tissue.**

4. Innervation [48], [50]

The cutaneous innervation of the penis is from **the right and left dorsal nerves of the penis (DN)** which supply: the **dorsal** penile **skin**, the **glans** and **glanular urethra**.

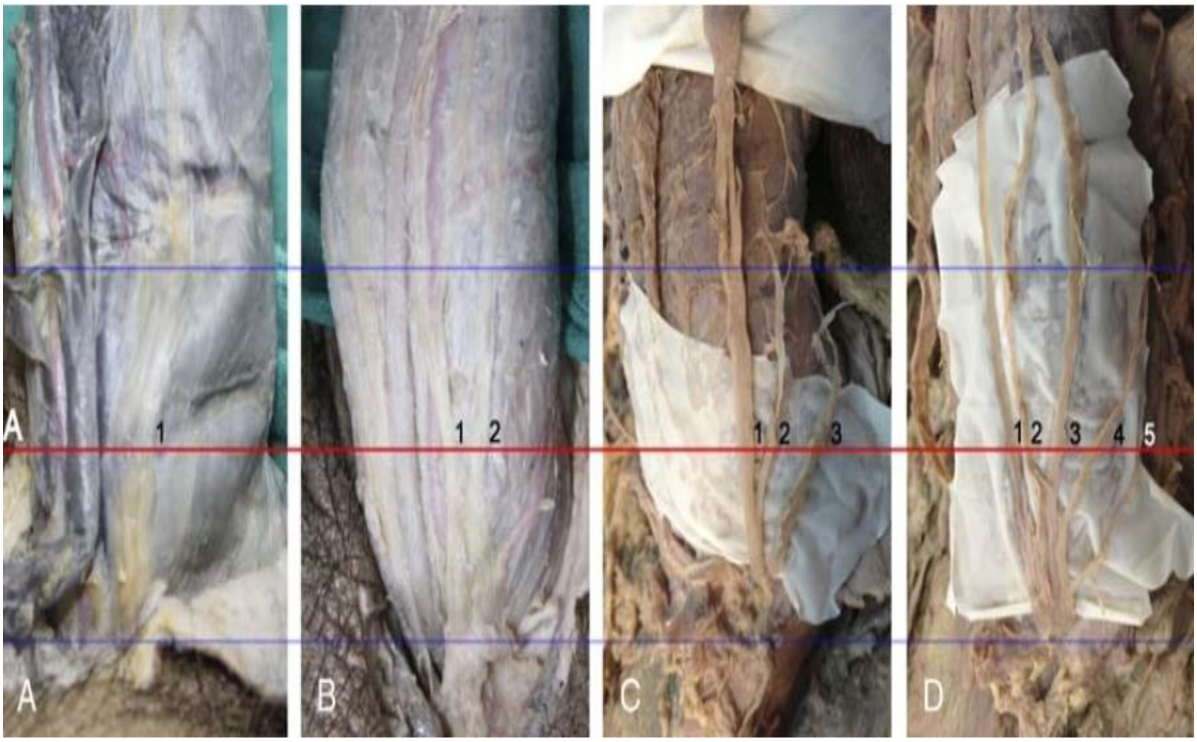
Each **DN** of the penis is a terminal branch of the corresponding **pudendal nerve**.

The **ventral skin** of the penis is innervated by the **right and left posterior scrotal nerves**, in turn, branches of the corresponding **perineal nerves (PN)**.

S2 is the **dermatome** represented by the penile skin.

The muscles of the penile root (the **BS** and the **IC**) are **striated** muscles and derive their motor innervation from the **right and left PN**, each being a terminal branch of the corresponding **pudendal nerve.**

The erectile tissue comprising the **CC** and **CS** is innervated by the **parasympathetic fibres** in the **pelvic splanchnic nerves** (**S2, S3 and S4**).



<u>Figure 32.</u> Branching pattern of DN in the proximal third of penile shaft [60]

The layers of **Buck's fascia** have been removed meticulously. At point A:

(A): DN may not have branched yet, **(B)**: may have 2 branches; **(C)**: may have 3 branches; **(D)**: or 5 branches.

III. <u>LIGAMENTOUS SUPPORT OF THE PENIS</u> [50], [53]

At the **junction** of the penile **root** and **shaft** on the **dorsal** aspect of the penis, **two** ligaments are attached in order to provide suspensory support.

The **suspensory (or triangular) ligament** is the more deeply placed of the two.

Arising from the **anterior** aspect of the **pubic symphysis,** it runs inferiorly to meet with **Buck's fascia** on each side of the proximal end of the penile shaft.

The second ligament is called the **fundiform ligament**. From its attachment to the lower end of the **linea alba** just above the **pubic symphysis,** it runs downwards and splits into **left** and **right laminae**. Each lamina runs on the ipsilateral side of the proximal penile shaft to meet on the ventral penile aspect and pass into the **scrotal septum**.

Trauma to the anterior part of the **pelvic ring** may result in an injury to either of these ligamentous structures with a resultant **ventral angulation** of the penile **shaft** during **erection**.

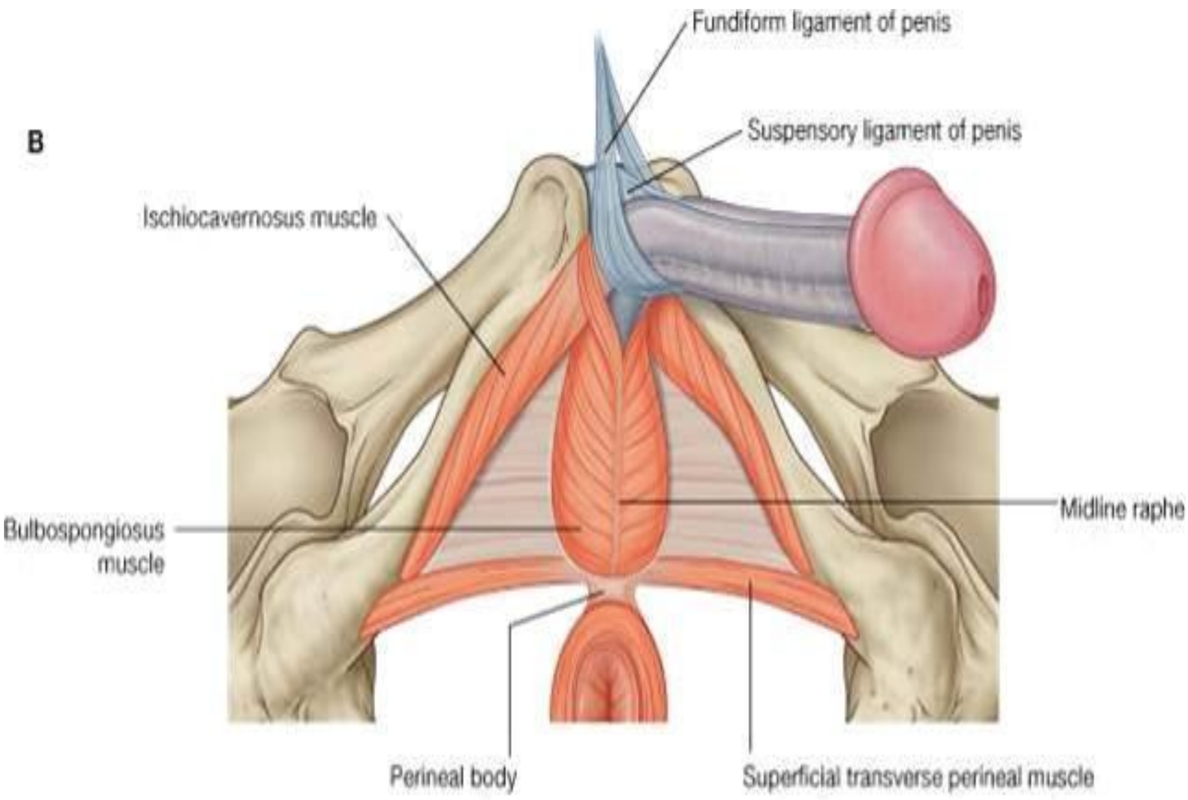


Figure 33. Superficial perineal pouch showing perineal ligaments [61]

IV. THE URETHRAL ANATOMY [62]

The urethra is enclosed within the vascular **CS** and the **glans**. The urethral **diameter** is **8 to 9 mm** in normal cases. Anatomists have categorized the urethra into **two broad segments**:

- **The posterior urethra:** begins distal to the **bladder neck** and continues as the anterior urethra at the **perineal membrane**.
- **The anterior urethra:** begins at the **perineal membrane** and ends distally by the **urethral meatus**.

A **flaccid** (non-erect) penile state shows the urethra with a **double curvature** and **4 parts**: **Pre-prostatic** (intramural), **Prostatic**, **Membranous** (**intermediate**), and **Spongy** (**Penile**) urethra.

The urethral **epithelium** is of a **transitional** type until it traverses the **glans** where it becomes **squamous.**

A smooth muscle with connective and elastic tissue, made up the so-called **submucosa** that comprises the **glands of Littre** that empty their ducts into the urethral lumen.

The urethral **arterial supply** is from **the internal pudendal artery** that irrigates: urethra, corpus spongiosum, and the glans, through its **bulbourethral branches.**

The **venous drainage** of the urethra is via **the pudendal plexus,** which joins later the **internal pudendal vein.**

The **lymphatics** from the urethra drain to **the internal iliac (hypogastric)** and **common iliac nodes**.

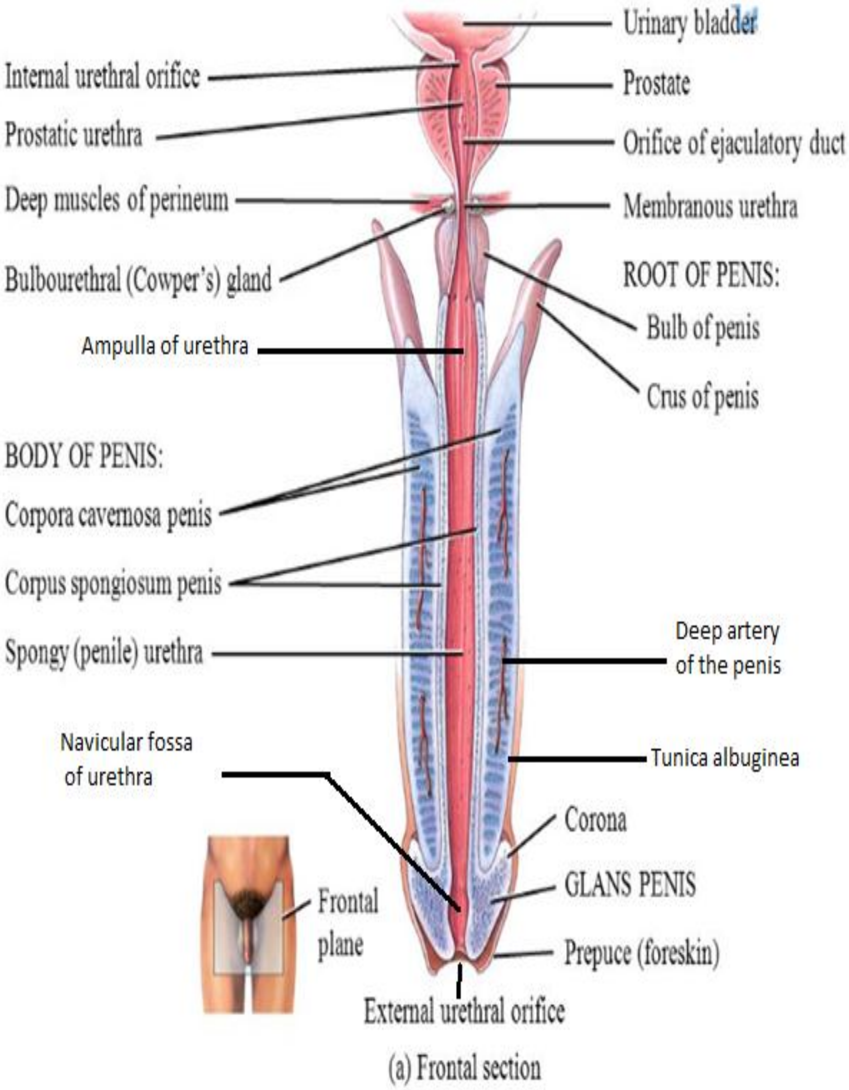


Figure 34. Illustration of the posterior wall of the male urethra [52]

The Penile Urethra (PU): [62]

The **Penile urethra**, also termed the **Pendulous urethra** or the **Spongy urethra**, as it is surrounded by the **CS**, is the segment distal to the membranous urethra. **PU** is furtherly subdivided into **2 parts**:

-At the **membranous-penile** urethra junction, the segment is specifically termed the **bulbo-membranous urethra**. It comprises a **2-cm** length of the urethra within the **urogenital diaphragm** as well as being within the **striated urethral sphincter** and the first few proximal centimetres of the **bulbous urethra**, just distal to the sphincter within the penile **bulb**.

-Continued with the **bulbo-spongy urethra** that extends distally to the level of the **suspensory ligament**. The lumen widens to form the **urethral bulb.**

The **bulbourethral glands** (also termed **Cowper glands)** that are located more proximally on either side of the membranous urethra, empty into this part of the urethra at the 3 o'clock and 9 o'clock positions.

From the **suspensory ligament** to the **meatus**, the **PU** measures around **15 cm** in length in its entirety. Within the corpus spongiosum, the **PU** is positioned more dorsally than ventrally.

There are 2 segments where the urethral lumen is **widening**: the **bulb** and the **fossa navicularis**; otherwise, the lumen diameter is consistent throughout.

The **mucosa** of the **PU** includes a **transitional epithelium** until it traverses the glans at the **fossa navicularis**, where it becomes a **squamous epithelium,** then **keratinized** near the **meatus.**

The **muscle layer** is composed of **3** layers: an **inner** and an **outer longitudinal**, and a **middle circular**.

Between the trabeculae and the vascular spaces, the **glands of Littre** enter the spongy tissue. They are made up of small **mucus-secreting** cells that lubricate the urethra before ejaculation, and they empty their ducts into orifices on the **posterior wall** of the **PU**.

The bulbourethral artery, which is a **branch** of the **internal pudendal artery,** enters at the level of the penile bulb to supply the penile urethra.

Venous drainage of the bulbar urethra is by **bulbar veins** that drain into the **pudendal plexus**, which drains into the **internal pudendal vein**.

Some of the penile urethral **lymphatic drainages** travel along the **urethral artery** or **artery of the bulb**, while others drain to the **medial retro-femoral node** after travelling behind the pubic symphysis.

The **sensory innervation** of the **PU** runs through **submucosal axons** that pass centrally through the **dorsal nerve** of the penis.

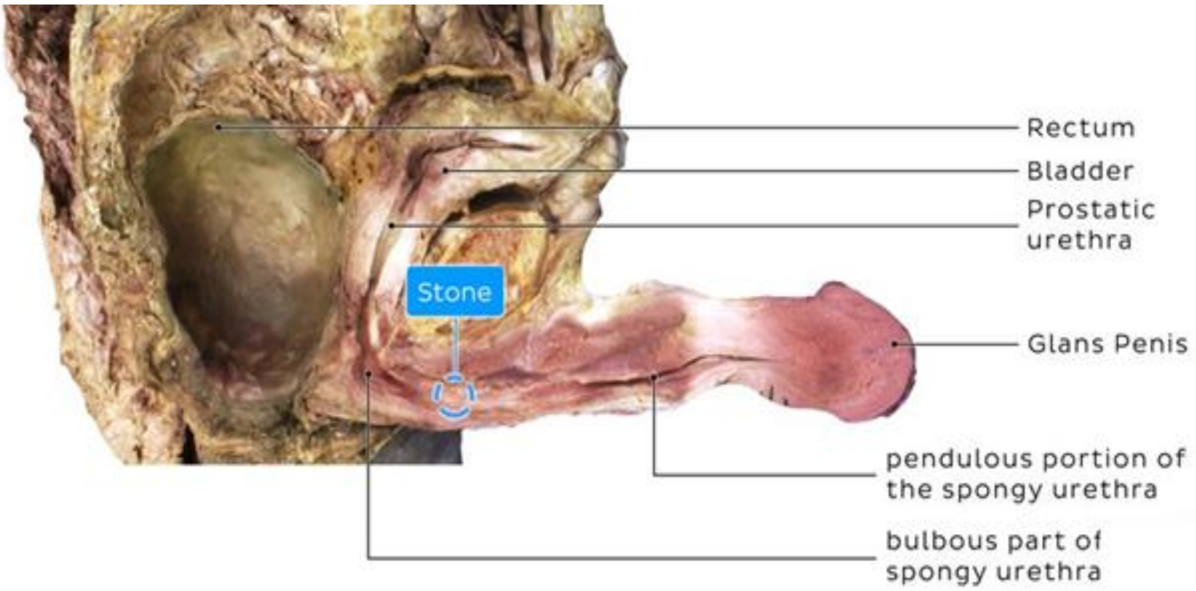


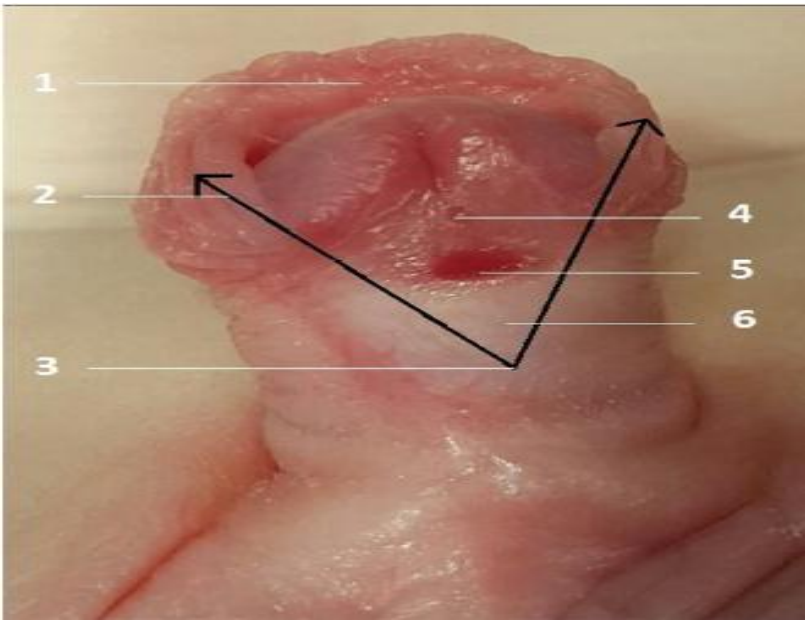
Figure 35. Cadaveric dissection of male urethra [63]

V. MORBID ANATOMY [64]

Anatomically, hypospadias includes the following:

- A ventrally opened glans
- A urethral plate extending from the **ectopic urethral meatus** up to the tip of the glans is replacing the missing segment of the tubular urethra that is of a variable length.
- The urethral tube between the two CC is described as hypoplastic since it is not surrounded by any CS.
- A **ventral curvature** of the penis (chordee) and
- A **hooded foreskin**: marked excess of skin on the dorsum of the penis and a lack of skin on the ventral surface of the penis.

The last two features are not constant findings.



1.Incomplete prepuce resembling a dorsal hood

2. Internal and external blade of the prepuce

3. Division of CS

4. Urethral plate

5. Hypospadiac meatus

6. Hypospadiac urethra

Figure 36.Anatomical features of hypospadias [65]

Neurovascular anatomy of hypospadias:

Using immunohistochemical localization and three-dimensional computer reconstructive techniques, **Baskin and colleagues** [66] studied **neural** and **vascular** anatomic features of **10 normal** and **1 hypospadias** fetal penis.

They showed that the **dorsal nerves** originate proximally from the **pudendal nerve** and continues as **2** well-defined **bundles** under the **pubic rami** superior and slightly lateral to the urethra. This was **similar** for **both** the hypospadiac and normal fetal penises compared. As the 2 crural bodies converge into the CC, the nerves diverge, spreading around the CC to the junction with the urethral spongiosum.

Nervous tissue fans out in this way **from the 11 and 1 o'clock positions** all along the penis and ceases being confined to 2 well-defined bundles. They also reported, just as in a normal penis, an **absence of neuronal structures at the 12 o'clock position** along the **entire shaft** of the penis, providing a **guide for dorsal plication**.

Moreover, **Baskin et al. (1998)** [67] continued on the comparison, this time using immunostaining techniques that detected the **vascular supply** as the most striking difference.

The **distal urethral spongiosum** and **glans** in the **hypospadiac** penises were **extensively vascularized** compared with the normal examined ones.

Baskin et al. proposed to make the **incisions** during hypospadias repair in these sites (distal urethral spongiosum & glans), which are **rich** in **large endothelial-lined sinuses**, which results in the release of epithelial **growth factors** that encourage tissue repair without significant **scar** or **stricture** formation.

The **blood supply of the prepuce** has also been delineated with **70%** of patients having **1 or 2 predominant vessels** that allow for well vascularized preputial flaps. Conversely, 30% of patients had a **capillary network** present without dominant vessels, thus creating a challenge for the development of preputial flaps. [68]

Histological analysis has shown that the **UP** in **hypospadias** is **well vascularized**, with **sinusoids** of **abortive urethral spongiosum**, and **without scar tissue**. These features may explain the successful use of incorporating the UP or abortive spongiosum into hypospadias **reconstruction**.

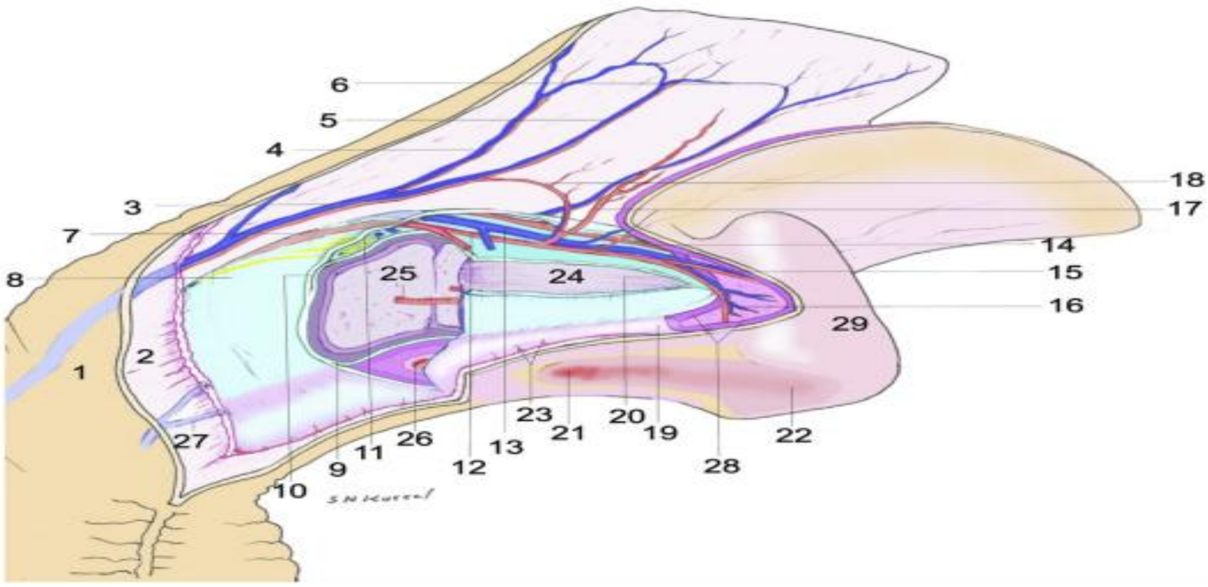


Figure 37. Schematic diagram, on the basis of magnetic resonance and operative findings, showing the relevant surgical anatomy of tissue planes and the vessels in a case of distal hypospadias [69]

NB:

- Inner preputial skin with lamina propria is shown as split off of the **preputial dartos** and outer preputial skin to show the arrangement of vessels in preputial dartos and the **penile dartos**.
- The part of the penile skin and dartos from the right lateral aspect of the penile shaft is shown as schematically removed.
- Just proximal to the hypospadiac meatus, the transverse wedge of tissue from the lateral aspect of the penile shaft is shown as removed.
- A slice of tissue from the lateral aspect of the corona, glans, and the corpora-glanular junction is also shown as removed.
- Dorsal split of **Buck's fascia** (**BF**) is shown as opened up at the sub-coronal level to show the arrangement of vessels and sub-glanular extension of **BF**.
- Parallel to bifurcated CS on the lateral aspect of CC, the **BF** is shown as opened up to show the subfascial plane.

(1) Penile shaft skin **(2)** Penile **dartos**

(3) Dorsal superficial penile vessels coming from external pudendal vessels running in the dartos fascia and dividing into:

(4) dorsolateral & (5) dorsomedial transverse branches

(6) Just proximal to preputial edge transversely oriented terminal bifurcations anastomose with similar vessels of the contralateral side. Midline is relatively avascular.

(7) The plane of loose areolar tissue between the penile dartos and BF

(8) Buck's fascia:

(9) Ventral splitting of **BF** to encase **CS**

(10) Dorsal splitting of **BF** to encase:

(11) Dorsal nerve (12) Dorsal penile artery (13) Dorsal penile vein

(14) Dorsal penile vessels entering the base of glans at the coronal sulcus and remain dorsal to **BF** and the **tunica albuginea**, but perforating the lamina propria of the base of glans

(15) Medial terminal branches of the **dorsal penile artery** run into the glans as straight branches, while

(16) Lateral terminal branches run towards the laid open glanular meatus as an arcade

(17) Branches from the dorsal penile arteries to the inner prepuce and the preputial dartos

(18) Anastomosis between the dorsal penile branches and dartos vessels at the coronal sulcus

(19) Bifurcated CS continuous with glans tissue

(20) Subfascial plane between BF and the tip of corpora for glans wing mobilization

(21) Hypospadiac meatus

(22) External **meatal groove** ventrally migrated and shallow

(23) Perforators between CS and paraurethral dartos

(24) Tunica albuginea of the CC **(25)** Right **cavernosal artery** **(26)** Urethra

(27) Attenuated ventral dartos vessels from anterior scrotal vessels

(28) Lamina propria of the glans **(29)** Flattened glans.

EPIDEMIOLOGY

"The penis is mightier than the sword"

-Mark Twain

I. EUROPE AND THE USA

In **Europe** and the **USA**, the estimated prevalence of hypospadias ranges up to a maximum of **3 per 1,000 births**, with about **two-thirds** to **three-quarters** of cases being **glanular** or **coronal** varieties. [1]

Numerous studies reported **increasing trends** in the prevalence of hypospadias. **Hungary** and the **UK** in the 1980s [70], [71], and later in **Australia** and the **USA** [72], [73] and the **Scandinavian** countries [1], [74].

In their **30-years** experience, during the period **1940 to 1970**, inclusive, **Sweet and colleagues** noted **113** cases of hypospadias in **13,776** live male births (**1 of every** 122), **87%** of defects were **coronal** or **glanular**.

In their review of the literature from **five** different **countries**, **Sweden** had the **lowest** reported prevalence, **1 in 1250** live male births. [75]

In **1997**, two independent and well-established surveillance systems in the **United States**, the Metropolitan Atlanta Congenital Defects Program (**MACDP**) and the nationwide Birth Defects Monitoring Program (**BDMP**), reported near-**doubling** of hypospadias rates in the most recent compared with the immediately preceding decades; from **2.02 per 1000** male births in **1970** to **3.97 per 1000** in **1993**. In other words, approximately **1 in every 250** live male births was a boy with hypospadias. [73]

A **Dutch** study (**2002**) reported a higher prevalence of **3.8 per 1,000**. That may be relatively related to **sensitization to diagnosis** by special **training** of child health center **physicians** for the survey, although it should be noted that the proportion of distal cases was not higher than habitual. [76]

II. DATA OUTSIDE EUROPE AND USA

The obtainable literature reviews on the prevalence of hypospadias revealed an **upsetting silence** from **Africa**. However, there are some hospital-based cohort studies published in **Nigeria, Egypt,** and **South Africa**. [77]

Same matter for **South-East Asia**, there are **limited national registries**, which are generally hospital-based, and very **little surveillance data** available. There are hardly any population-based information surveys [78].

A rate of **5.41/10,000** births has been roughly estimated in **India**, equivalent to **15,000** hypospadias **cases/year** [78].

On the other hand, **China** with a national birth defect monitoring network has repeatedly reported a **very low prevalence** of hypospadias. This singular fact deserves further genetic and environmental researches. [79]

ETIOLOGICAL HYPOTHESIS OF HYPOSPADIAS

"The brain is viewed as an appendage of the genital glands"

–Carl Jung

It's generally agreed that the **incomplete closure** of the **urethral folds** located in the undersurface of the penis and furtherly form the urethra, results in hypospadias. [80] More recent reviews suggest a **multifactorial etiology** of hypospadias, which may include one or more of the following:[81]

I. HEREDITARY FACTORS

It has been demonstrated that one of the **sons** of a hypospadias **carrier father** has an **8%** chance to be a carrier himself. In comparison, the likelihood that one of his **brothers** will also be affected reaches **12%**. Moreover, the **next generation's** risk increases to **26%** if **2** members of the same family are carriers. (when the father & one of the sons are affected). [75], [82] These findings may explain the tendency to higher prevalence over time since patients with hypospadias themselves reach paternity thanks to surgical success. [74]

In the other hand, low birth weight **LBW** has been incriminated to be a risk factor, as shown by **Roberts and Lloyd**. They noted an **8.5**-fold higher rate of hypospadias in **monozygotic male twins** than **singleton** live male births.[83]

They suggested that this association of monozygotic twinning and hypospadias may result from an **inability** of a **single placenta** and **reduced hCG** levels to meet the requirements of two developing male fetuses. To note that the twin with the **LBW** was the one affected. [84]

II. GENETIC FACTORS

Earlier molecular analyses have revealed that there might be a **mutation of the gene** responsible for the enzyme activity of **5-alpha-reductase II** which catalyzes the conversion to **dihydrotestosterone (DHT)** from **testosterone**. Leading to disturbance of DHT production, which is necessary for the development of the male genito-urinary tract by binding to androgen receptors, resulting in urethral closing. [85]

Recent studies have shown that **alterations** affecting certain genes - **gene HOXA13** - are susceptible to change the **receptor's response** to **androgens** (located at the level of the **genital tubercule**) and lead to the phenotypic expression of hypospadias. [86]

III. ENDOCRINAL FACTORS

Nowadays, it is widely accepted that **androgens** play a **crucial** role in the development of the male external genital organs. Recently, anatomical studies support the hypothesis that the **ventral urethral part** is formed thanks to androgens essentially. This type of research supports even more strongly the possibility that hypospadias can appear:

- Following insufficient **testosterone** and/or **dihydrotestosterone production** (due to defective or deficient **5α-reductase** enzyme activity).
- Via qualitatively and/or quantitatively **defective androgen receptors.** [87]
- Abnormal **androgen production** by the **fetal testis.**
- **Premature cessation** of androgenic **stimulation** secondary to premature involution of **Leydig cells** of the fetal testis. [88]
- Limited **androgen sensitivity** in the target tissues of the developing external genitalia.
- **Androgen resistance** (androgen insensitivity syndromes).[89]

It has been elucidated that males born through in vitro fertilization **(IVF)** have an increased risk of hypospadias due to maternal exposure to **progesterone**, commonly administered in IVF protocols, which is a substrate for 5-alpha reductase and acts as a competitive inhibitor of the T-to-DHT conversion. [90]

Excessive production of the **anti-Müllerian hormone** (AMH) may contribute to hypospadias development by interfering with testosterone's biosynthesis. [87]

It has been identified that genotypic male infants born with a **severe deficiency** of **3β-hydroxysteroid dehydrogenase enzyme** (a microsomal enzyme essential in the biosynthesis of almost every biologically active steroid hormone) have incomplete masculine development and hypospadias.[91]

IV. ENVIRONMENTAL FACTORS [92]-[94]

In recent years, it has begun a debate centered on the hypothesis that certain exogenous origin substances that mothers may be exposed to, known as **endocrine disruptors (**the **xenoestrogens** & the **anti-androgens)**, could be responsible for masculine sexual differentiation disturbances. Mainly through affecting the normal development of the **urethra**, but equally influencing **testicular descent** and **cancer**, and **spermatogenesis'** physiology; as a part of the Testicular Dysgenesis Syndrome (TDS).

The use of oral contraceptives during a part of the pregnancy results in estrogen exposure, but no substantial evidence has been found for this correlation. [95]

CLASSIFICATION

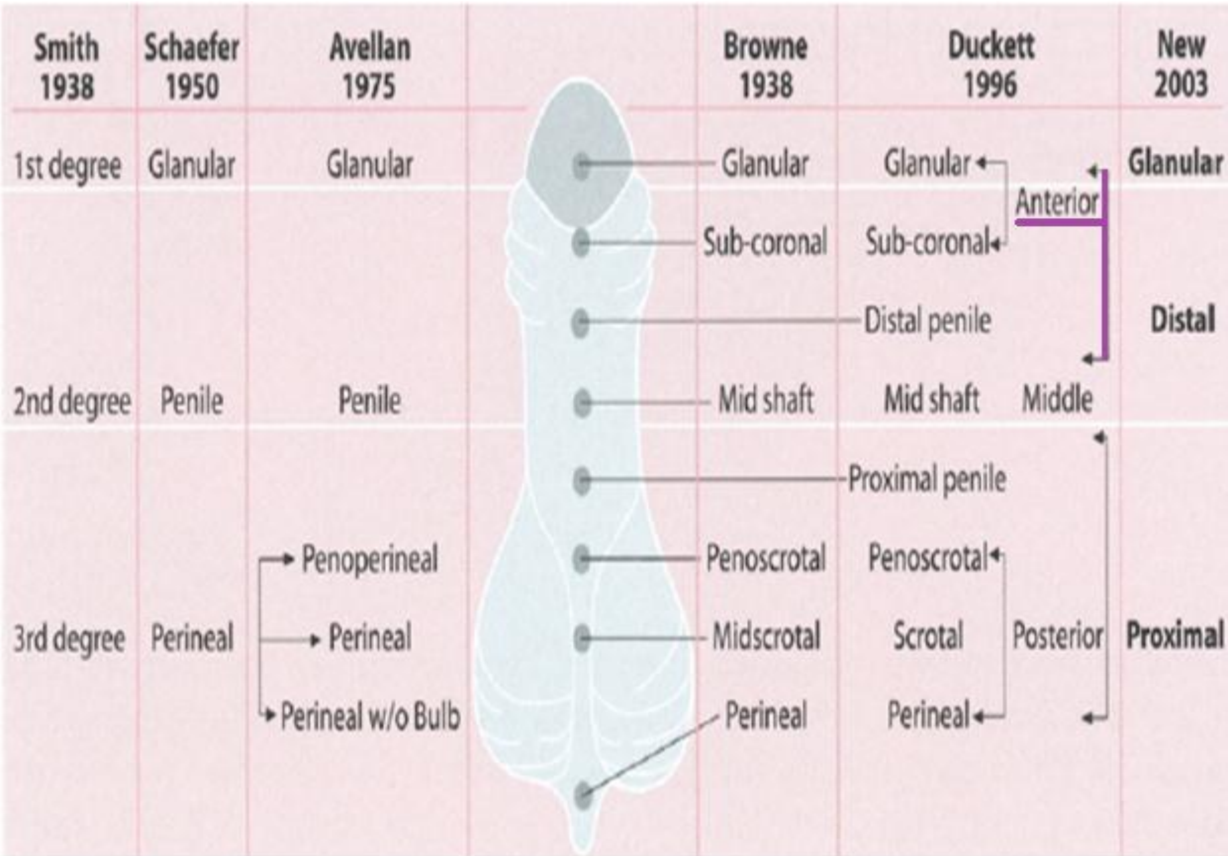
"No matter how far a man can urinate, the last drop will always land between his feet"

-Kenyan Proverb

Many different classification systems with varying utility have been proposed throughout history.

In our thesis, we are adopting the **Duckett**'s. [96] He classified hypospadias according to the meatal location after the release of curvature into:

- **Anterior** (=distal= the **most predominant** variety): **Glanular**, **Sub-coronal** and **Distal penile**,
- **Middle**: **mid-shaft**,
- **Posterior** (=proximal): **Proximal penile**, **Penoscrotal**, **Scrotal** and **Perineal**.



<u>Figure 38.</u> Different classifications of hypospadias, according to EML [97]

Usually, the **degree of curvature** is not remarked upon and may go unnoticed except by wide experienced urologists. Therefore, in order to achieve a universal, comparable classification, **two assessments** are recommended:

(1) A preoperative evaluation, as regards the meatal location, should indicate the presence or absence of visible penile curvature.

(2) An intraoperative evaluation, based on the position of the meatus after correction of penile curvature. We use either technique designed for **distal** or **proximal** hypospadias, whilst **mid penile** hypospadias, for its part, there are no specific designed operations. [98]

In our thesis we are interested in **anterior** hypospadias only:

A) **Glanular** hypospadias: meatus on the ventral surface of the glans penis

B) **Sub-coronal**: meatus on the balano-penile furrow (or coronal sulcus)

C) **Distal penile hypospadias**: meatus on the distal third of the penile shaft

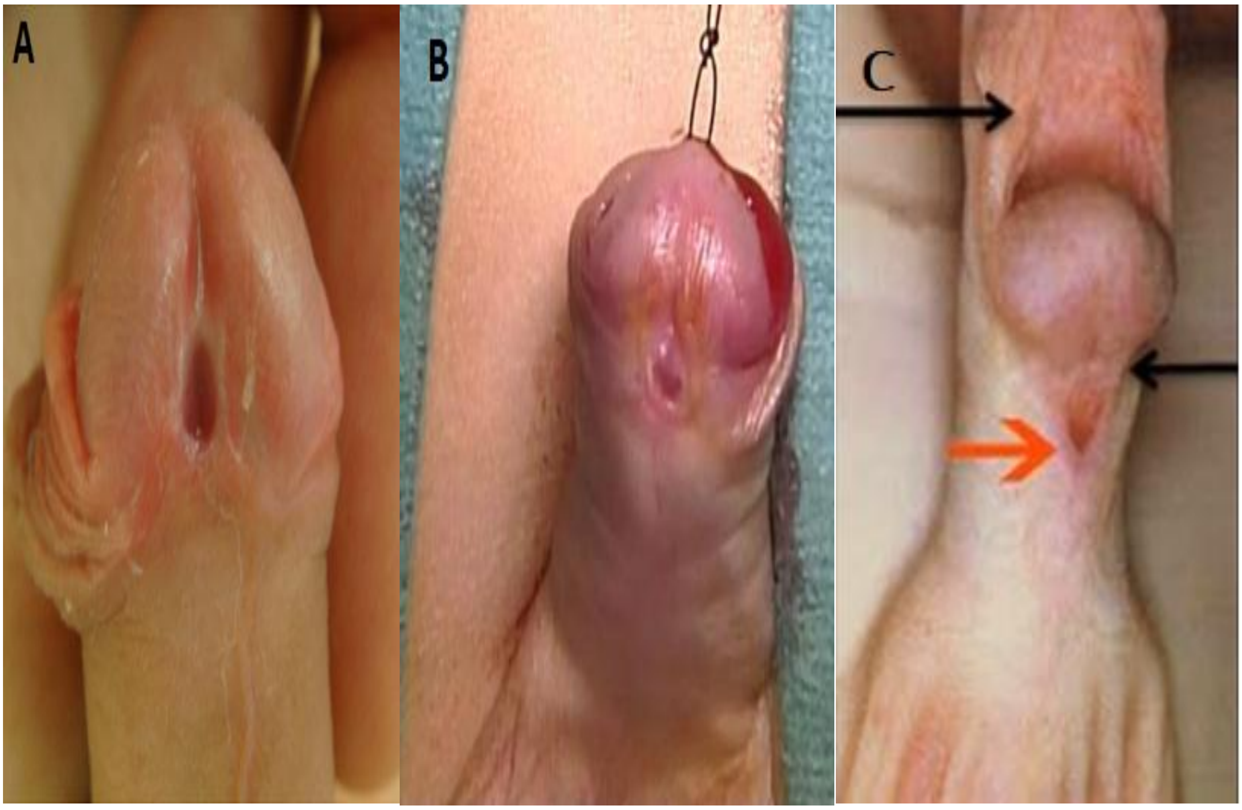


Figure 39. (A) Glanular hypospadias (B) Subcoronal hypospadias (C)Distal penile hypospadias [99], [100]

DIAGNOSIS & ASSOCIATED ANOMALIES

"A penis never lies"

-Thomas Szasz

I. PRENATAL SCREENING

Hypospadias may be associated with some **syndromes** and **chromosome abnormalities**. Therefore, prenatal diagnosis is important to **plan karyotyping**, to look for association with any possible dysmorphic syndromes and to **reassure the parents**. We can perform **sonography** with a **vaginal probe** in **early** pregnancies and an **abdominal** sector **scanner** in the **advanced** ones. [101]

Meizner et al presented a specific sonographic appearance of **severe** hypospadias termed the "**tulip sign**", referring to an incurved, small penis with a blunted tip situated between the 2 scrotal folds. [102]

In our country, where families are very curious about the **gender of the fetus**, prenatal ultrasound should include not only fetal sex determination but also detection of **abnormal genitalia**.

II. POST-NATAL DIAGNOSIS

1. History [103]

Detailed family history should be obtained. We should record all previous members of the family with hypospadias. To note that **14%** of male siblings of an index child have hypospadias. If **2** members of the family have hypospadias, then the risk is **21%** in subsequent male children. Also, maternal ingestion of hormone medications during pregnancy should be ascertained.

2. Physical Examination [62], [103]

The diagnosis of hypospadias is generally made upon physical examination of the newborn infant. A closer inspection shows an asymmetrical preputial development: **hooded dorsally** and **incomplete ventrally** with a ventral **glanular groove** and an **ectopic** urethral **meatus**.

Rarely, the prepuce may be **complete**, and only at the time of **circumcision,** we discover the hypospadias. In this case, after the dorsal slit has been performed, we should **halt the procedure**, and **refer** the patient for **urologic evaluation**.

Ventral chordee may be present, it may be readily apparent or only discernible during intraoperative erection test.

One should assess the **elasticity** and/or **agility** of the **ventral skin** and the **urethral plate** and the adequacy of the **foreskin**, without omitting careful **palpation** of the **testes** in the scrotum.

3. Radiological Evaluation [104]-[106]

In general, the literature doesn't support routine **urinary tract** imaging with either **ultrasonography** or **intravenous urography** for evaluation of children with **isolated** non-syndromic hypospadias**, regardless of** its **severity,** particularly when the ectopic meatus is anterior or middle in location. It is widely recognized that **upper renal** and **ureteric anomalies** are extremely rarely found with hypospadias.

III. ASSOCIATED ANOMALIES

Hypospadias appears most often in an isolated manner, **approximately 90% of cases are isolated penile defects**. However, it is known that other genital malformations or anomalies, some more serious than others, sometimes accompany this condition. [107]

1. Cryptorchidism and Inguinal Hernia

Associated abnormalities include **cryptorchidism** (**8% to 9%**) and **inguinal hernia** and/or hydrocele (**9% to 16%**). These overall rates for males with hypospadias increase significantly in those with more proximal defects.

The **concomitant** occurrence of **hypospadias** and **cryptorchidism** even in the setting of non-ambiguous genitalia should alert the urologist to evaluate for the possible presence of an **intersex state**. [7], [108], [109]

2. Urinary Tract Anomalies [110]

They are **infrequent** as the external genitalia are formed much later.

The penile skin must be well developed, elastic and non-tethering; however, it may be:

- very thin, preventing the use of perimeatal skin flaps for urethral plate repair.
- underdeveloped and act as a tethering fibrous band that bends the penis during micturition or erection.

Müllerian duct remnant may be associated with penoscrotal hypospadias and be responsible for recurrent urinary tract infections.

Utriculus masculinus may be mild, but may also cause recurrent urinary tract infection and difficulty in passing a urethral catheter.

3. Genetic Associations

Aarskog [111] was one of the first to perform **cytogenetic analyses** in patients with hypospadias. He found a **normal karyotype** in **all** cases of **glanular hypospadias** and noted that abnormal karyotypes tended to occur among patients with severe varieties, especially with **associated cryptorchidism**.

Yamaguchi and colleagues [112] studied 110 patients who had cryptorchidism and/or hypospadias. 7 (6.4%) patients were found to have chromosomal anomalies. 4.8% (4/83) in patients with cryptorchidism only, compared to **5.6% (1/18)** in patients with **hypospadias only**, and **22.2% (2/9)** in **concomitant cases.**

4. Syndromic Hypospadias [113]

According to Smith's text "**Recognizable Patterns of Human Malformation**", there are approximately **49** recognized **syndromes** in which hypospadias is either a "frequent" or an "occasional" associated finding. 38 of those syndromes also have associated **micropenis, cryptorchidism**, and/or a **scrotal abnormality.** Which supports endocrinopathic theory. Syndromic hypospadias is suspected with **development delay, dysmorphic facies**, and/or **anorectal malformation**.

5. Disorders of Sex Development (=Intersex States)

Disorders of sex development (**DSD**s) are possible in phenotypic boys with the coexistence of **hypospadias and undescended testes**, with the more posterior location conferring a significantly greater likelihood of intersexuality [114].

Isolated hypospadias is **not** considered a **DSD.** The DSD is considered as an indication for **karyotyping**, and the most common diagnosis is **mixed gonadal dysgenesis**, followed by **ovotesticular DSD** in the second position. [115], [116]

SURGICAL TECHNIQUES

"Perfectionism rarely begets perfection, or satisfaction-only disappointment"

-Ryan Holiday

Three surgical steps characterize hypospadias surgery: [117]

1) The **correction of VPC**, which is the result of the ventral radius's atresia.

*Degloving the penis represents the 1st step of this surgery and straightens the penis in **80%** cases.

*In **15%** cases, the persistent VPC is due to an abnormal tethering of the UP and the hypoplastic urethra onto the corpora's ventral aspect.

Lifting the UP from the corpora is a valuable additional maneuver that straightens the penis in most cases.

*There are still **5%** cases where the penis remains bent, although all the tissues forming the ventral radius have been freed. The residual VPC is due to asymmetrical CC and requires a dorsal corporeoplasty (dorsal shortening of the albuginea of the CC).

In most cases, the UP can be preserved, although there are situations where the urethral strip is very poor, and the 2 corpora writhe around it. In these cases, the UP is usually sacrificed.

2) Once the penis is straight, the missing **urethra should be replaced**. The technique chosen depends on the size and quality of the UP:

* If the UP is wide and healthy, it can be tubularized following the **Thiersch-Duplay technique**.

* If it is too narrow to be tubularized, the **Snodgrass urethrotomy** is one option, or additional tissue can be laid on the UP using a rectangle of pediculized preputial mucosa (**Onlay urethroplasty**), or a flap of ventral penile skin (**Mathieu procedure**).

* If the segment of the urethra to replace is short (<2 cm), and if the distal urethra is not hypoplastic, a complete mobilization of the whole penile urethra may be adequate to bridge the defect. This is **Koff technique**, like the Thiersch-Duplay technique, has the advantage of avoiding the use of non-urethral tissue.

* If the UP is not preservable, a tube needs to be made to replace the missing urethra using either a pediculized rectangle of preputial mucosa (**Asopa-Duckett technique**) or **buccal mucosa**.

* In major hypovirilization of the genital tubercle, the **Koyanagi procedure** mobilizing the whole mucosal tissue of the ventral radius and the preputial hood is a reliable option to reconstruct the missing urethra.

Two stage procedures (**Bracka - Cloutier procedure**) are an alternative for long urethroplasty using either preputial mucosa or buccal mucosa.

3) Once the urethra is repaired, the **ventral radius** of the penis needs to be **reconstructed.** This includes:

* **Meatoplasty** trying to create a slit-shaped meatus.

* **Glanuloplasty** to reconstruct the ventral aspect of the glans.

* The creation of a mucosal collar around the glans.

* Coverage of the reconstructed urethra using the lateral pillars of spongiosum (**spongioplasty**), or other alternative barriers (i.e.dorsal or ventral dartos flap).

* **Skin cover** with a redistribution of the skin shaft bringing the excess dorsal skin to the ventrum.

* Some prefer to **reconstruct the foreskin** (**preputioplasty**), others favor **circumcision.**

I. THE DUPLAY TUBULARIZED PLATE URETHROPLASTY [118]-[123]

DR. EMMANUEL SIMON DUPLAY

(1836–1924)

*A 5-0 polypropylene **traction suture** is placed through the **glans**, along with additional stay sutures in the edges of the incomplete **prepuce**.

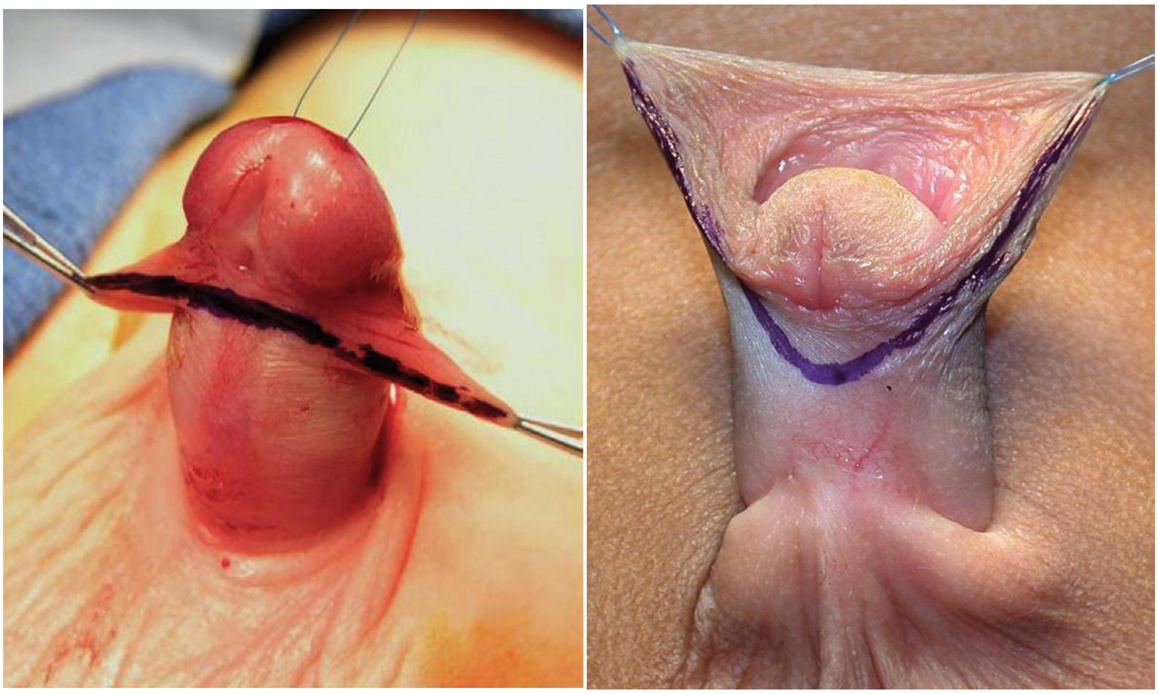


Figure 40. *Stay stitches through the glans and in the prepuce edges* [118]

*A **U-shaped** incision is **marked** to below the hypospadiac meatus, and then a rubber band, which serves as a **tourniquet**, surrounds the penile base.

***Dissection** is performed immediately under the skin to preserve the **ventral dartos,** which can be used as a **barrier flap** and to avoid inadvertent injury.

*The U-shaped **incision** is made encircling the meatus (**2-3 mm** proximal to the ectopic meatus) up to the corona with **two parallel incisions** (Mirror image incisions) in the **skin**; all along the visual junction of the **UP** within the glans using a 69 blade on a Beaver knife handle. In the Duplay procedure, the urethral strip must be sufficiently **wide** (approximately **10-12 mm**).

*The incision is then extended **circumferentially** around the corona, and along the median raphe as needed for additional exposure.

Penile **degloving** is done when required, up to the root of the penis by creating a plane at the level of **Buck's fascia**.

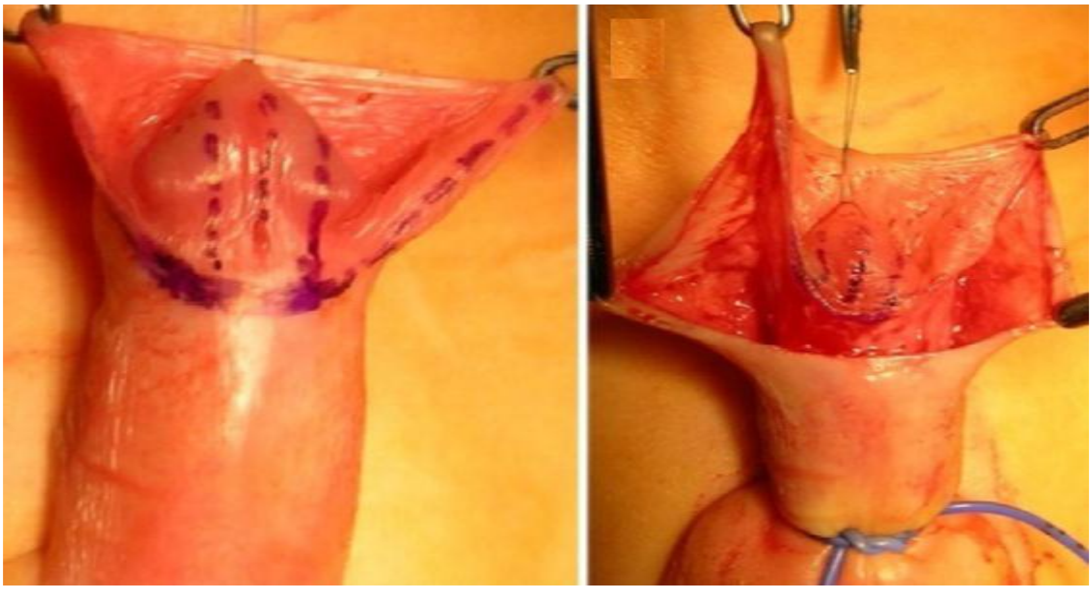


Figure 41. *Operative photos showing the U-shaped circumferential incision through the skin* [122]

*Tenotomy scissors are then used to **extend** the dissection **deep down** in the **glans** until the underlying **CC** are clearly identified, and **laterally** to ensure subsequent tension-free approximation.

In patients with maximum glans width <14 mm, further **mobilization** of the **glans wings** is performed by advancing the dissection along the surface of the corpora at 3 and 9 o'clock, extending the dissection from proximal to distal for about 4 mm.

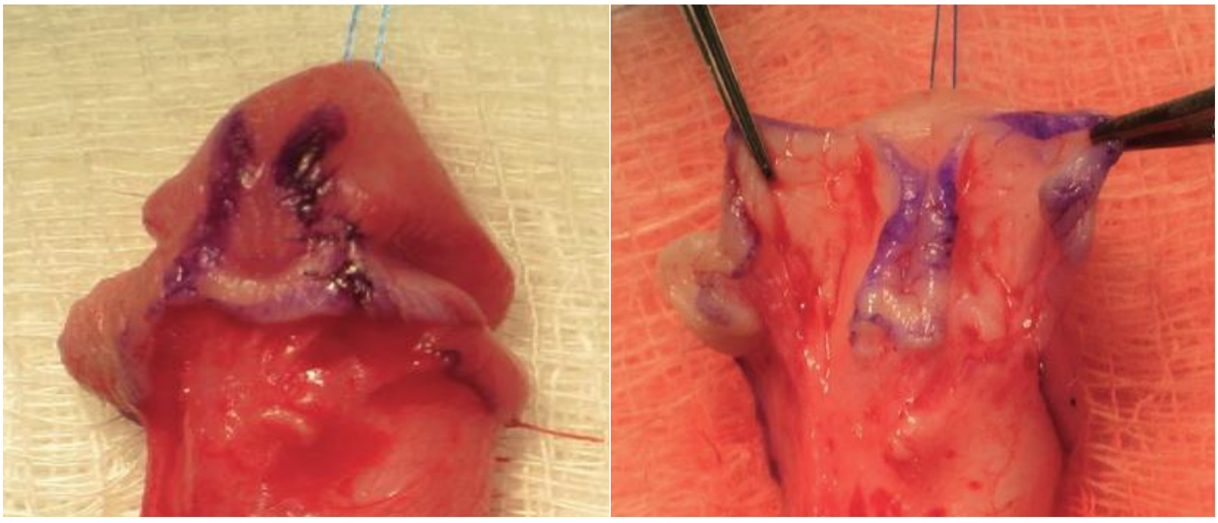


Figure 42. *Operative photos showing the Glans wings mobilization* [118]

*A 6-10 Fr **catheter** is passed into the bladder and secured to the glans stay suture.

UP **tubularization** is then performed with 5/0-7/0 **absorbable running** sutures (Polyglactin, PDS) on a TG 140-8 needle.

The **most distal stitch** should be at least **3 mm from the tip** of the UP to avoid iatrogenic **MS**, with the resulting meatus **oval** in shape.

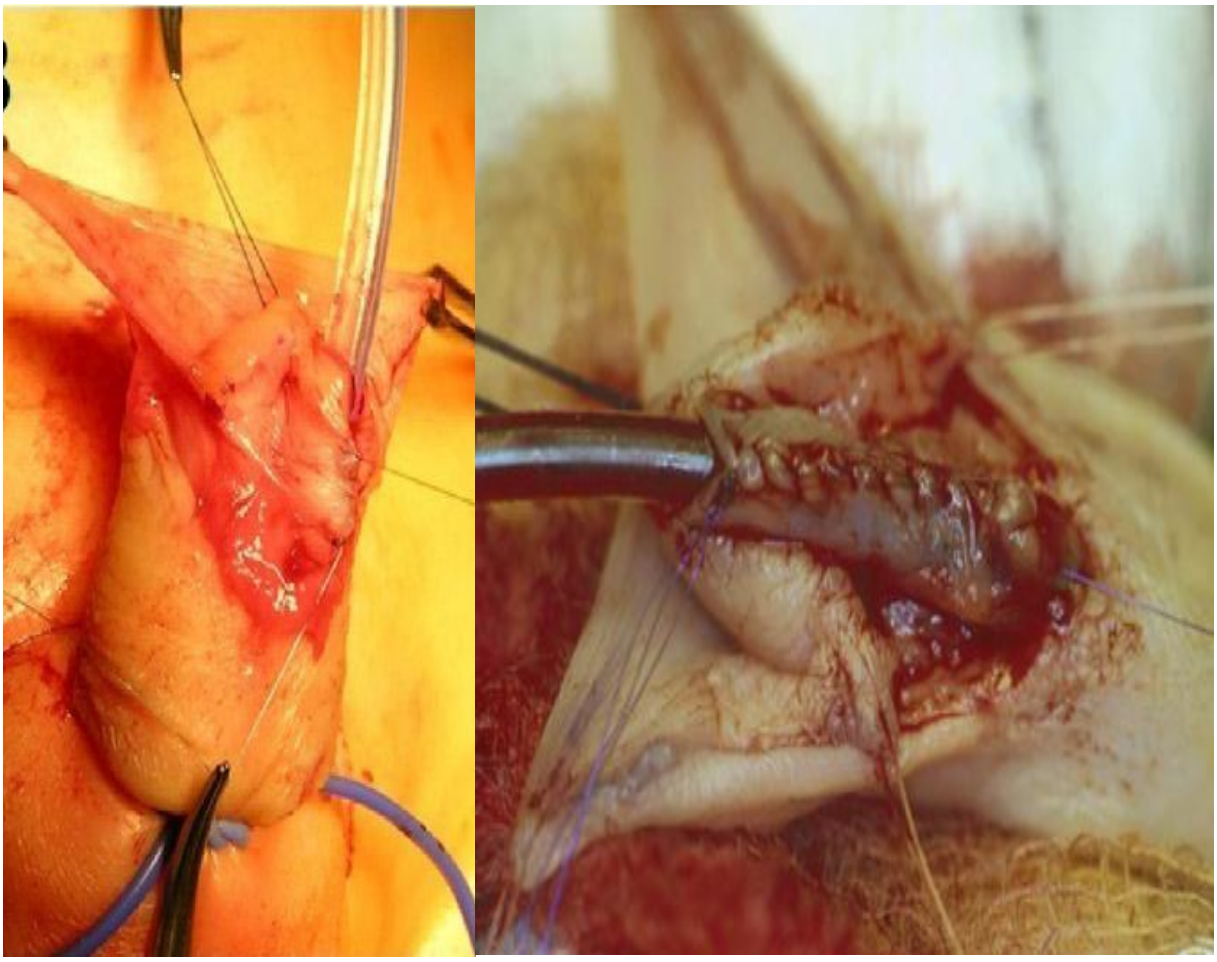


Figure 43. *Operative photos showing the Urethral plate tubularization* [122], [124]

*A **flap** is then created from the **preserved ventral dartos** and flipped up to **cover** the **neourethra** (barrier flap), anchored in place with 6-0 or 7-0 separated **polyglactin** sutures.

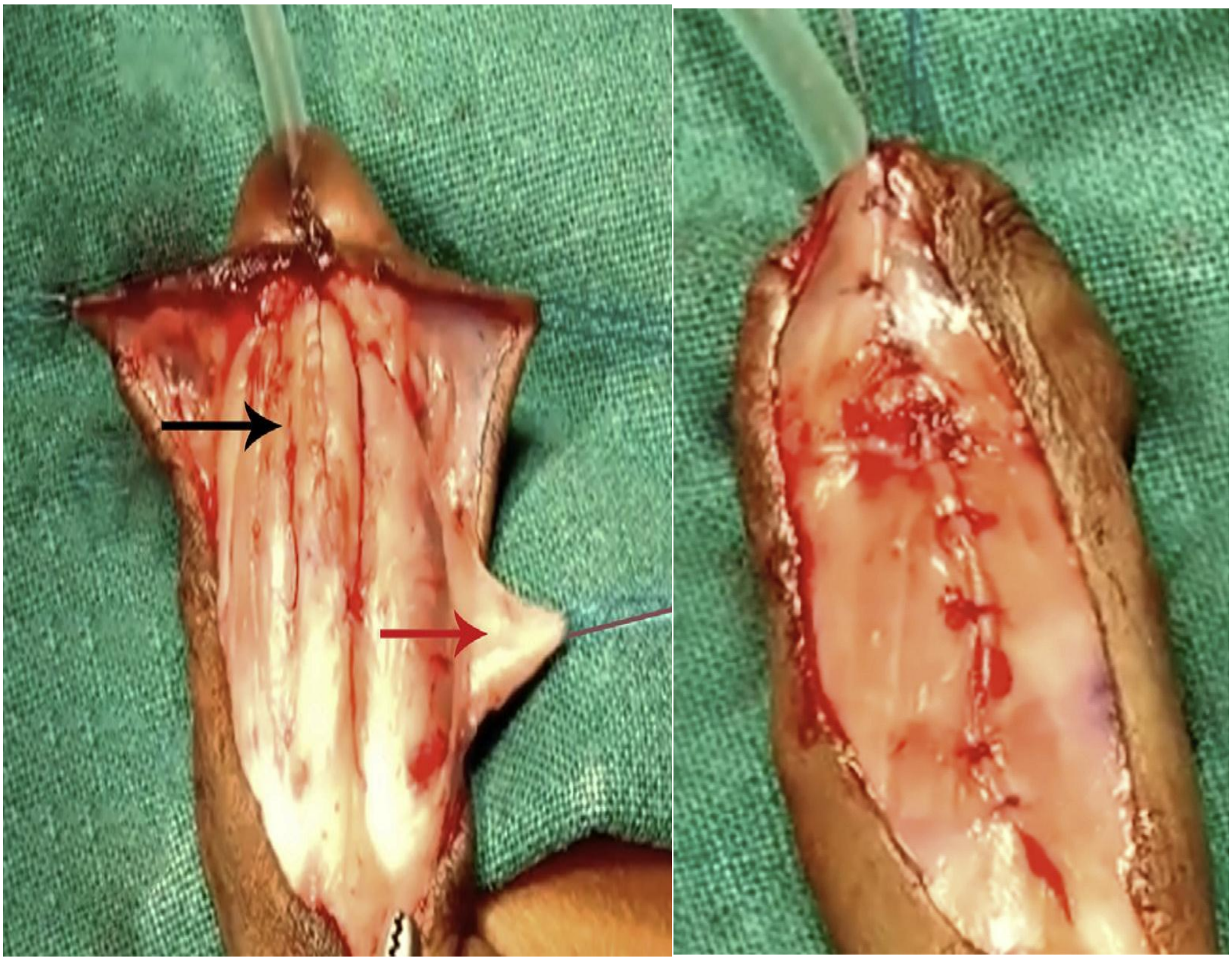


Figure 44. *Operative photos showing the coverage with the dartos layer* [123]

Left: showing the completion of urethroplasty (**black arrow**) and the dartos layer being dissected (**red arrow**).

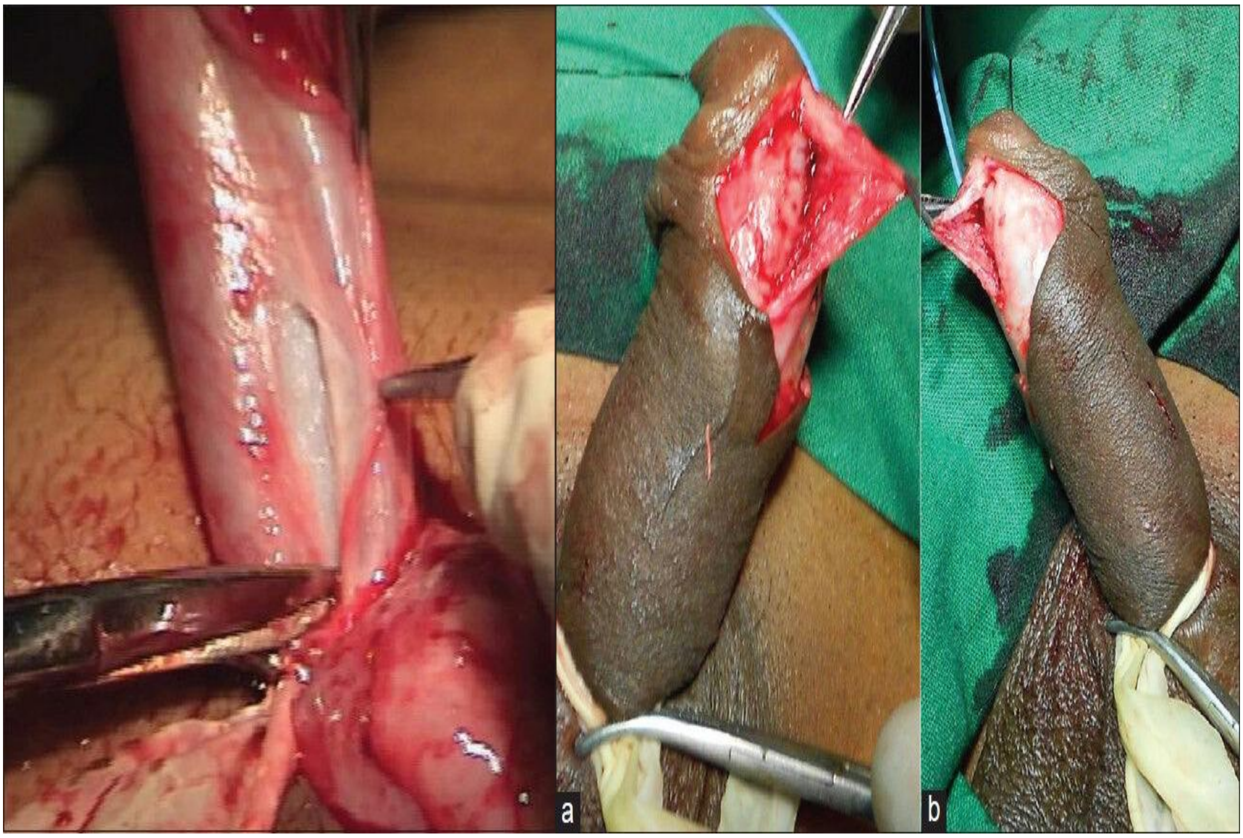
Right: showing the approximation of the dartos layer vertically in the midline till the tip of glans.

*But when there is insufficient dartos, this neourethra may be covered by **spongioplasty**:

Starting well proximal to the hypospadiac meatus, a **plane is created between the **Buck's** fascia and **tunica albuginea** and the dissection is carried out on the penile shaft just lateral to the margin of the CS.

From lateral to medial, the **spongiosum is dissected off the underlying CC. **Mobilization** is done well beneath the true UP on both sides, lifting off the midline spongiosum and UP from the CC when required, to correct chordee.

Dissection is performed with care, avoiding damage to the CS or CC.



<u>**Figure 45.**</u> *Operative photos showing the creation of plane between tunica and Buck's fascia and mobilization of the CS with UP* [121]

The mobilized **spongiosal pillars are then **approximated** in the **midline** with 7-0 **PDS running** sutures covering the entire neourethra right up to the glans.

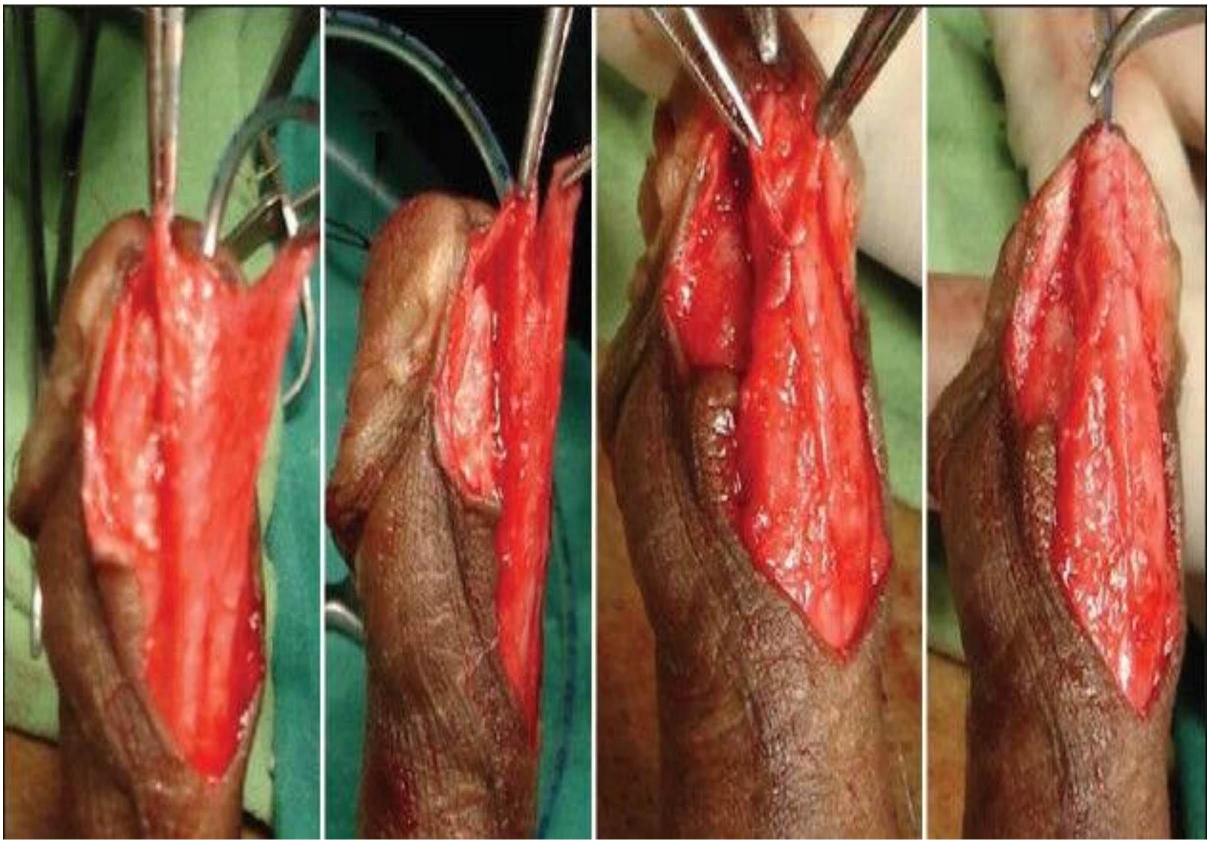


Figure 46. *Operative photos showing the spongioplasty of mobilized moderately developed CS* [121]

***Meatoplasty** and **Glansplasty** is independent of the underlying urethroplasty, meaning that the glans wings are not sutured to the neourethra.

The distal stitch **approximates** the **glans wings** at the point that visually corresponds to the correct location for the **ventral lip** of the **meatus**.

Additional subepithelial interrupted sutures continue to the corona, using 5-0 or 6-0 **polyglactin** for a total of approximately three stitches.

The skin edges are not sutured to avoid suture tracks.

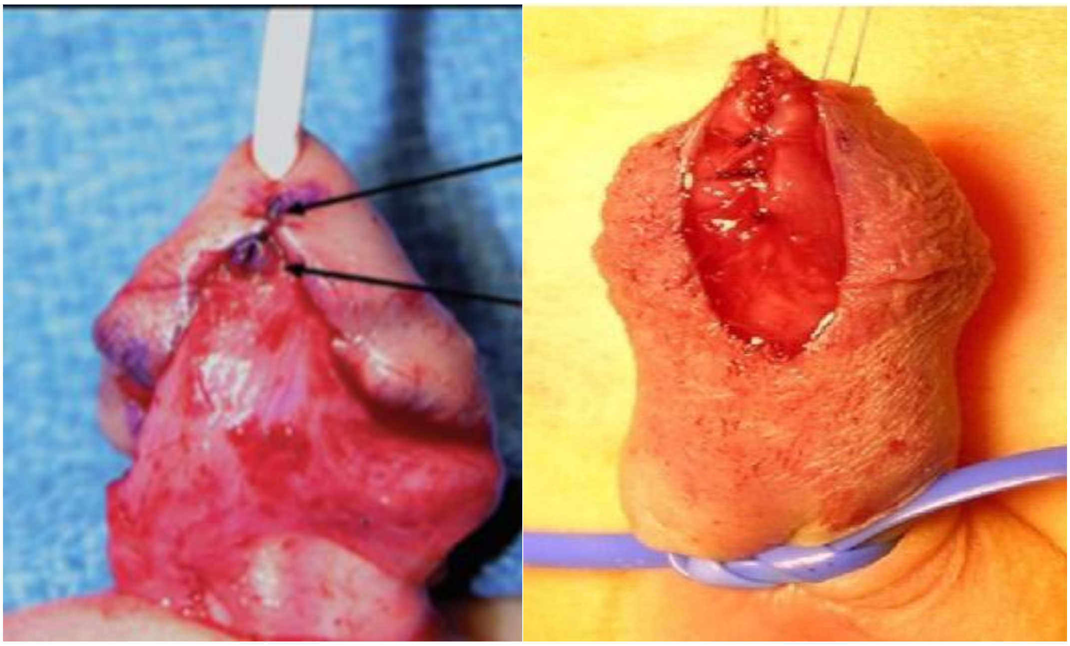


Figure 47. *Operative photos showing the meatoplasty+glansplasty* [118], [122]

***Preputioplasty** begins with the inner surface, approximated with subepithelial interrupted 7-0 polyglactin.

The skin is then reduced over the glans, and additional interrupted stitches are placed to reinforce the inner layer closure.

Finally, the outer surface is approximated, beginning with the distal corners after ensuring closure does not restrict retraction over the glans.

The retractability of the preputial hood over the glans is checked and viewed as sufficient when the prepuce can easily be rolled over the glans.

If the foreskin is too tight and not retractable, this distal stitch is removed and replaced slightly more proximally, with closure completed using 7-0 polyglactin interrupted subcuticular stitches.

Any gap between the first distal stitch and the end of the prepuce is closed via a Heineke-Mikulicz maneuver.

***Skin** is rotated ventrally as needed to cover the ventral surface and create a **median raphe**. Skin **closure** performed using **interrupted** 7-0 **polyglactin**.

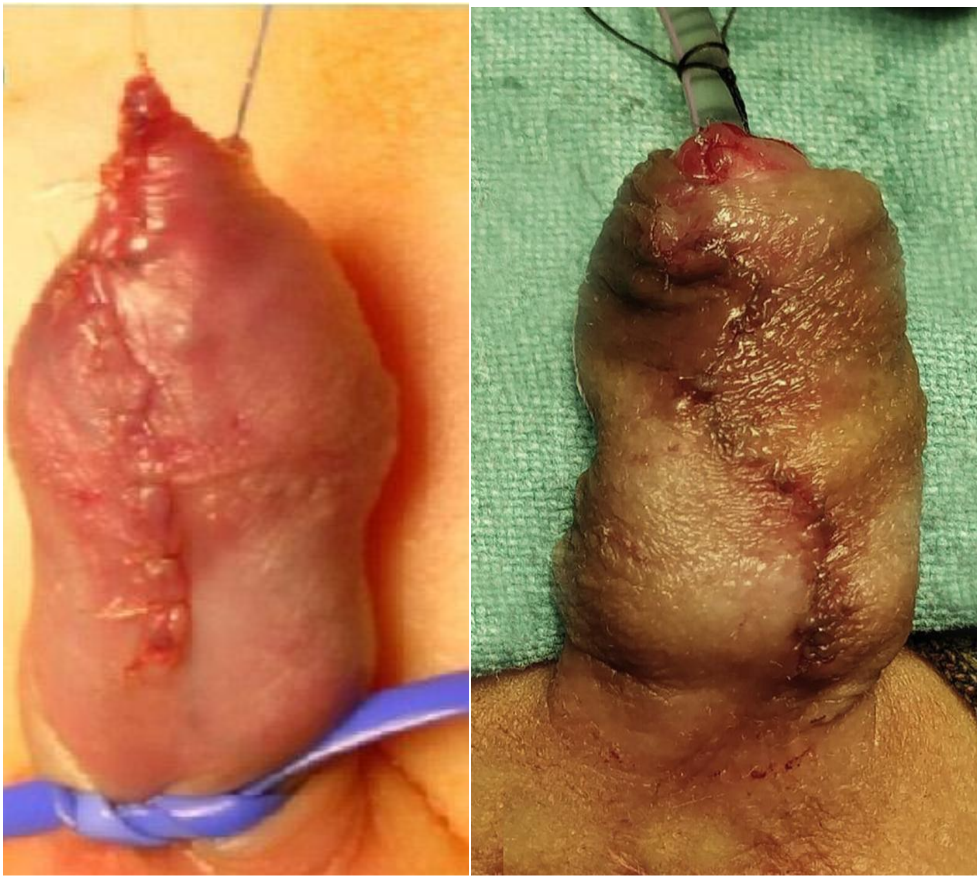


Figure 48. *Operative photos after foreskin repair and skin closure* [122], [123]

*The penis is wrapped with a gently **compressing dressing** placed over gauze to reduce post-operative hematoma and edema.

*The urethral catheter is removed approximately 5-7 days after surgery; patients still maintained under antibiotic prophylaxis while the catheter is in place. And they receive ibuprofen for pain relief.

II. THE KOFF URETHRAL MOBILIZATION AND ADVANCEMENT [4], [125]–[128]

Dr. Stephen A. KOFF

*A 5/0 polypropylene **stay suture** is placed at the tip of the glans.

*Final **assessment** of hypospadias **location** and an eventual **VPC** measurement is performed after artificial erection is created before skin dissection.

*A 6-10 Fr **catheter** is passed into the urethra to evaluate urethral tissue quality and left indwelling.

*Additional traction sutures are placed bilaterally at the lateral corners of the dorsal hood.

*Then, a rubber band, which serves as a **tourniquet**, surrounds the penile base.

Figure 49. *Pre-operative photos showing catheter placement & UP measurement* [127]

*The initial **incision** is **circumferential** through the **skin** of the penile shaft about **0.5 cm** proximal to the **corona dorsally**, while **ventrally,** the incision is made **proximal** to the urethral **meatus** preserving the distal UP.

Figure 50. *Operative photo showing the incision around the meatus* [125]

*The avascular **plane** between **Buck's** fascia and the **dartos** fascia is developed to **mobilize** the **skin** completely from the penile shaft.

*When the thin **ventral skin** is **separated** from the often **hypoplastic** underlying **urethra,** care must be taken not to enter or **injure** the **urethra.**

*The **degloving** of penile shaft skin is continued proximally to the **penoscrotal junction** to release eventual cutaneous VPC.

***Circumscription** of the urethral **meatus** is completed next, with an incision extending through the skin **down** to the **CC** of the **glans.**

*Any rudiments of **CS** distal to the meatus or **fibrous bands** that contribute to the VPC are **removed** at this time.

*The next step is to **detach** the **urethra** and **surrounding CS completely** from the **anterior surface** of the CC.

The choice of a **site to begin separation** is determined by the degree to which the CS invests the urethra.

When the urethral **meatus** is **fully surrounded** by the **CS**, the **dissection** can **begin** at the meatus with gentle traction on the catheter as an aid to develop an avascular plane between the CS and the CC.

Dissection must be maintained **above the tunica albuginea** covering each CC. In cases when decussation of the CS with lateral fanning has occurred proximal to the meatus, the dissection may be started at a more proximal point where the spongy investment is whole.

*When a **circumference of the urethra** encased in **CS** has been fully **freed** at this point, the **cleavage** is easily continued **distally** to include the urethral meatus.

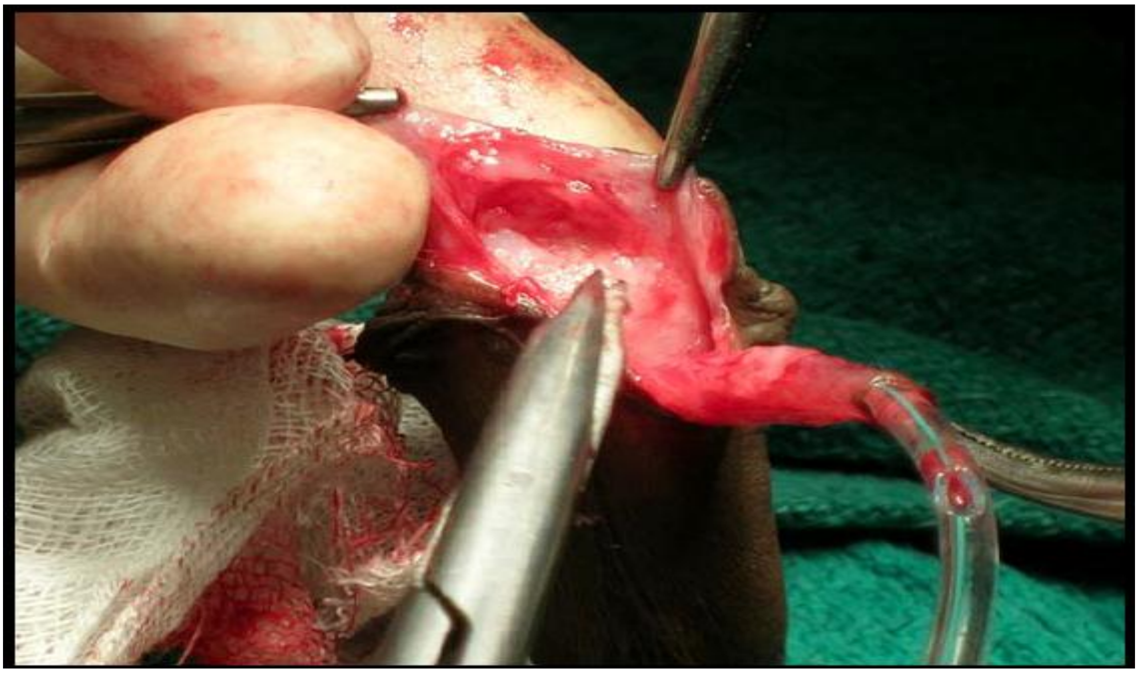


Figure 51. *Operative photo showing the urethral mobilization distally* [125]

*With the urethral catheter providing gentle counter traction, **mobilization** of the urethra is continued **proximally** past the penoscrotal junction to the region where the **pendulous urethra** angulates dorsally to become the **distal bulbous urethra**.

*Since there is no natural cleavage plane between the corporeal bodies, sharp dissection must be continued until the **urethra is fully mobilized**.

Bleeding may be brisk if the corpora are entered; however, bleeding from small vessels penetrating the inter-cavernous septum should not be mistaken for corporeal bleeding.

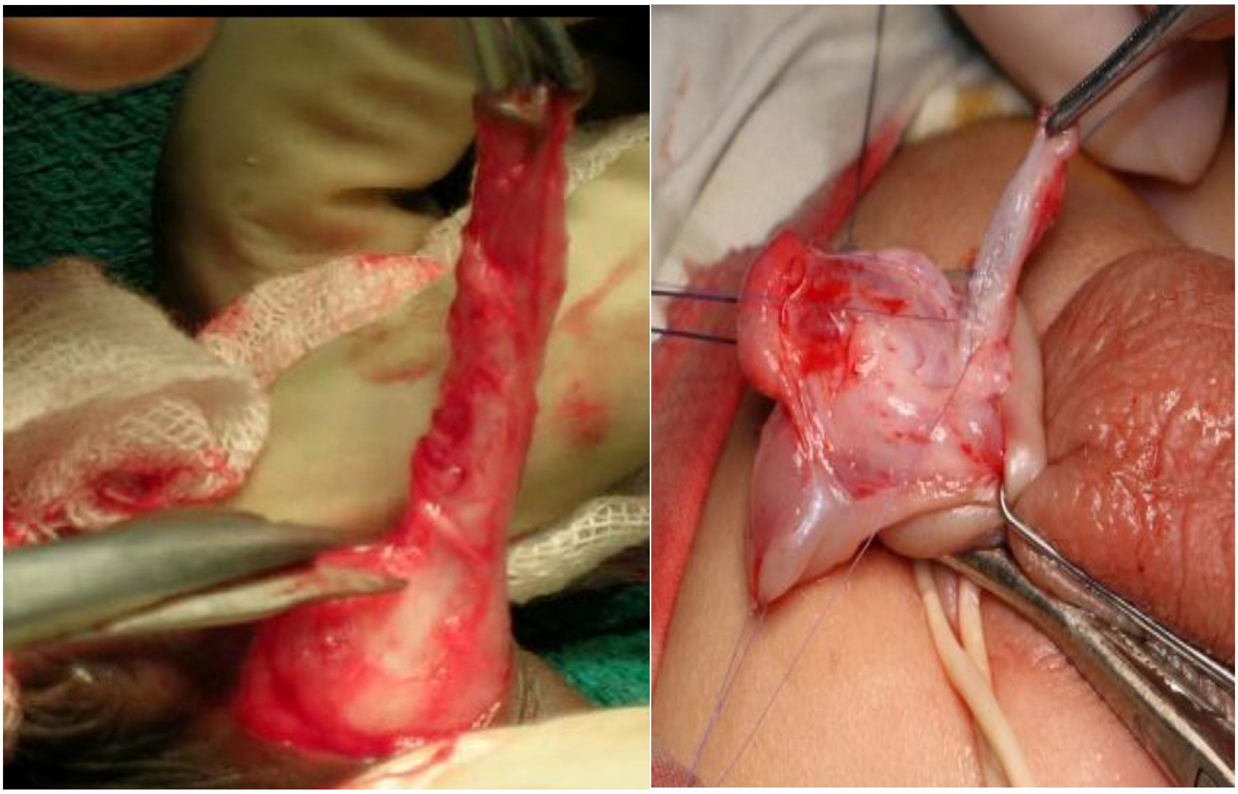


Figure 52. *Operative photos showing the complete mobilization and release of the urethra* [125], [128]

*The separated urethra is now **measured against** the **taut phallus** to determine whether a **tensionless anastomosis** to the tip of the glans is feasible.

*If the mobilized urethra has been **lengthened sufficiently** for direct anastomosis to the glans, the urethral **meatus** is inspected to identify any **hypoplastic** ventral urethral tissue unsupported by CS which, if present, must be **excised**.

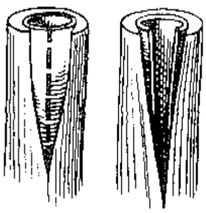


Figure 53. *Schema showing the excision of the hypoplastic ventral tissue* [4]

*Then we have 3 choices:

***The **glans** is **prepared** by excising a large triangular piece of epithelium distal to the urethral groove. With fine pointed iris scissors, a capacious **subepithelial tunnel** is created under the **glans groove**, taking care to avoid the glans' penetration.

The urethra is then **spatulated** (after catheter removal), passed through the **tunnel** and **anastomosed** to the glans after reinsertion of the catheter was done, using 6/0 polypropylene. [4], [128]

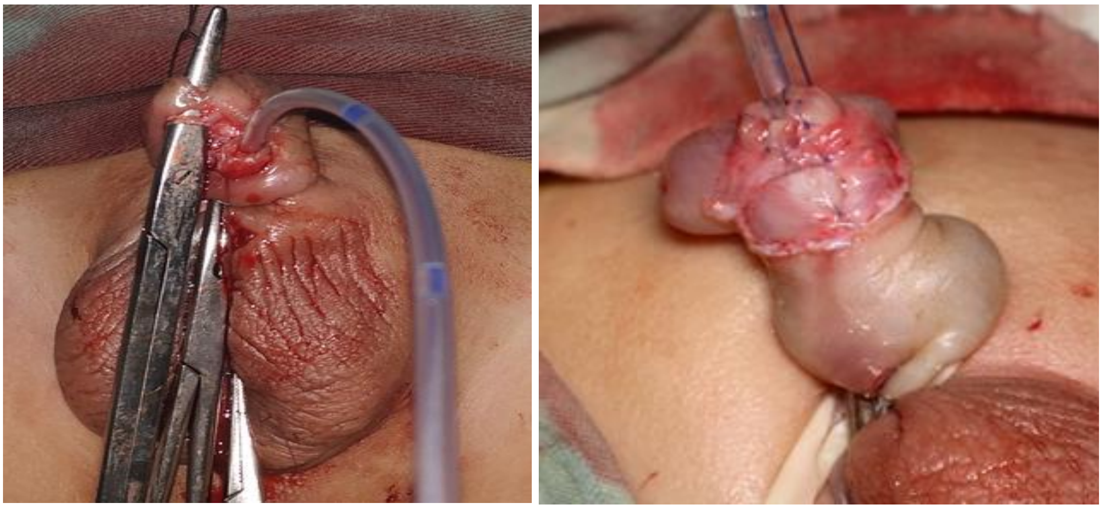


Figure 54. *Operative photos showing the Patulus tunnel in the glans and the suturing of the meatus at the tip after urethral tunneling* [128]

***If the end of the urethra is **trimmed** due to **insufficient spongy** tissue, it's preferred not to tunnel it but to create **triangular glans flaps** to accommodate the urethra.

In other words, the glans wings are extensively developed. The **glans spongiosum** is **opened down** to the surface of the **CC** on each side of the UP using a size 15 blade.

The mobilized urethral **meatus** is spatulated and **anastomosed** to the central triangular flap with 5-0 polyglactin suture.

The lateral **glanular wings** are **wrapped around it** with a combination of a subcuticular PDS and a 6-0 polyglactin suture.

This technique creates a **wide meatus** and gives good coverage of the mobilized urethra. At present, the triangular flaps have replaced the tunneling procedure in all cases. [126]

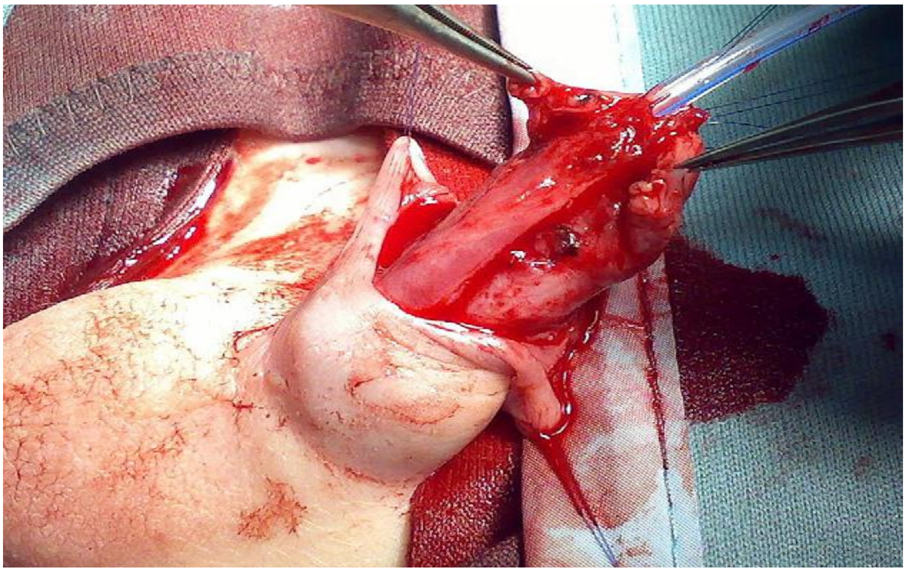


Figure 55. *Operative photo showing the neo-urethra positioned in the new glans* [129]

Figure 56. *Operative photo showing the meatoplasty and glanuloplasty* [125]

***Some authors [127] prefer in spite of deep vertical or transverse glanular slit, to excise **1-2mm rim of ventral glanular mucosa** in full depth along **with strip of UP** so that to have adequate space to accommodate the urethra.

Trimming of distal urethra in **oblique** fashion about 2mm more on ventral aspect.

*The mobilized urethra with CS are **re-anchored** to the ventral aspect of the **tunica albuginea** of the CC with several interrupted stitches of 7/0 PDS to **release** any **traction** on the **glans**. It contributes to **urethral stability** as well.

*The 2 **glanular wings** satisfactorily mobilized laterally.

*Tension-free **anastomosis** from the urethra to glans with **interrupted** sutures.

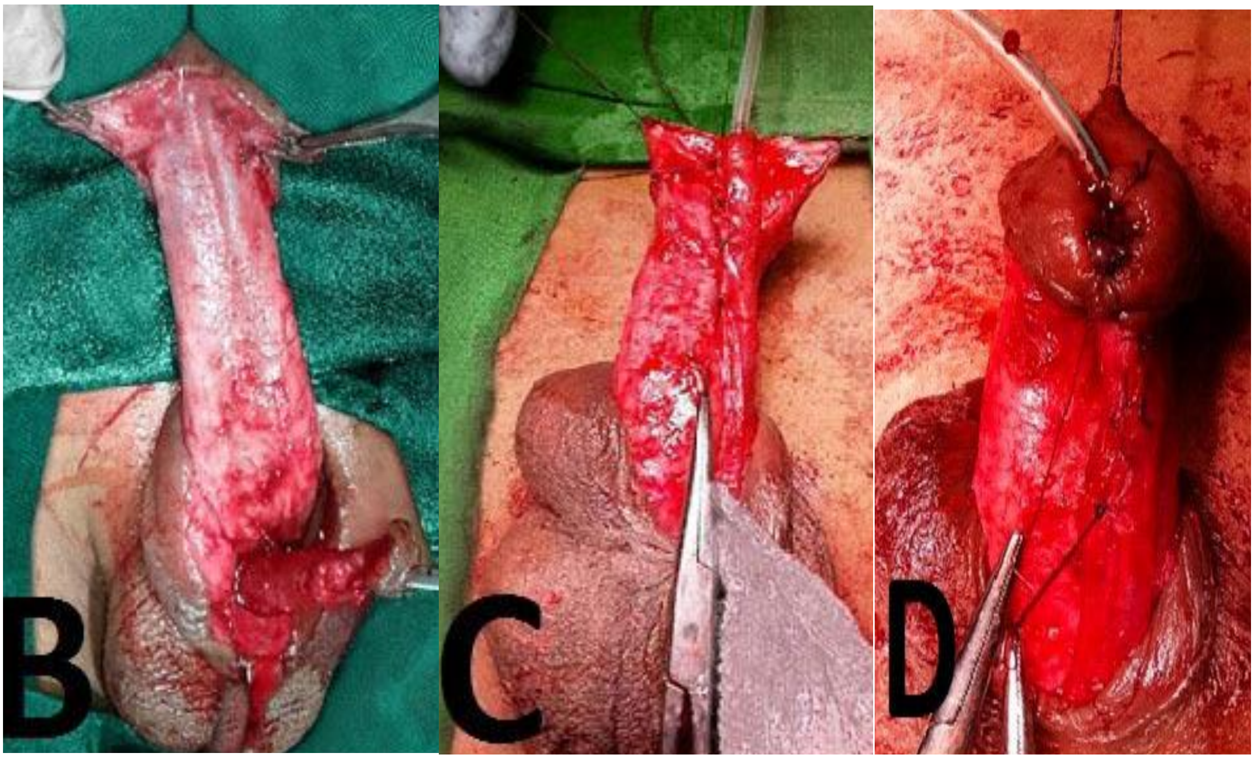


Figure 57. *Operative photos showing the fixation process* [127]

B) Excision of ventral glanular mucosa with UP

C) Intermittent fixation sutures between tunica and of CC and CS

D) Glans wings closed in layers

*Finally, the degloved penile skin is pulled back, and the penile shaft is **resurfaced** in a standard fashion.

***Preputioplasty** or **circumcision** is performed.

*The urethral **catheter** is left in place for several days postoperatively as well as a circumferential **compression dressing** as no diathermy or cauthery is used all along this operation.

*Until the silicone tube is removed, patients are maintained on oral **antibiotics.**

*Boys receive ibuprofen for pain relief.

Figure 58. *Postoperative images* [125], [127]

PATIENTS AND METHODS

"God will not look you over for medals, degrees or diplomas, but for scars!"

-Elbert Hubbard

I. JUSTIFICATIONS

Hypospadias is **getting on the rise** both in international statistics and locally, as we observed during our clinical practice. This anomaly has different **presentations**, tremendous **surgical options** without any evidence of superiority,

and a wide spectrum of **complications**.

This study is expected to add more to the current perplexing question; in dealing with **primary anterior hypospadias**, the **Thiersch-Duplay** procedure is better or is it the **Koff**?

II. OBJECTIVES

1. General Objective

To compare the **effectiveness** and the **success rates** between the 2 procedures; **Koff** versus **Thiersch-Duplay**.

2. Specific Objectives

- To determine and compare the different **complications** requiring or not subsequent intervention, specifically: Dehiscence, Urethro-cutaneous fistula, Meatal stenosis, and Residual penile curvature.
- To name the **best surgical treatment** for **anterior** hypospadias to obtain better results for the **meatus position** and **voiding function**.
- To compare the **complications** rates **within the same group**, considering some **specific parameters'** impact.

For that aim, we conducted **subgroups analysis** of the patient's age at repair, the ectopic meatal location, the surgeon's expertise, the anesthetic technique, the neourethra suture materials and suturing techniques, and the types of dressing during the post-operative care period.

III. STUDY DESIGN AND PERIOD

We assessed the two surgical techniques in a **hospital-based retrospective comparative study** conducted from **January 2016** to **December 2019**.

IV. STUDY AREA

Pediatric Surgery Department, Hassan II University Hospital, Fes-MOROCCO. It is a reputable center that recruits patients from all over the Fes-Meknes region.

V. STUDY POPULATION

1. Inclusion Criteria

All boys admitted for **anterior** hypospadias (glanular/coronal, sub-coronal, distal penile) who underwent **primary** hypospadias repair. We chose to review exclusively **primary cases** because it allows **better assessment** of the surgical **technique** and better evaluation of **results** since all patients had the quite same penile tissue condition.

2. Exclusion Criteria

- **Distal** hypospadias with a **history** of **previous repair** (**Secondary** hypospadias).
- Other types of hypospadias, namely **mid-shaft** or **proximal/posterior.**
- Cases operated on with **other techniques,** namely Mathieu, MAGPI…

3. Sample Size

We reviewed a total of **90 children** that we divided into **2 groups** based on the procedure they received:

- **Group A**: Comprises **50** patients who underwent **Thiersch-Duplay** urethroplasty.

- **Group B**: Comprises **40** patients who underwent **KOFF** urethral mobilization and advancement repair.

VI. DATA COLLECTION

A specially designed **questionnaire** was used for data collection.

All required parameters of the questionnaire were **collected retrospectively** from reviewing patients' **medical records** and filtering the computerized **operating room's reports**. At each post-operative visit in the outpatient clinic, complications (if present) were consigned on the files. A successful outcome was defined based on the absence of mentioned complications.

In addition, we tried to **recontact** all of our **90 cases** for a check-up in **September 2020**. This was essentially to assess the **cosmetic** and **functional results**. We contented ourselves with few simple questions. We counted only on the phone calls and sent pictures and videos from the parents because it was difficult to receive patients for a direct physical examination (due to the pandemic situation and personal-financial issues).

The **literature review** was carried out using the Internet search, Pub-Med, Research Gate, medical journals, and textbooks to cover various aspects.

VII. METHODS OF DATA ANALYSIS

The obtained raw data were edited and coded in a **database table** on **Microsoft Excel.** Then, with the team's valuable collaboration from the **Epidemiology Department** of our medical school, we used the software program "Statistical Package for the Social Sciences" (**SPSS**). The variables were selected, and their statistic values were obtained.

Since all of our variables are **categorical /qualitative**, they were expressed in **numbers/frequencies** and percentages. They were compared using **Chi-square** or

Fisher's exact test in order to assess the relationship between the adopted **surgical technique** and the **complications'** development.

With a Probability: < 0.05

*p-value < **0.05** indicated that differences were **statistically significant**.

*p-value < **0.001** was considered as **highly significant.**

*p-value > **0.05** was considered **insignificant**.

A graph analysis was performed using **Microsoft Excel.**

VIII. ETHICAL CONSIDERATIONS:

We have to stress that the data were collected with **full respect for the patients' privacy** and **anonymity.**

IX. DATA COLLECTION QUESTIONNAIRE

1)-Full name of the patient:

2)-Identification number:

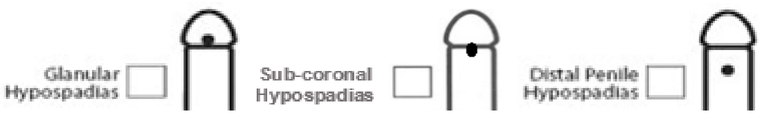
3)-Phone number:

4)-Age at repair groups:

☐ < 2 yo ☐ 2 to 5 yo ☐ >5 yo

5)-Clinical assessment:

5-1)-Position of the ectopic urethral meatus:



5-2)-Chordee assessment:

5-3)-Prepuce condition:

5-4)-Penile torsion:

5-5)-Associated anomalies:

☐Isolated ☐Cryptorchidism ☐Inguinal hernia ☐Mega meatus ☐Uropathy

6)- Surgical technique:

☐Thiersch-Duplay ☐KOFF

7)-Perioperative management:

7-1)-Hormonal manipulation:

☐ None ☐ Androgens ☐Other

7-2)-Surgeon qualification:

☐Experimented professor ☐Young surgeon

7-3)-Anesthesia:

☐ General anesthesia ☐Spinal block ☐ Sedation + Caudal block

7-4)- Prophylactic antibiotics:

☐Indicated ☐Not indicated

7-5)-Hemostasis:

☐Cautery ☐ No cautery

7-6)-Suture technique:

☐ Uninterrupted technique ☐ Interrupted technique

7-7)-Suture materials:

☐Polydioxanone suture (PDS) ☐ Polyglactine suture (VICRYL)

7-8)-Foreskin:

☐Reconstruction ☐ Circumcision

7-9)-Urethral intubation:

☐Trans-urethral catheterization ☐Suprapubic catheterization ☐ None

***Removal of the catheter if used at day: …………

7-10)-Dressing:

☐Simple Gauze dressing ☐Honey dressing ☐No dressing

***With a change of dressing if used at day:…………

7-11)-Length of hospital stay:

☐<48h ☐48 h to 1 week ☐ > 1 week

8)-Postoperative management:

8-1)-Postoperative penile erection and bladder spasms:

☐Use of ketoconazole ☐ Use of Amyl Nitrite ☐ None

8-2)-Clinical outcomes/Complications:

Complications	1st week	1st month	2nd month	>3rd month
Success (no complication)				
Meatal stenosis (MS)				
Urethro-cutaneous fistula (UCF)				
Residual penile curvature (RPC)				
Wound dehiscence (WD)				

8-3)- Check-up of September 2020:

a)- Patient availability: ☐Reachable ☐Not reachable

b)- Total number of surgeries besides circumcision:

☐ 1 ☐ 2 ☐ 3 ☐ >3

c)- Cosmetic appearance: ☐ Sufficient ☐Insufficient

*Apical meatus ☐Yes ☐ No

*Absence of any residual chordee ☐Yes ☐ No

*No excess ventral or dorsal skin ☐Yes ☐ No

d)- Fistula:

☐Present ☐ Absent

e)- Urinary stream:

☐Strong and straight ☐Reduced stream

f)- Circumcision:

☐Circumcised ☐Not yet

STATISTICAL RESULTS

"THE GOOD, THE BAD, AND THE UGLY…"

I. BASELINE CHARACTERISTICS

1. Age at Repair

There is still much debate regarding the effect that age at hypospadias repair has on surgical complication rate despite the kind of surgical repair.

In our series, age at surgery was collected and analyzed as a trisected (<2 years, 2-5 years, >5 years).

As shown in the Table and Chart next page, the surgery was mostly performed on boys presented around the age of **2-5 years** for **both groups (68.9%; N=62/90),** followed by boys aged **more than 5 years (17.8%; N=16/90)**, then those **less than 2 years (13.3%; N=12/90).**

The difference between the **2 groups** was **not statistically significant** in terms of **age at repair** (**p-value=0.646**).

Table 1. Series comparison concerning the age at repair

	Group A		Group B		
Age range (years)	N	%	N	%	**p-value**
< 2	5	10	7	17.5	0.646
2 to 5	36	72	26	65	
> 5	9	18	7	17.5	
Total	50	100	40	100	

N: Number of cases

%: Percentage

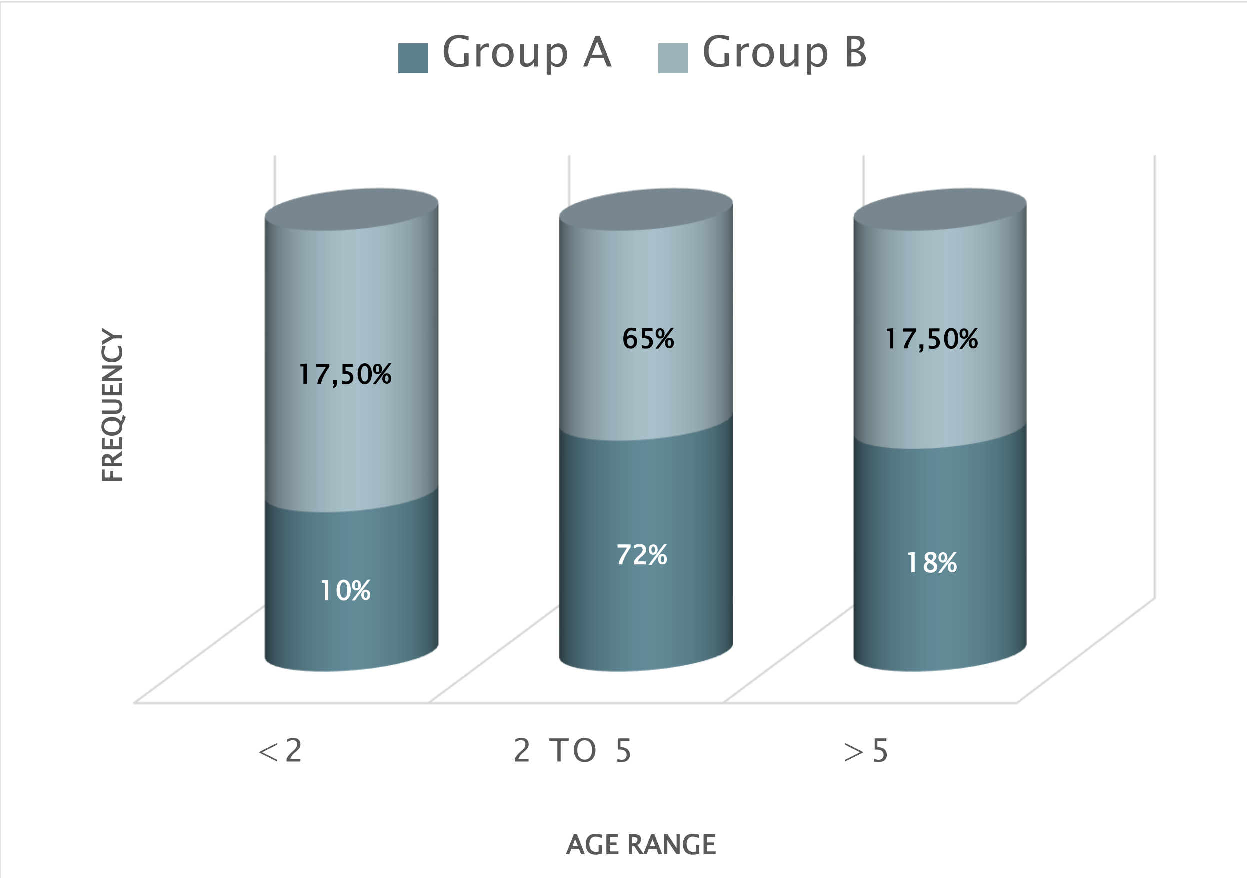


Chart 1. Distribution by the age at repair and operative procedure

2. Pre-Operative Clinical Assessment

A. Primitive Ectopic Meatal Location

Hypospadias is a midline anomaly that can be of **varying severity**, usually divided into **degrees,** according to where the meatus is situated. The more proximal, the more complex is the anomaly.

The penial clinical assessment revealed the **distal penile** location as the **most common** hypospadiac location in **both groups (61.1%; N=55/90)**, followed by **glanular (26.7%; N=24/90),** and **sub-coronal** at the last position **(12.2%; N=11/90).**

The difference between the **2 groups** was **not statistically significant** in terms of **hypospadias severity.** (**p-value=0.748**)

Table 2. Series comparison according to the ectopic meatal location

Ectopic meatal location (EML)	Group A N	Group A %	Group B N	Group B %	p-value
Glanular	12	24	12	30	0.748
Sub-coronal	7	14	4	10	
Distal penile	31	62	24	60	
Total	50	100	40	100	

N: Number of cases

%: Percentage

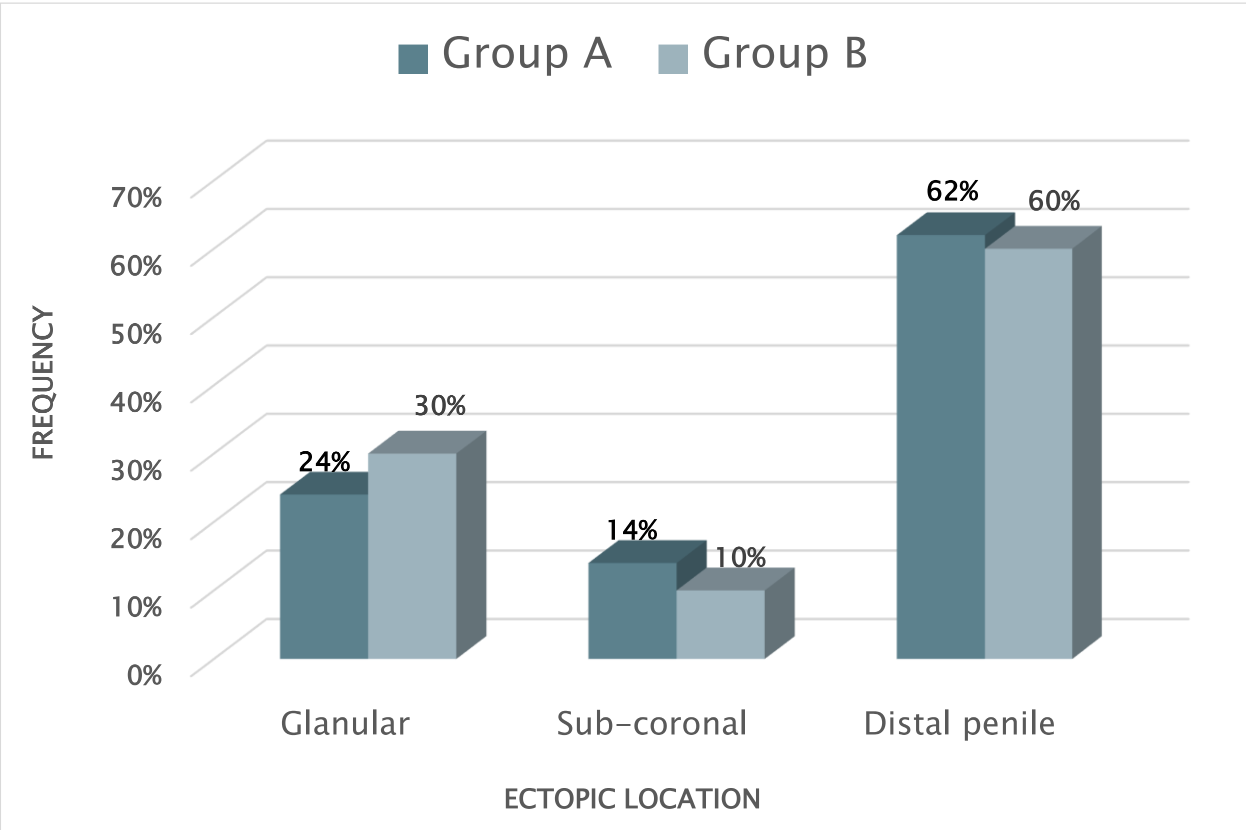


Chart 2. Distribution by ectopic meatal location and type of repair

B. Prepuce Condition

The foreskin's examination highlighted the **Incomplete prepuce** (deficient ventrally and hooded dorsally) as the **predominant** presentation in **both studied groups**, marked by **93.3%** (N= **84/90**) cases compared to **6.7 %** (N= **6/90**) cases with **Complete prepuce**. Also demonstrated in the Table and Chart next page.

The difference between the **2 groups** was **not statistically significant** in terms of **Prepuce condition (p-value=0.689)**.

Detailed results deemed to be as the following:

Group A:

Of **50** patients who were operated on with the **Thiersch-Duplay** procedure,

The prepuce was **Incomplete** in **92 %** (N=**46**), and

Complete in the remaining **8 %** (N=**4**).

Group B:

Of **40** patients who were operated on with the **Koff** procedure,

The prepuce was **Incomplete** in **95 %** (N=**38**), and

Complete in the remaining **5 %** (N=**2**).

To note that the **Mega meatus** was the **most common** associated anomaly present in **6.7%** (N= **6/90**) cases, including **8 %** (N=**4/50**) cases in **Duplay** group and **5 %** (N=**2/40**) cases in **Koff** group. All of these cases were accompanied by a **complete prepuce** within a particular variant labeled Mega meatus intact prepuce **(MIP)**.

Table 3. Series' comparison regarding the prepuce condition

	Group A		Group B		
Prepuce condition	N	%	N	%	**p-value**
Complete	4	8	2	5	0.689
Incomplete	46	92	38	95	
Total	50	100	40	100	

N: Number of cases

%: Percentage

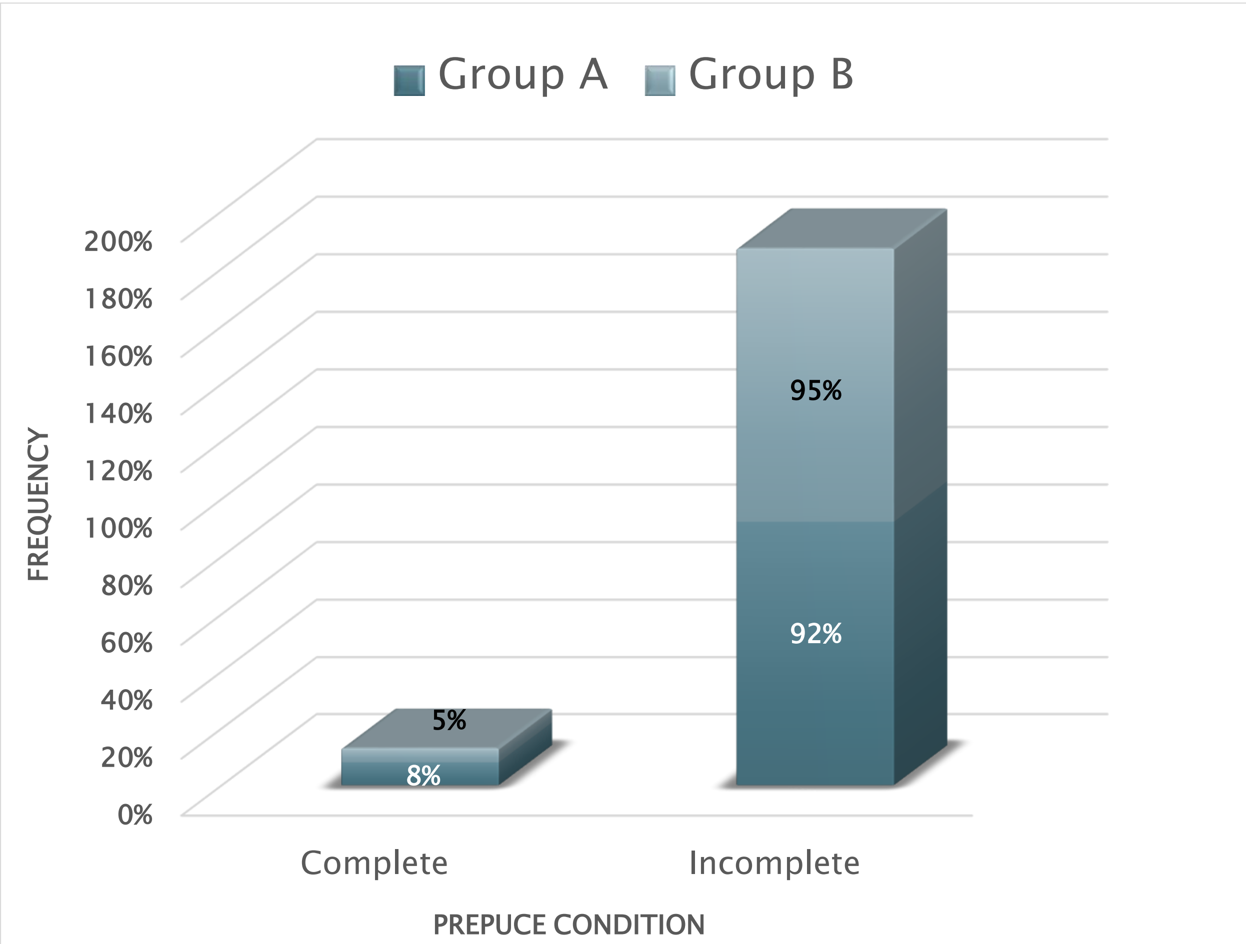


Chart 3. Distribution by prepuce condition and type of repair

C. Chordee and Penile Torsion Assessment

Before carrying out any surgical repair, **none** of our **90** patients presented with a **Chordee**, whereas **Penile torsion** (**PT**) was **hardly** present (**2.2%**; N= **2/90**).

Specifically, PT was **objectified** in **2 %** (N=**1/50**) cases in **Duplay** group, and in **2.5 %** (N=**1/40**) cases in **Koff** group.

As outlined in the Table and Chart next page, the PT was mostly **missing** for **both groups,** which joins the reported literature studies that indicate an incidence ranging from **1.7%** to **27%.**

Bear in mind that **none** of these 2 PT was a **consequence** of the hypospadias surgical repair, and both were **improved** postoperatively.

Also, the choice of the surgical technique to repair hypospadias wasn't in any case preferred based on the presence or not of the PT.

Table 4. Series' comparison in terms of penile torsion assessment

	Group A		Group B		
Penile torsion (PT)	N	%	N	%	**p-value**
Absent	49	98	39	97.5	1.000
Present	1	2	1	2.5	
Total	50	100	40	100	

N: Number of cases

%: Percentage

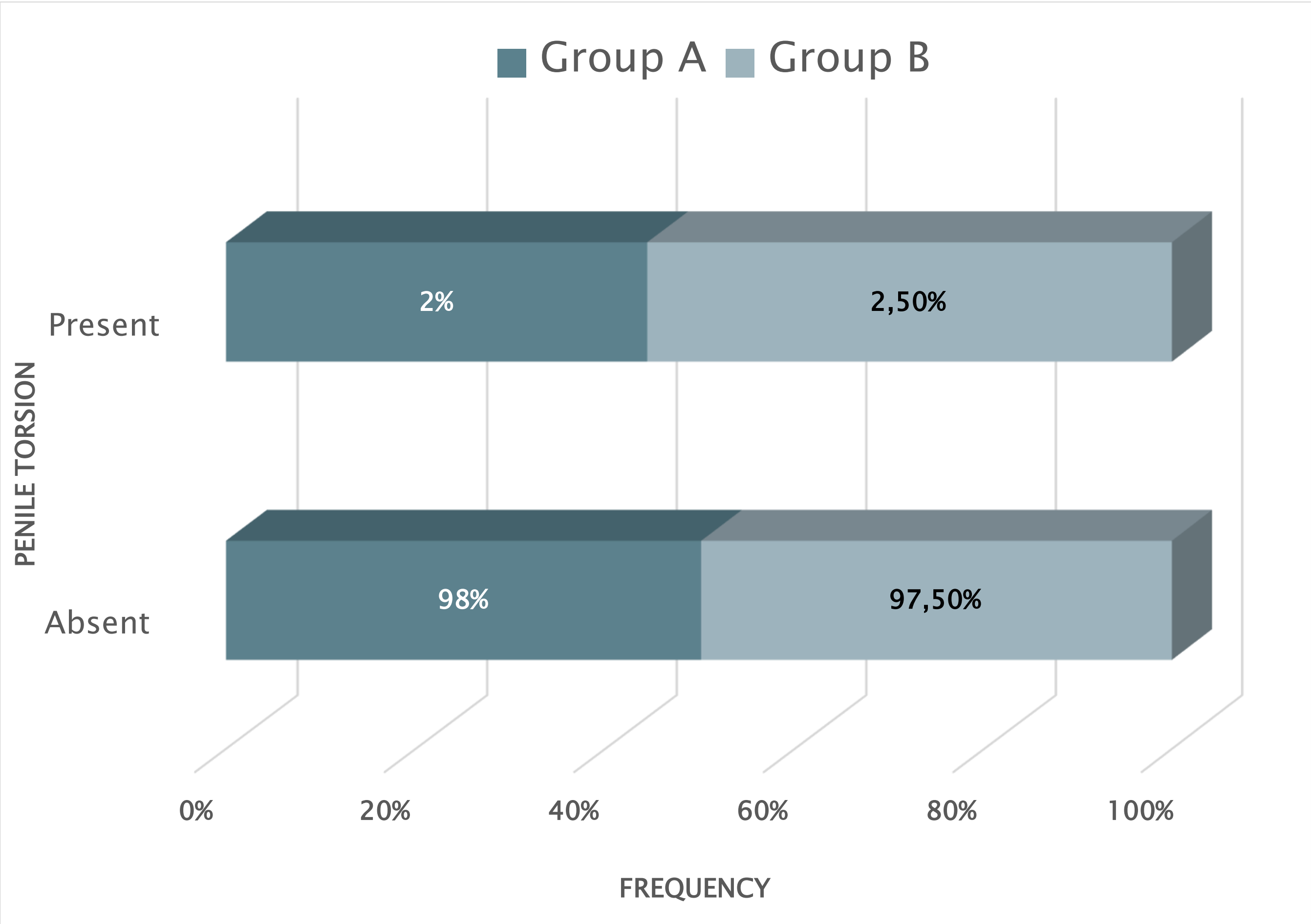


Chart 4. Distribution by the PT assessment and operative procedure

II. PERI-OPERATIVE MANAGEMENT

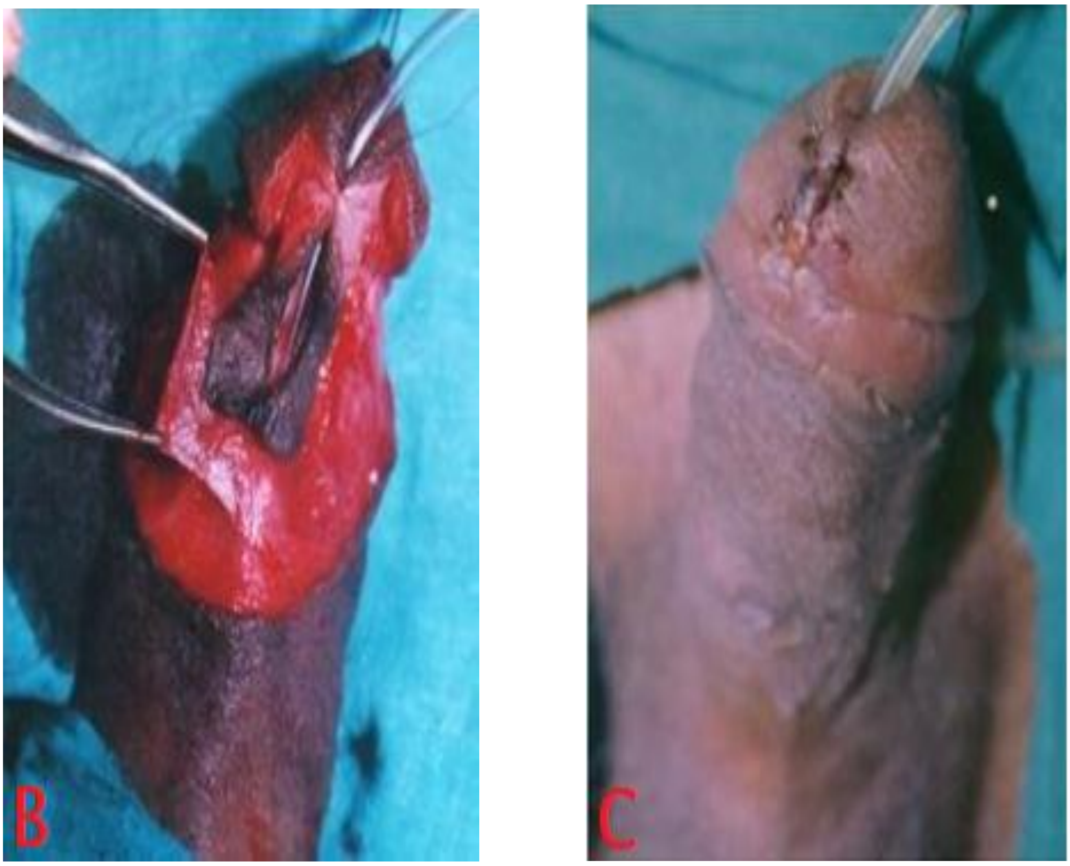
1. Hormonal Manipulation

None of the **90** patients of our study received any **adjunctive hormonal supplementation**, **replacement**, or **stimulation** prior to the surgery.

2. Hypospadias Surgery

A. Surgical Techniques

A) Operative photos showing the U-shaped incision to below the hypospadiac meatus + Snodgrass incision of the UP



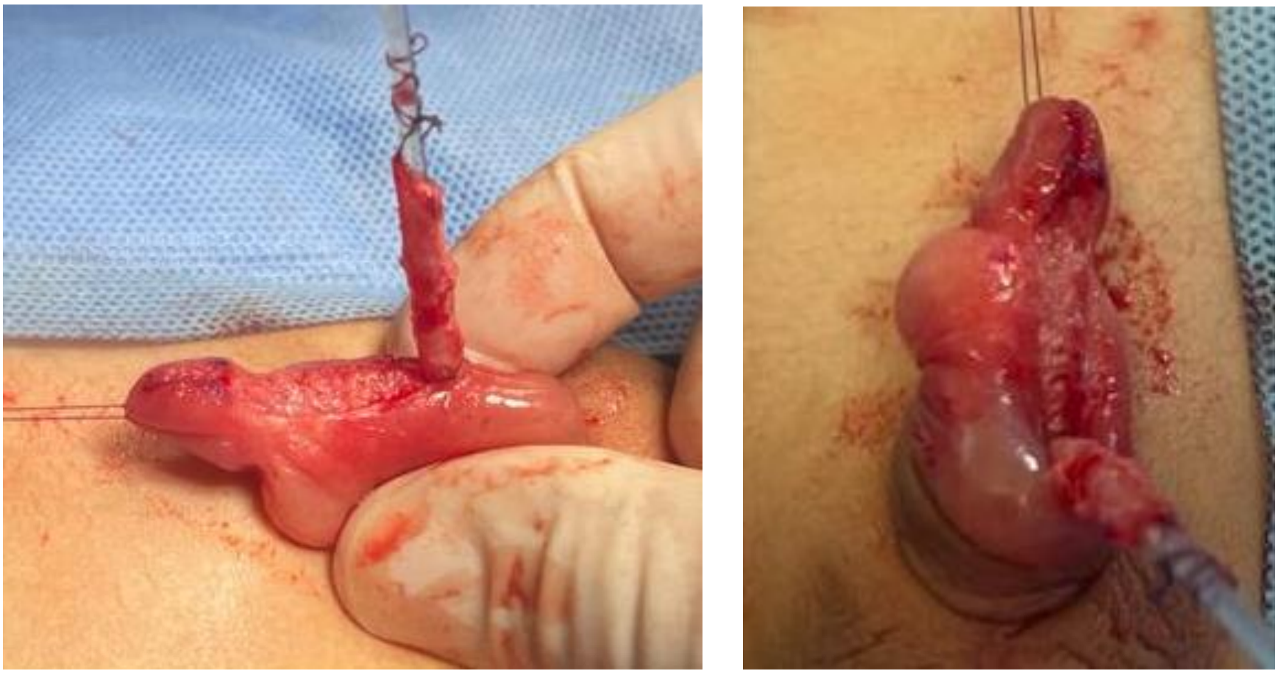
B) Operative photo showing the Urethral plate tubularization

C) Operative photo showing final aspect after glanuloplasty+skin closure

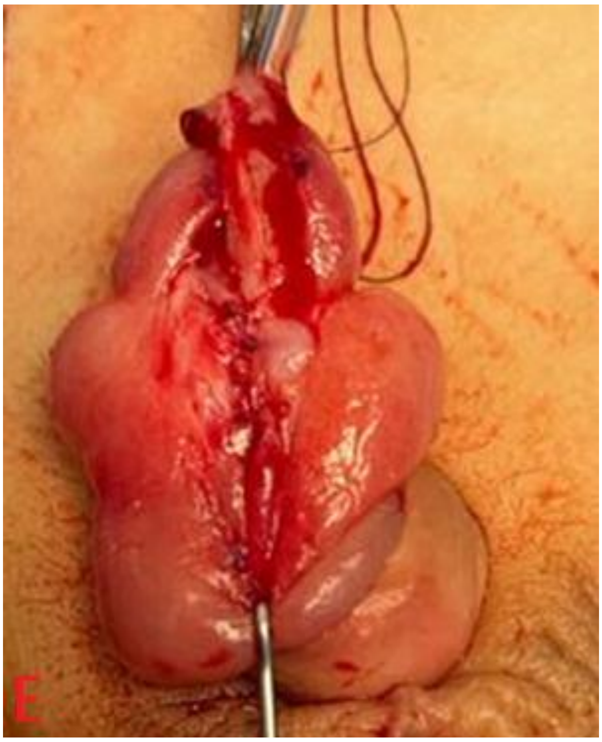
Figure 59. *Duplay-Snodgrass technique performed in our Pediatric Surgery Department. CHU HASSAN II-FEZ (A->C)* [258]

A) Pre-operative photo showing an ectopic meatus located 1 cm away from the tip of the glans

B) Operative photo showing the incision around the ectopic meatus

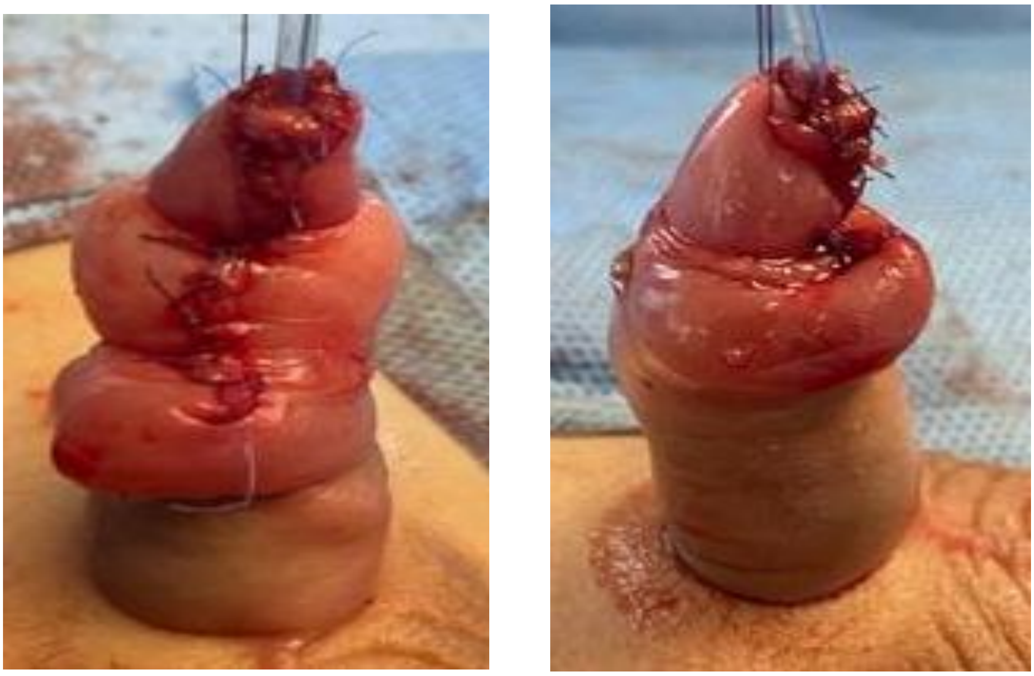


C) Operative photos showing the complete mobilization and release of the urethra



D) Operative photo showing the urethra positioned in the mobilized glans and meatoplasty

E) Operative photo showing the coverage with the dartos layer



F) Operative photos showing final aspect after glanuloplasty+skin closure

Figure 60. *Koff technique performed in our Pediatric Surgery Department. CHU HASSAN II-FEZ (A->F)* [258]

B. Surgeons Qualification

In ***our study***, surgeons of 2 different expertise statuses performed the surgical repair: **recently matriculated**/**junior surgeons** and their **mentors**/**experimented professors**.

As illustrated in the Table and Chart next page, in **both groups**, **Junior surgeons** performed more surgeries **(54.4%; N=49/90),** while **Mentors** operated on the remaining **41/90 (45.6%)** cases**.**

The difference between the **2 groups** was **not statistically significant** in terms of **Surgeons qualification** (**p-value**=**0.832**).

Table 5. Series' comparison concerning the surgeon qualification

	Group A		Group B		
Surgeons qualification (SQ)	N	%	N	%	**p-value**
Mentors	22	44	19	47.5	0.832
Junior surgeons	28	56	21	52.5	
Total	50	100	40	100	

N: Number of cases

%: Percentage

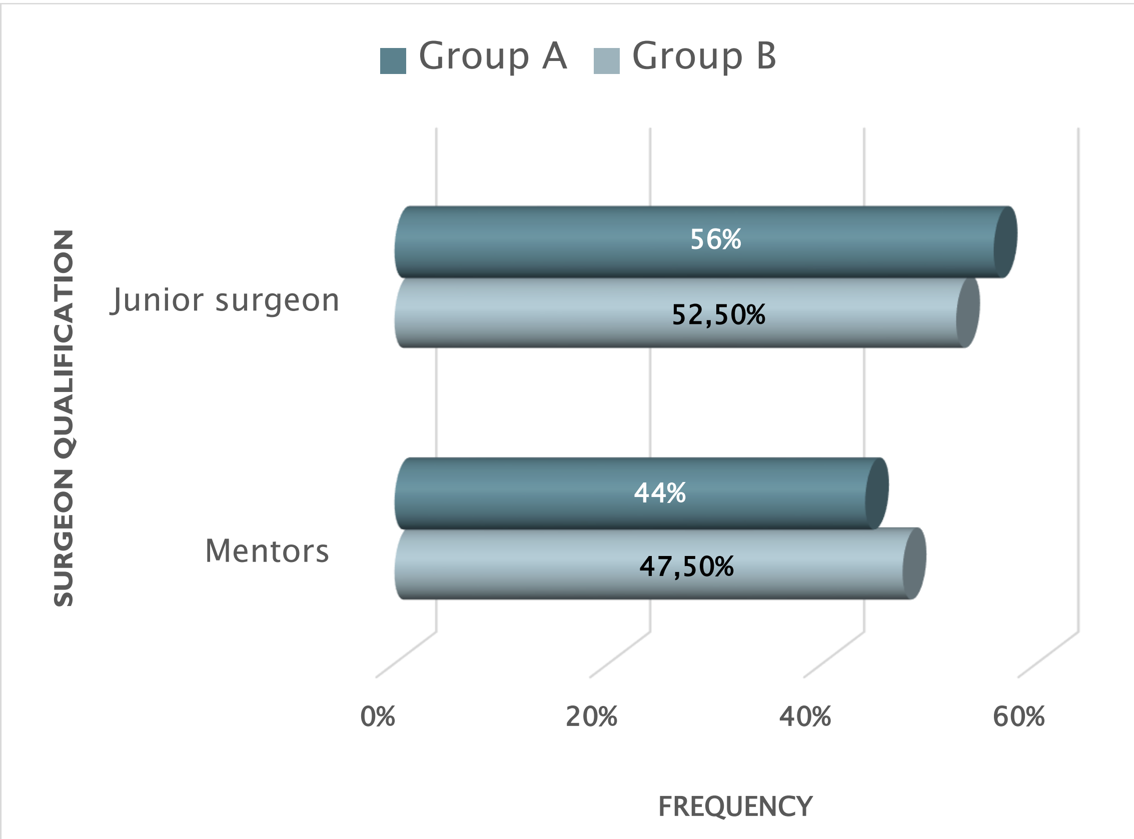


Chart 5. Distribution by surgeon qualification and type of repair

C. Anesthesia

Regarding the performed anesthesia techniques, ***our series*** disclosed **3 different methods**, which the selection was based on urologist-anesthesiologist's discretion.

As shown in the Table and Chart next page, **General anesthesia** (**GA**) was the most commonly used in **both groups (85.6%; N=77/90),** followed by **Spinal block (SB)** received by **12.2% (N=11/90)** cases**,** while Sedation supplemented with **Caudal block** (**CB**) was utilized occasionally **(2.2%; N=2/90)**. However, **none** of the patients had a **Penile block.**

The difference between the **2 groups** was **not statistically significant** in terms of **anesthesia technique** choice (**p-value=0.299**).

Table 6. Series' comparison according to the selected anesthesia technique

	Group A		Group B		
Anesthesia	N	%	N	%	**p-value**
General anesthesia	43	86	34	85	0.299
Spinal block	7	14	4	10	
Caudal block	0	0	2	5	
Total	50	100	40	100	

N: Number of cases

%: Percentage

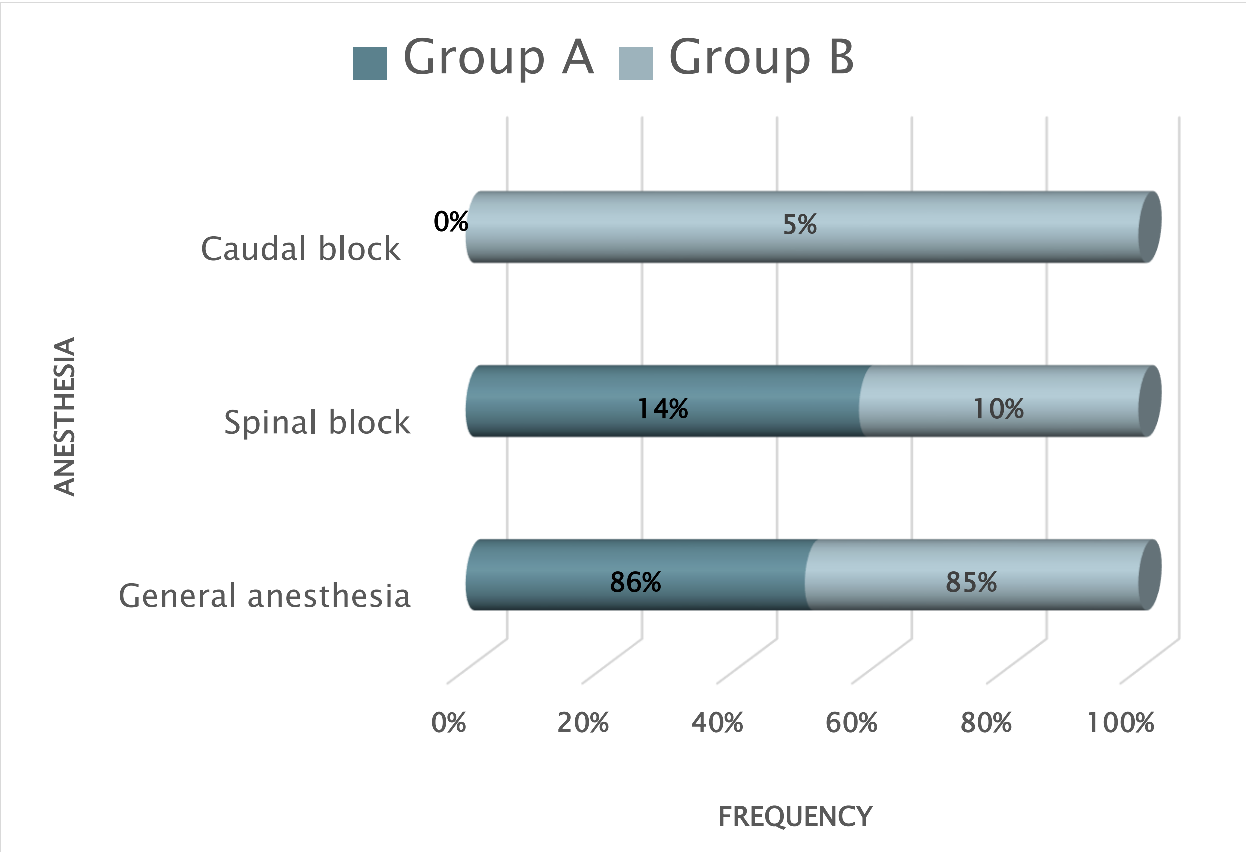


Chart 6. Distribution by the anesthesia technique and operative procedure

D. Prophylactic Antibiotics

All of the **90** patients received prophylactic antibiotics systematically.

Pre-operative antibiotics were given **intravenously** upon anesthesia induction, in the form of **1 dose** of **third-generation cephalosporin** (**ceftriaxone or cefotaxime 50 mg/kg**) or **first-generation** (**cefazolin 30 mg/kg**).

Postoperative oral antibiotics consisted of **Amoxicillin Clavulanate 3 times daily** starting from **day 1** after surgery up to **2 days** beyond removing the indwelling urethral catheter.

Topical antibiotics were **not used**.

E. Hemostasis

In our study, all **90** bloodless fields were maintained during surgery using a penile **tourniquet**, without cauterization or epinephrine injection.

F. Suture Materials and Suturing Techniques

In ***our study***, regarding the **urethral reconstruction** for the patients who underwent **Thiersch-Duplay urethroplasty**, **5/0** to **7/0 Polyglactin** (**VICRYL**) and **Polydioxanone (PDS)** sutures were used.

They were sewn over a 6 to 10 Fr catheter either with **Running** or **Interrupted** patterns mainly dictated by the **surgeon preference** based on the **local prerequisites.**

As summarized in the Table and Chart next page, among the **50** cases who underwent the **Thiersch-Duplay** procedure,

The urethral plate was tubularized in a **Running** fashion from a proximal to distal direction toward the normal opening on the glans in **98% (N=49)** procedures, while **only 1** procedure which counts for **2%** was accomplished using several **Interrupted** stitches of 6/0 VICRYL sutures.

The closure of the neourethra when performing the tubularization technique was done most commonly using as appropriate **5/0, 6/0** or **7/0 PDS** sutures in **70% (N=35)** cases, whereas **6/0 VICRYL** sutures were performed in **30% (N=15)** cases.

Table 7. Distribution of G.A patients by the ST

	Group A	
Suturing technique (ST)	N	%
Running	49	98
Interrupted	1	2
Total	50	100

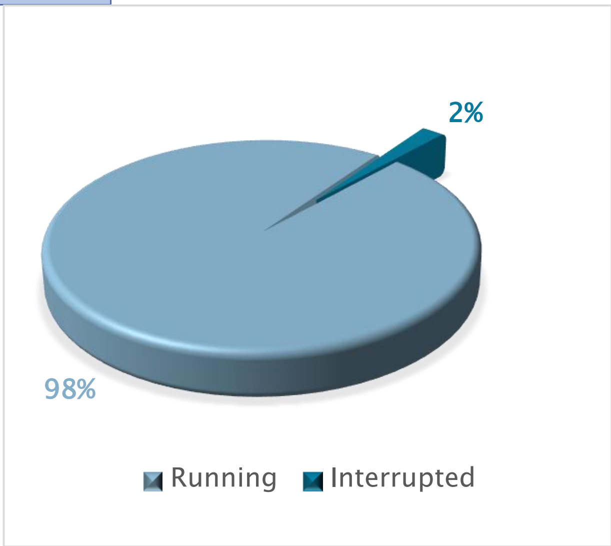


Chart 7. Distribution of G.A patients by the ST

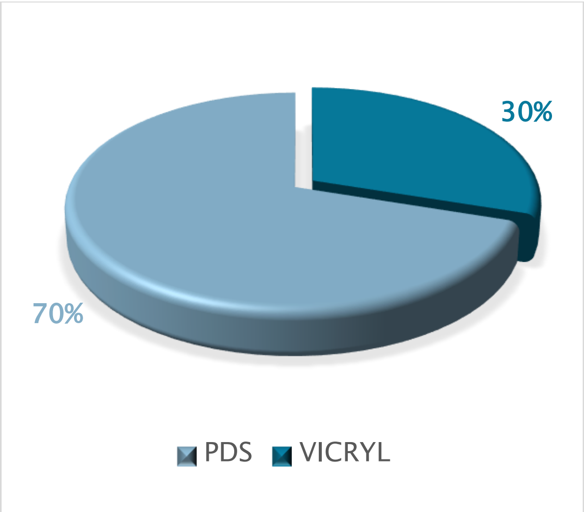


Chart 8. Distribution of G.A patients by the SM

Table 8. Distribution of G.A patients by the SM

	Group A	
Suture materials (SM)	N	%
PDS	35	70
VICRYL	15	30
Total	50	100

G. Foreskin

Although there remains a certain amount of skepticism and reluctance in offering **preputioplasty** to all patients, it's still a **desirable** component of every and each distal hypospadias repair performed in ***Our department***, whenever the case is considered **suitable**. Indeed, in ***our study***, **all** the **Duplay** and **koff** patients underwent a **preputioplasty** procedure.

In ***our department***, we don't circumcise our patients until the repair has definitely healed. We prefer to keep the prepuce **intact** to ensure adequate tissue **availability** to correct any future complication of the primary repair.

In ***our series***, and till September 2020, a **total** of **40** cases out of **74 reachable** patients (**54.1 %**) were **circumcised {N=18/39; 46.2 %** in G.A vs N=**22/35; 62.9 %** in G.B**}**, while the remaining **34/74** (**45.9 %**) patients are **still having their prepuce {N=21/39; 53.8 %** in G.A vs. **N**=**13/35; 37.1 %** in G.B**}.**

As we see, the circumcision rate within the **Koff** group was **higher** compared to **Duplay's**.

H. Urethral Intubation

Catheterless or catheterized approach remains a source of controversy among surgeons performing **distal** hypospadias repair.

Every patient of our series was equipped at the end of surgery with an indwelling **transurethral** urinary **catheter**, not only to maintain urinary diversion but also to keep the reconstructed plate pushed back into its bed and avoid the immediate post-operative painful micturition.

We used silicone catheters with different **sizes** between **6** Fr and **10** Fr.

None of our boys got a **suprapubic** diversion.

I. Catheter Removal

All of the patients in the present series had their bladders drained with a transurethral catheter for approximately **5 to 7 days**, and all patients voided spontaneously after catheter removal.

Although in our practice, objective tools (uroflowmetry, urethral calibration, standard questionnaires) are not used in routine post-operative assessments, we can state that **none** of our patients had **troublesome voiding or urinary retention**.

In our department, we do **not** routinely stent the distal one-stage hypospadias repairs for **more than 1 week**.

J. Dressing

In order to evaluate **postoperative care** in affecting surgical **success rate** or **wound healing**, we compared the **2 series** regarding the dressing type (**DT**), as noted on the Table and Chart next page.

The majority of our boys had **Honey** dressing for **both groups (63.3%; N=57/90),** while the remaining **33/90** cases **(36.7%)** were dressed using **simple Gauze compresses** dressing followed by a bandage.

The difference between the **2 groups** was **not statistically significant** in terms of **Dressing type** (**p-value=0.078**).

The penis was kept elevated, and the glans visible and checked regularly postoperatively.

Although a regimen of **no dressing** appears to result in increased patient comfort and decreased burden for the caregiver, **none** of the patients of our **series** was **deprived of dressing**.

K. Dressing Removal

For **all our study patients**, the dressing was kept with the trans-urethral catheter, and the patient was discharged with both. We believe that it protects the repair in the postoperative period.

The dressing **wasn't changed** until simultaneous **removal** with the urethral catheter on the **5th – 7th** postoperative day.

Table 9. Series' comparison regarding the dressing type

	Group A		Group B		
Dressing type	N	%	N	%	**p-value**
Gauze	14	28	19	47.5	0.078
Honey	36	72	21	52.5	
No dressing	0	0	0	0	
Total	50	100	40	100	

N: Number of cases

%: Percentage

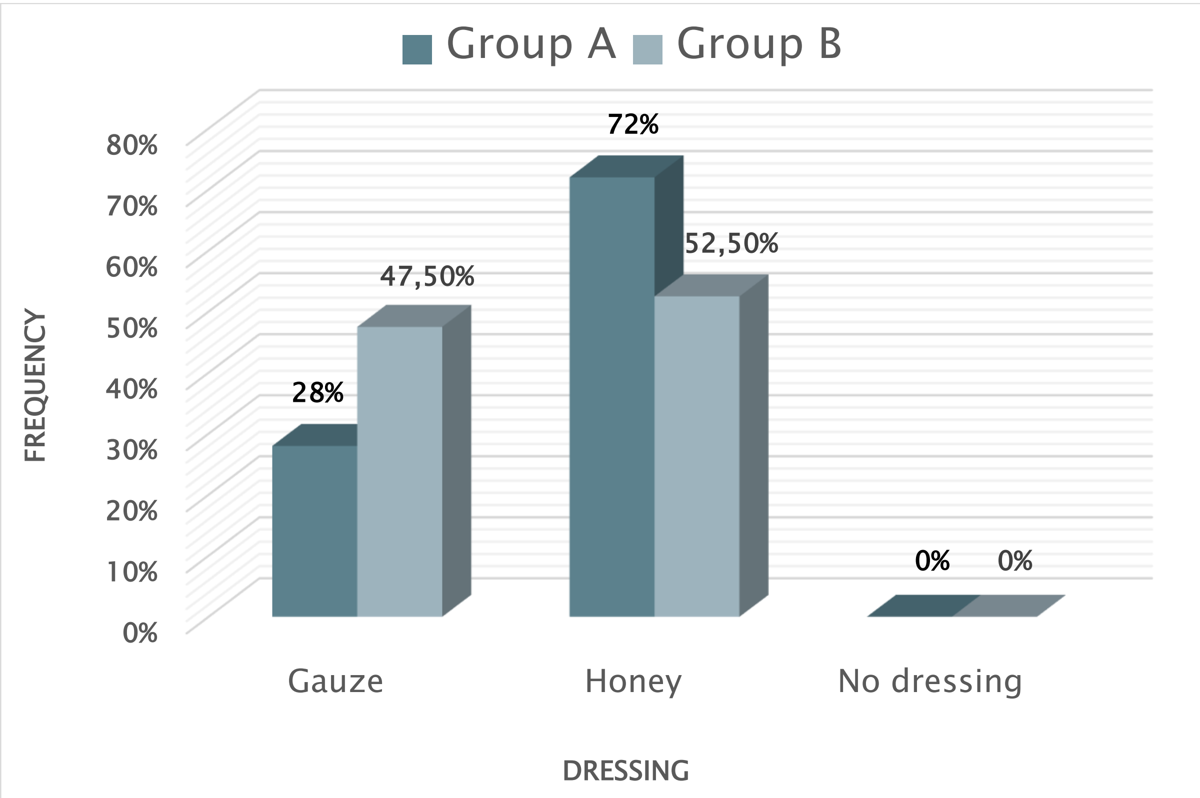


Chart 9. Distribution by the dressing type and surgical repair

L. Length Of Hospital Stay

In the present study, the appraisal of the length of hospitalization after surgical repair reported that-in **both studied groups-** the **majority (95.5%; N=86/90)** of children were discharged during the **first 48h post-surgery,** mostly the **next morning,** while **none** of them exceeded **1week.** Also demonstrated in the Table and Chart next page.

Elaborated data are described hereunder:

Group A:

Among the **50** cases who underwent the **Thiersch-Duplay** procedure,

96 % (N=**48**) were discharged in less than **48h,**

While the rest **4 %** (N=**2**) remained on the ward until the **5th -7th** postoperative day.

Group B:

Among the **40** cases who underwent the **Koff** procedure,

95 % (N=**38**) were discharged in less than **48h,**

While there was a prolonged hospital stay in **5 %** (N=**2**) cases for **5-7 days**.

As we see, the average hospital stay **did not differ significantly (p-value=1.000)** between the **2 groups.**

Table 10. Series' comparison in terms of the length of hospital stay

	Group A		Group B		
Length of hospital stay	N	%	N	%	**p-value**
<48h	48	96	38	95	1.000
48h-1week	2	4	2	5	
>1week	0	0	0	0	
Total	50	100	40	100	

N: Number of cases

%: Percentage

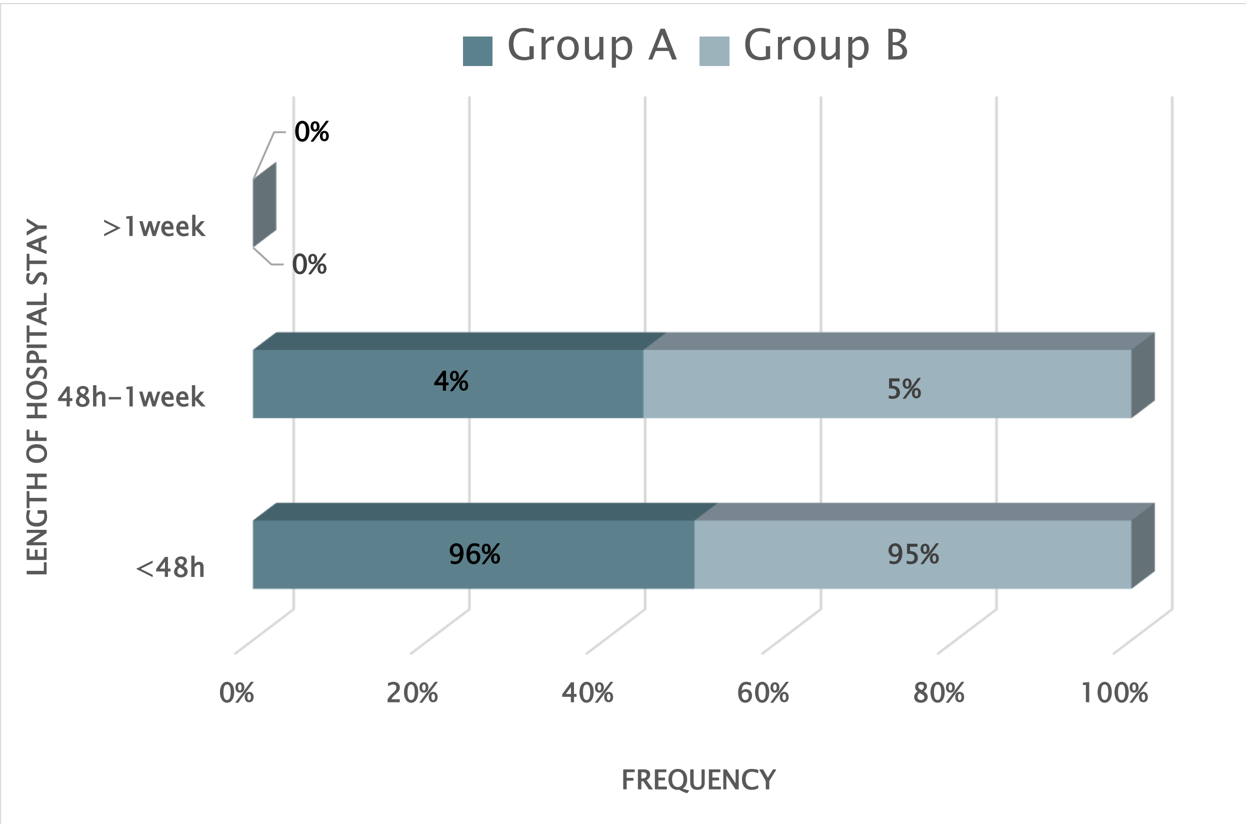


Chart 10. Distribution by length of hospital stay and operative procedure

III. POST-OPERATIVE MANAGEMENT

1. Postoperative Penile Erection and Bladder Spasms

ketoconazole wasn't administered to any of our **90** patients, whereas all of them received **Anticholinergics.** Our current regimen is to administer **orally 5mg** of **oxybutynin (Ditropan)** prior to surgery, then **5mg every 8 hours** until **catheter removal.**

Furthermore, to adduce more comfort to the child, we carefully monitor the stent for kinks and **small clots** of mucus or blood. Also, we ensure that any drainage device fitted to the catheter is appropriate for the **child's size**. And we inform the caregivers to **empty** the drainage before it is too full. And to minimize any **excessive pressure** in the drainage system, we recommend placing the drainage **bag on a level with the child**

2. Complications

A. Complications Rates Analysis Based on Different Confounding Factors

a. Age at Repair

Overall, postoperative **complications** occurred in **34/90 (37.8%)** patients, and the rates were **not significantly different** (**p-value = 0.605**) when assessing for the impact of **age at repair**. Specifically, in **2-5 years** range, >**5 years** range, and <**2 years** range, the overall complication rates were **40.3% (25/62)**, **37.5% (6/16)**, and **25% (3/12)** respectively.

Elaborated data found to be as the following:

Group A:

Of **50** patients who were operated on with the **Thiersch-Duplay** procedure,

10 % (N=**5**) were aged less than **2** years, **1** of them which counts for **20%** developed at least one **postoperative surgical complication.**

72 % (N=**36**) were aged **2** to **5** years, **17** of them which counts for **47.2%** developed at least one **postoperative surgical complication.**

18 % (N=**9**) were aged more than **5** years, **5** of them which counts for **55.5%** developed at least one **postoperative surgical complication.**

Group B:

Of **40** patients who were operated on with the **Koff** procedure,

17.5 % (N=**7**) were aged less than **2** years, **2** of them which counts for **28.6%** developed at least one **postoperative surgical complication.**

65 % (N=**26**) were aged **2** to **5** years, **8** of them which counts for **30.8%** developed at least one **postoperative surgical complication.**

17.5 % (N=**7**) were aged more than **5** years, **1** of them which counts for **14.3%** developed at least one **postoperative surgical complication.**

When adjusting to the surgical technique used for the hypospadias repair, the postoperative **surgical complication rates** were **not significantly correlated** with the **age at repair** (G.A: p-value=0.474 / G.B: p-value=0.875), even though we had **more complications** in >**5 years** range in **group A** vs. **more complications** in <**5 years** range in **group B.**

Table 11. Distribution of complicated cases with regard to the age at repair

Age at repair (years)	Number of cases	Complications	
		N	%
< 2	12	3	25
2 to 5	62	25	40.3
> 5	16	6	37.5
Total	90	34	

N: Number of cases

%: Percentage

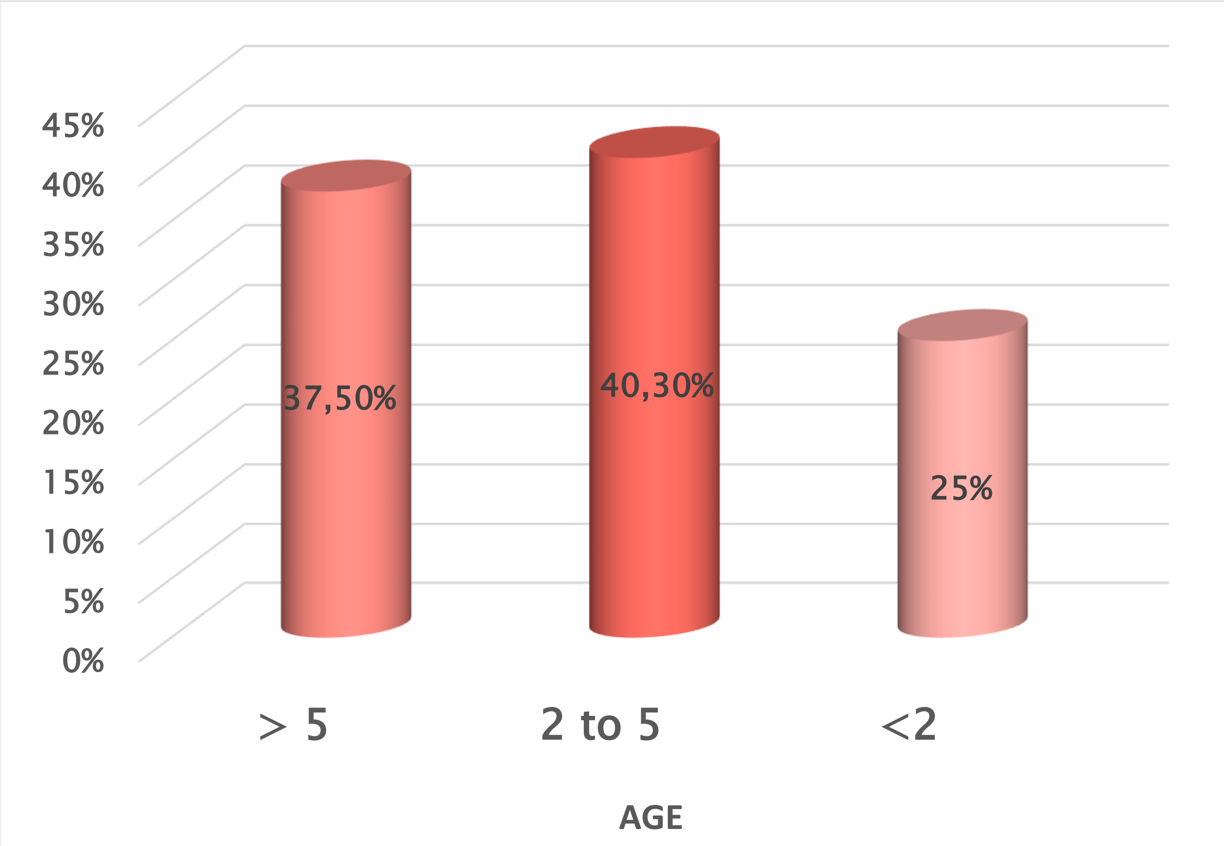


Chart 11. Distribution of complicated cases with regard to the age at repair

Table 12. Distribution by age at repair in complicated G.A cases

Age (years)	Number of cases	Complications	
		N	%
< 2	5	1	20
2 to 5	36	17	47.2
> 5	9	5	55.5
Total	50	23	

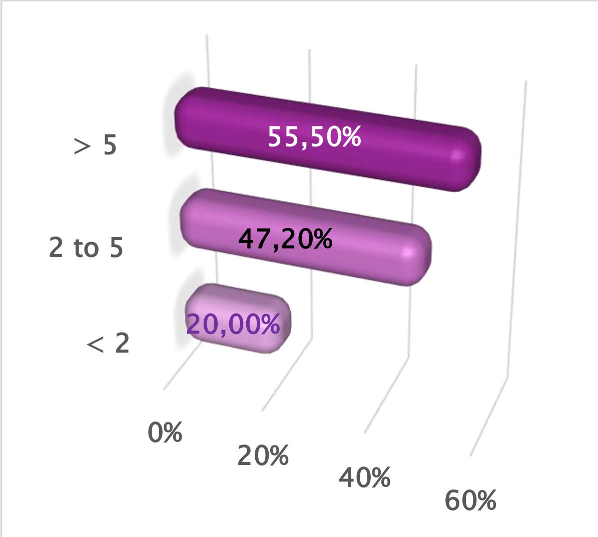


Chart 12. Distribution by age at repair in complicated G.A cases

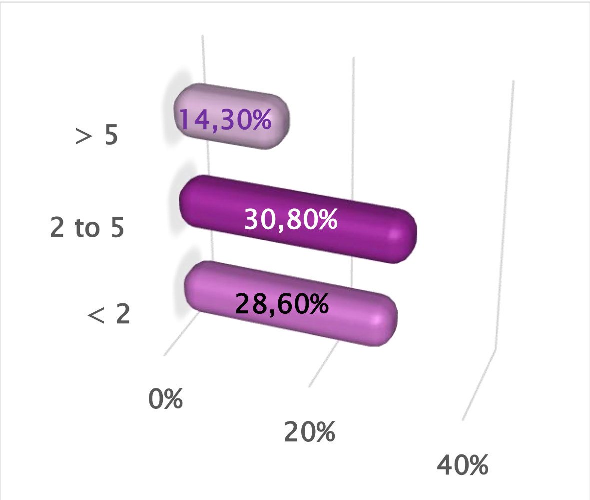


Chart 13. Distribution by age at repair in complicated G.B cases

Table 13. Distribution by age at repair in complicated G.B cases

Age (years)	Number of cases	Complications	
		N	%
< 2	7	2	28.6
2 to 5	26	8	30.8
> 5	7	1	14.3
Total	40	11	

b. Primitive Ectopic Meatal Location

In our series, we have evaluated the rates of **postoperative complications** in correlation with the **hypospadias severity** and the type of **operative intervention**, as noted on the Tables and Charts next pages.

Overall, postoperative **complications** occurred in **34/90 (37.8%)** patients, including **22/55 (40%)** patients with **distal penile** variant in 1st position, followed by **9/24 (37.5%)** with **glanular** in second position, and **3/11 (27.3%)** with **sub-coronal** in last position. No statistical significance was achieved **(p-value=0.728).**

Exhaustive details are as listed below:

Group A:

Among the **50** cases of **group A,** the **Thiersch-Duplay** procedure was used for:

-**Glanular** variant in **12/50 (24 %)** boys, **7** of them which counts for **58.3%,** developed at least one **postoperative surgical complication.**

-**Sub-coronal** presentation in **7/50 (14 %)** boys, **2** of them which counts for **28.6%,** developed at least one **postoperative surgical complication.**

-**Distal penile** hypospadias in **31/50** (62 %) boys,**14** of them which counts for **45.2%,** developed at least one **postoperative surgical complication.**

Group B:

Among the **40** cases of **group B,** the **Koff** procedure was used for:

-**Glanular** variant in **12/40 (30 %)** boys, **2** of them which counts for **16.7%,** developed at least one **postoperative surgical complication.**

-**Sub-coronal** presentation in **4/40 (10 %)** boys, **1** of them which counts for **25%,** developed at least one **postoperative surgical complication.**

-**Distal penile** hypospadias in **24/40** (**60 %**) boys,**8** of them which counts for **33.3%,** developed at least one **postoperative surgical complication.**

The **ectopic meatal location** in this study was **not significantly correlated** to the development of postoperative **complications** (**G.A: p-value=0.464 / G.B: p-value=0.753**). However, we had **more complications** with **glanular** variant than **distal penile** in **G.A** vs. **more complications** in **distal penile** variant than **glanular** in **G.B.**

Table 14. Distribution of complicated cases with regard to the EML

Ectopic meatal location (EML)	Number of cases	Complications N	Complications %
Glanular	24	9	37.5
Sub-coronal	11	3	27.3
Distal penile	55	22	40
Total	90	34	

N: Number of cases

%: Percentage

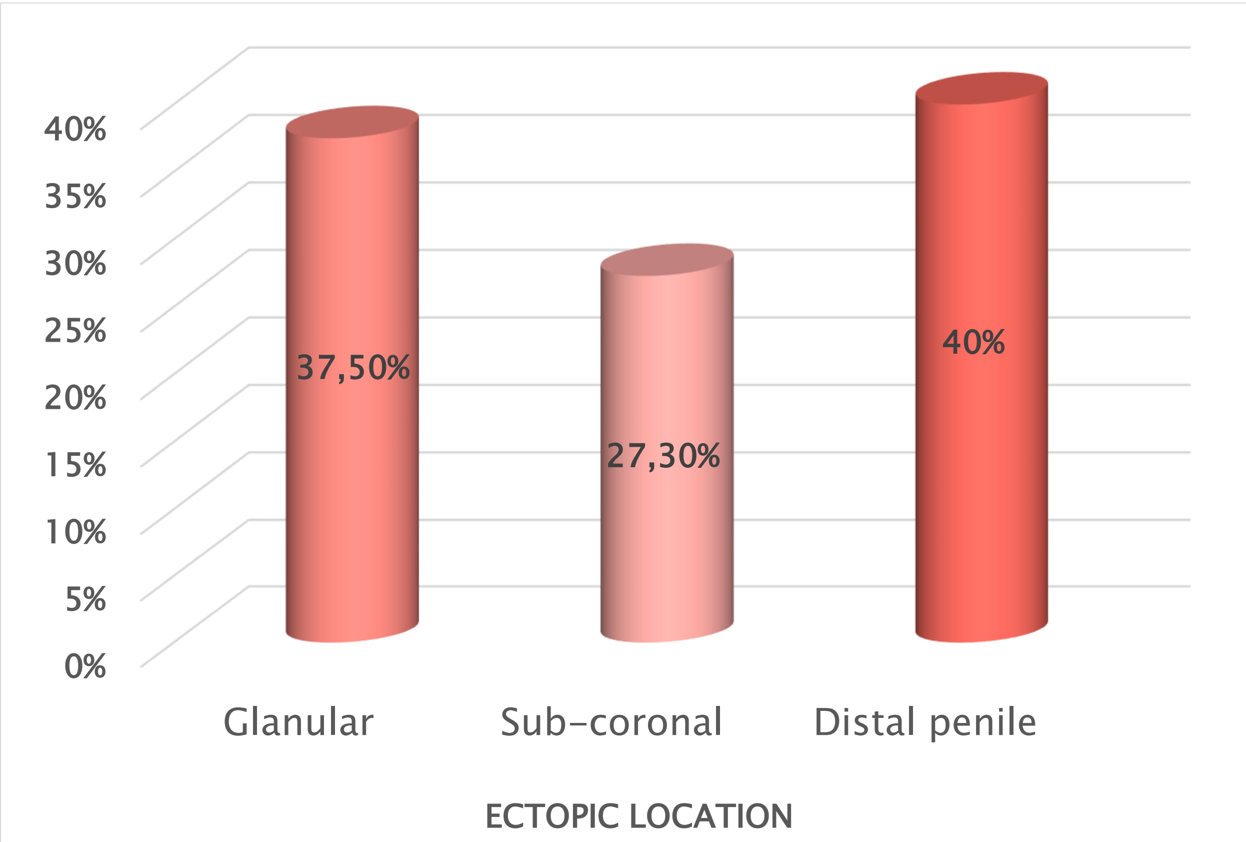


Chart 14. Distribution of complicated cases with regard to the EML

Table 15. Distribution by EML in complicated G.A cases

EML	Number of cases	Complications N	Complications %
Glanular	12	7	58.3
Sub-coronal	7	2	28.6
Distal penile	31	14	45.2
Total	50	23	

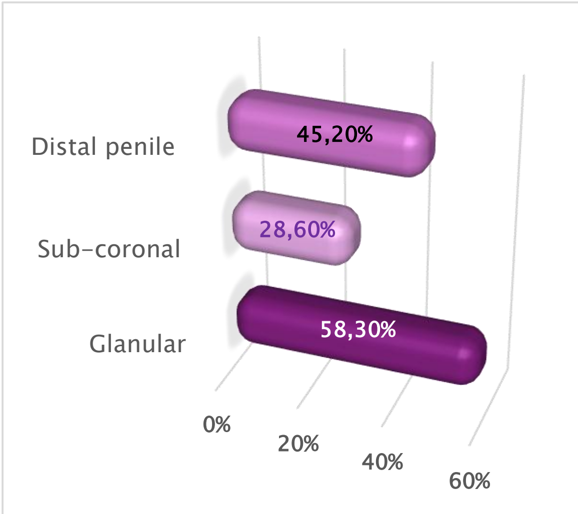


Chart 15. Distribution by EML in complicated G.A cases

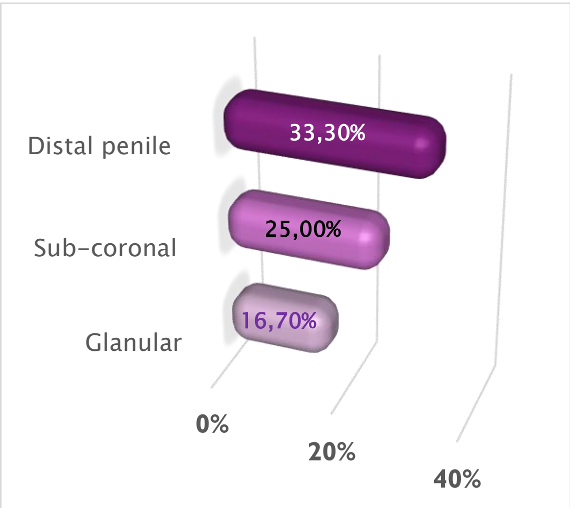


Chart 16. Distribution by EML in complicated G.B cases

Table 16. Distribution by EML in complicated G.B cases

EML	Number of cases	Complications N	Complications %
Glanular	12	2	16.7
Sub-coronal	4	1	25
Distal penile	24	8	33.3
Total	40	11	

c. Surgeons Qualification

Overall, postoperative **complications** occurred in **34/90 (37.8%)** patients, including **20/49 (40.8%)** cases repaired by **Junior surgeons** and **14/41 (34.1%)** cases fixed by **Mentors. (p-value=0.949)**

Elaborated data are described hereunder:

Group A:

Among the **50** cases who underwent the **Thiersch-Duplay** procedure,

Junior surgeons performed **56% (N=28)** cases; **13** of them, which counts for **46.4%,** developed at least one **postoperative complication.**

Mentors were involved in the remaining **44 %** (N=**22**) cases; **10** of them, which counts for **45.4%,** developed at least one **postoperative complication**.

Group B:

Among the **40** cases who underwent the **Koff** procedure,

Junior surgeons performed **52.5 %** (N=**21**) cases; **7** of them, which counts for **33.3%,** developed at least one **postoperative complication**.

Mentors were involved in the remaining **47.5 %** (N=**19**) cases; **4** of them, which counts for **21%,** developed at least one **postoperative complication**.

The postoperative **complication rate** was **not significantly correlated** with the **surgeon qualification** (G.A: p-value=0.967 / G.B: p-value=1.000), even though we had **more complications** under **Junior surgeons'** hands in **both groups**.

Table 17. Distribution of complicated cases with regard to the SQ

Surgeon qualification (SQ)	Number of cases	Complications	
		N	%
Mentors	41	14	34.1
Junior surgeons	49	20	40.8
Total	90	34	

N: Number of cases

%: Percentage

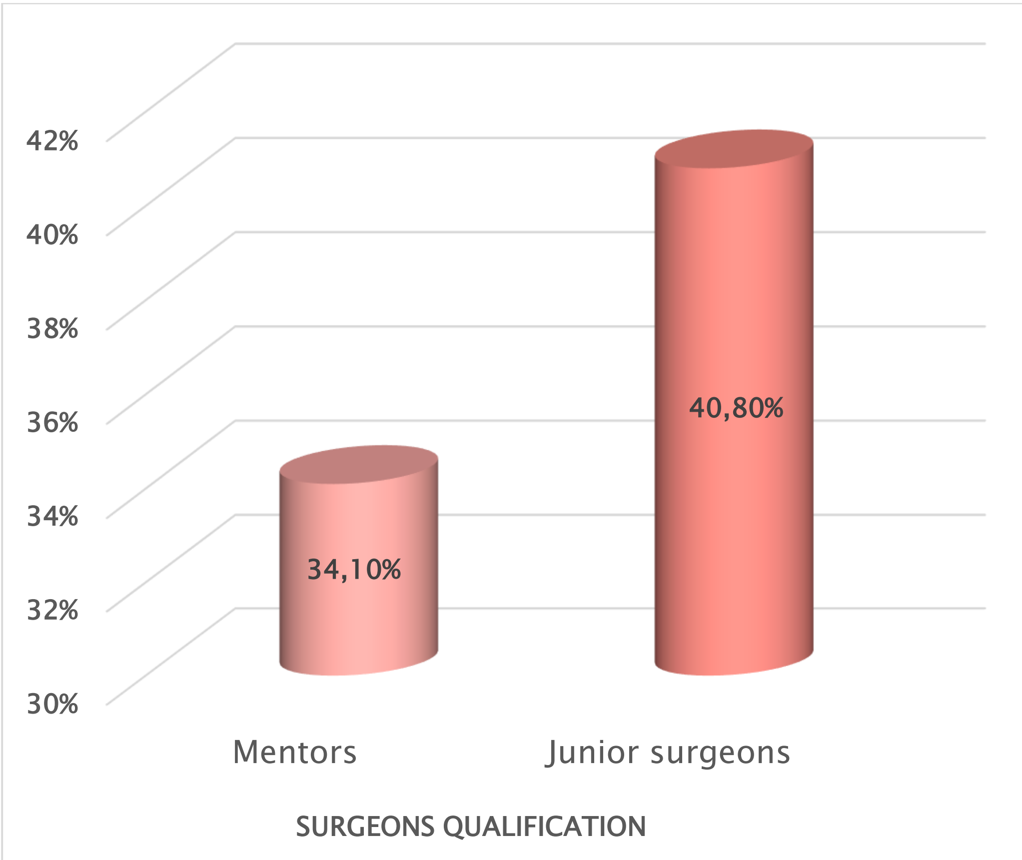


Chart 17. Distribution of complicated cases with regard to the SQ

Table 18. Distribution by SQ in complicated G.A cases

SQ	Number of cases	Complications	
		N	%
Mentors	22	10	45.4
Junior surgeons	28	13	46.4
Total	50	23	

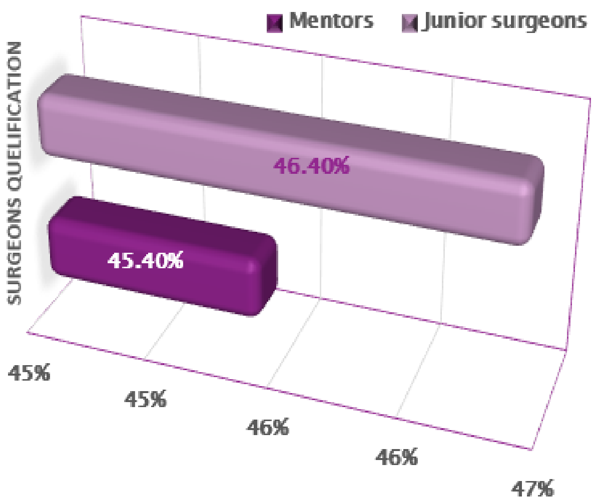


Chart 18. Distribution by SQ in complicated G.A cases

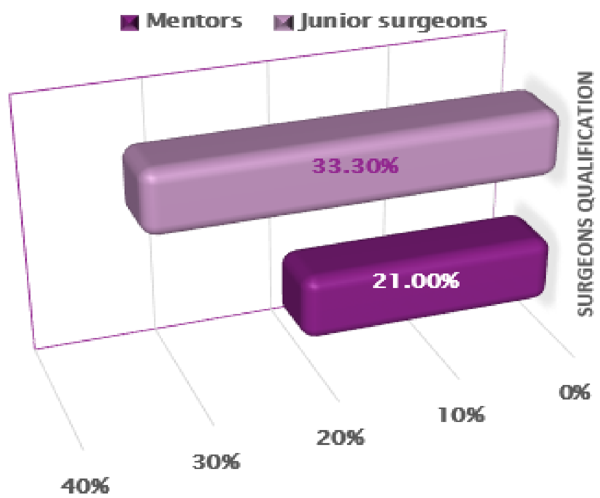


Chart 19. Distribution by SQ in complicated G.B cases

Table 19. Distribution by SQ in complicated G.B cases

SQ	Number of cases	Complications	
		N	%
Mentors	19	4	21
Junior surgeons	21	7	33.3
Total	40	11	

d. Anesthesia

None of our series' patients experienced **anesthesia-related complications.** Furthermore, all the surgeries under **SB** and **CB** were completed without conversion to **GA.**

Overall, postoperative **complications** occurred in **34/90 (37.8%)** patients, and the rates were almost **identical (p-value=0.474)** when assessing for the impact of **anesthetic technique**. Specifically, after **SB**, **GA**, and **CB**, the overall complication rates were **45.4% (N=5/11)**, **37.7% (N=29/77)**, and **0%** respectively.

Exhaustive details are as listed below:

Group A:

Of **50** patients who were operated on with the **Thiersch-Duplay** procedure,

86% (N=**43**) cases received **GA; 19** of them, which counts for **44.2%,** developed at least one **postoperative surgical complication.**

SB was performed in **14 %** (N=**7**) cases;**4** of them, which counts for **57.1%,** developed at least one **postoperative surgical complication.**

Whereas **none** of the patients experienced **Sedation with adjunctive CB.**

Group B:

Of **40** patients who were operated on with the **Koff** procedure,

85 % (N=**34**) cases received **GA; 10** of them, which counts for **29.4%,** developed at least one **postoperative surgical complication.**

SB was performed in **10 %** (N=**4**) cases; **1** of them, which counts for **25%,** developed at least one **postoperative surgical complication.**

Whereas **5 %** (N=**2**) cases experienced **sedation with adjunctive CB. None** of them developed any **postoperative surgical complication.**

When adjusting to the surgical procedure used for the hypospadias repair, the postoperative **surgical complication rate** was **not significantly correlated** with the **anesthetic technique** (G.A: p-value=0.523 / G.B: p-value=0.659), even though we had **more complications** under **SB** compared to **GA** in **group A.** versus **more complications** under **GA** compared to **SB** in **group B.**

Table 20. Distribution of complicated cases with regard to the AT

Anesthesia technique (AT)	Number of cases	Complications N	Complications %
General anesthesia	77	29	37.7
Spinal block	11	5	45.4
Caudal block	2	0	0
Total	90	34	

N: Number of cases

%: Percentage

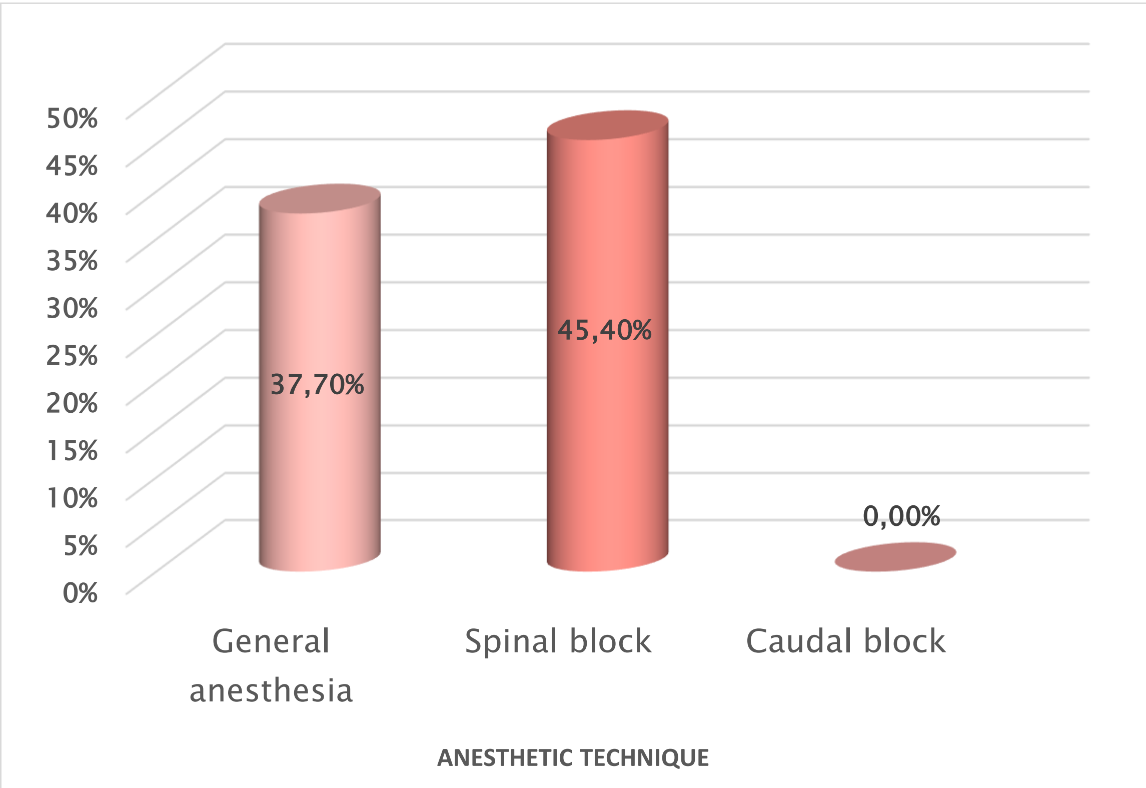


Chart 20. Distribution of complicated cases with regard to the AT

Table 21. Distribution by AT in complicated G.A cases

AT	Number of cases	Complications N	Complications %
General anesthesia	43	19	44.2
Spinal block	7	4	57.1
Caudal block	0	0	0
Total	50	23	

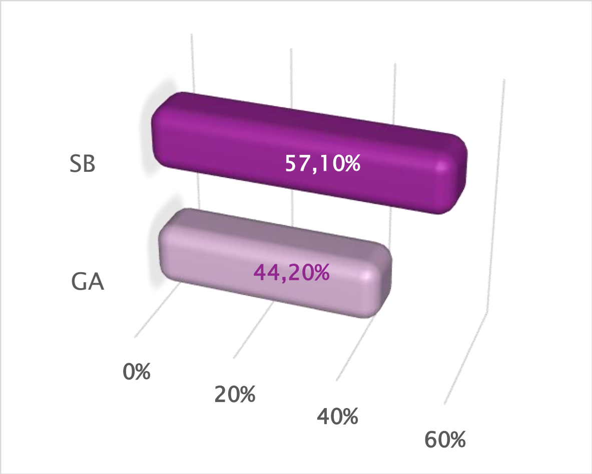


Chart 21. Distribution by AT in complicated G.A cases

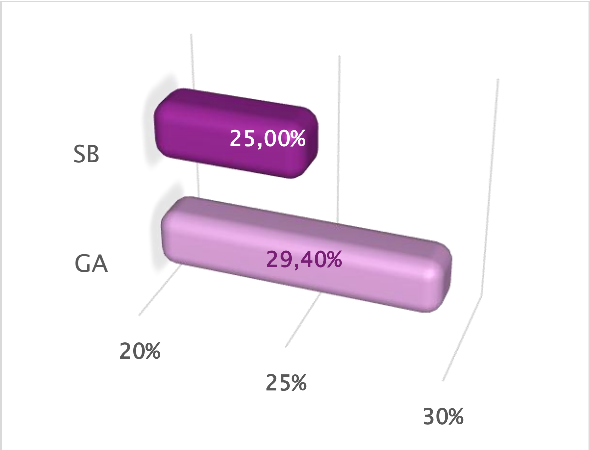


Chart 22. Distribution by AT in complicated G.B cases

Table 22. Distribution by AT in complicated G.B cases

AT	Number of cases	Complications N	Complications %
General anesthesia	34	10	29.4
Spinal block	4	1	25
Caudal block	2	0	0
Total	40	11	

e. Suture Materials and Suturing Techniques

The only patient who got the **Interrupted** pattern has exhibited **2 UCF,** whereas **22** patients which counts for **44.9%** out of the **49** who got the **Running** pattern developed at least one **postoperative complication**.

Overall, postoperative **complications** occurred in **23/50 (46%)** patients, and the rates **didn't differ significantly** (p-value = 0.359) when assessing for the impact of **Suture materials**. Specifically, with **PDS** and **VICRYL**, the overall complication rates were **51.4% (18/35)** and **33.3% (5/15)** respectively.

Table 23. Distribution of G.A complicated cases with regard to the ST

		Complications	
ST	**Number of cases**	**N**	**%**
Running	49	22	44.9
Interrupted	1	1	100
Total	50	23	

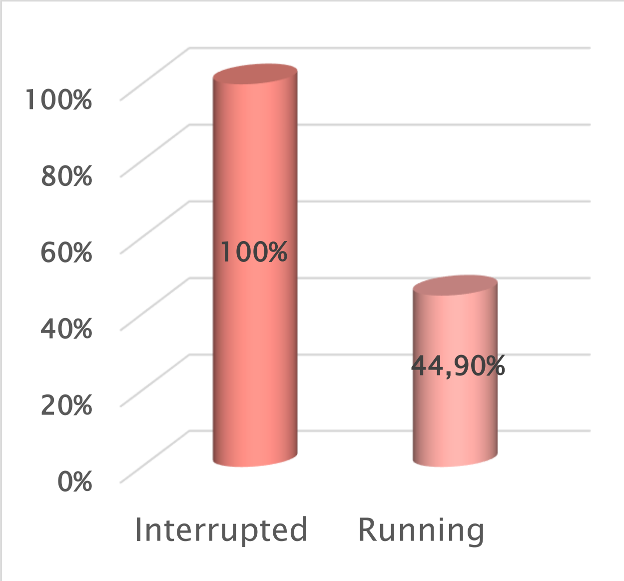


Chart 23. Distribution of G.A complicated cases with regard to the ST

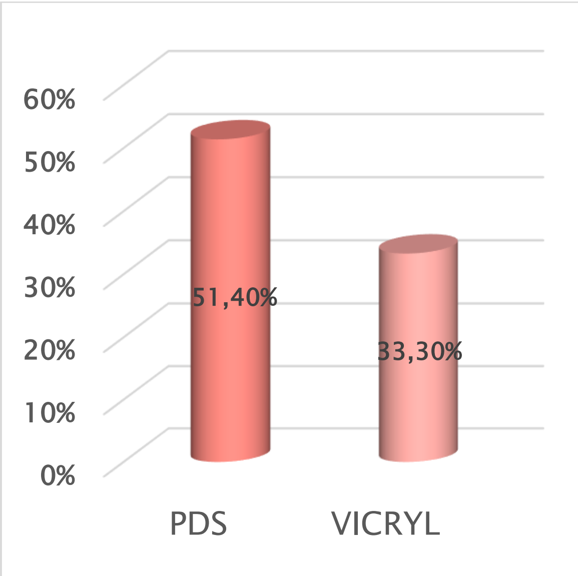


Chart 24. Distribution of G.A complicated cases with regard to the SM

Table 24. Distribution of G.A complicated cases with regard to the SM

		Complications		
SM	**Number of cases**	**N**	**%**	**p-value**
PDS	35	18	51.4	0.359
VICRYL	15	5	33.3	
Total	50	23		

f. Dressing

Overall, postoperative **complications** occurred in **34/90 (37.8%)** patients, including **16/33 (48.5%)** cases wrapped with **Gauze**, followed by **18/57 (31.6%)** covered with **Honey**. (**p-value=0.153**)

The detailed results found to be as the following:

Group A:

Of **50** patients operated on with the **Thiersch-Duplay** procedure,

Honey dressing was preferred in **72 %** (N=**36**) cases; **15** of them counted for **41.7%** developed at least one **postoperative complication**.

While simple **Gauze** compresses were applied to **28 %** (N=**14**) cases, **8** of them counted for **57.1%** exhibited at least one **postoperative complication**.

Group B:

Of **40** patients operated on with the **Koff** procedure,

Honey dressing was preferred in **52.5 %** (N=**21**) cases; **3** of them counted for **14.3%** developed at least one **postoperative complication**.

While simple **Gauze** compresses were applied to **47.5 %** (N=**19**) cases, **8** of them counted for **42.1%** exhibited at least one **postoperative complication**.

In this study, the postoperative **complications rates** were **not significantly correlated** with the **Dressing type** (G.A: p-value=0.458 / G.B: p-value=0.103), even though we had **more complications** with **Gauze** dressing than Honey dressing in **both groups**.

Table 25. Distribution of complicated cases with regard to the DT

Dressing Type (DT)	Number of cases	Complications	
		N	%
Gauze	33	16	48.5
Honey	57	18	31.6
Total	90	34	

N: Number of cases

%: Percentage

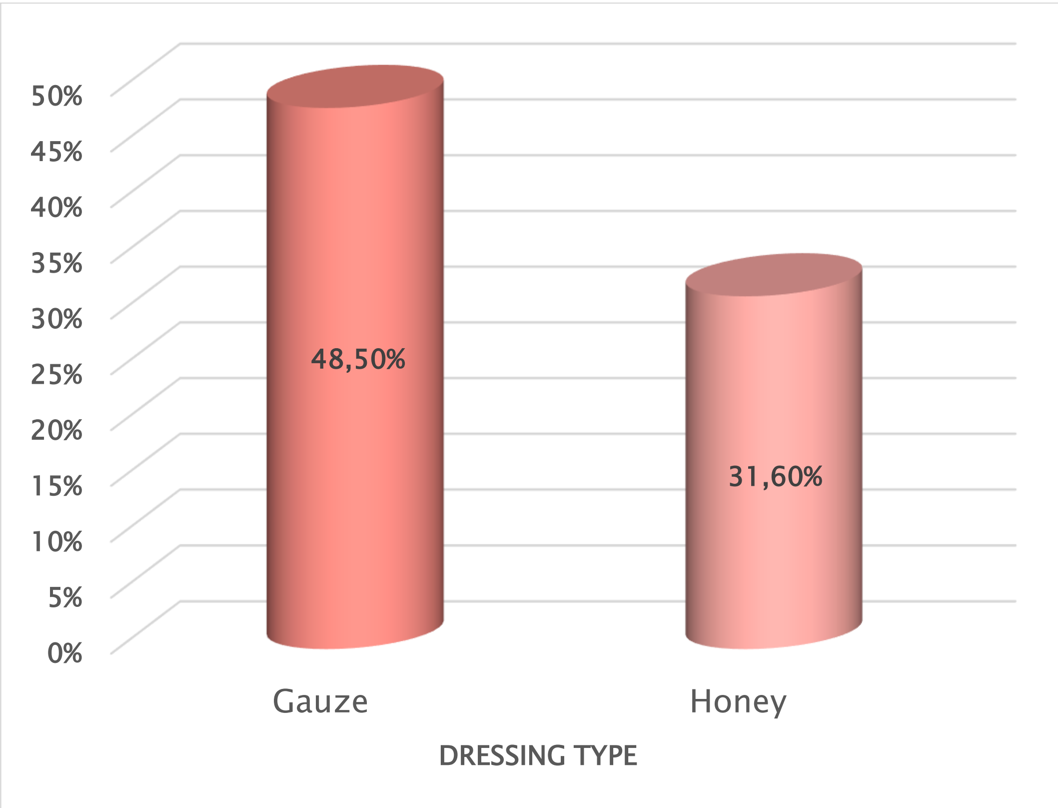


Chart 25. Distribution of complicated cases with regard to the DT

Table 26. *Distribution by DT in complicated G.A cases*

DT	Number of cases	Complications	
		N	%
Gauze	14	8	57.1
Honey	36	15	41.7
Total	50	23	

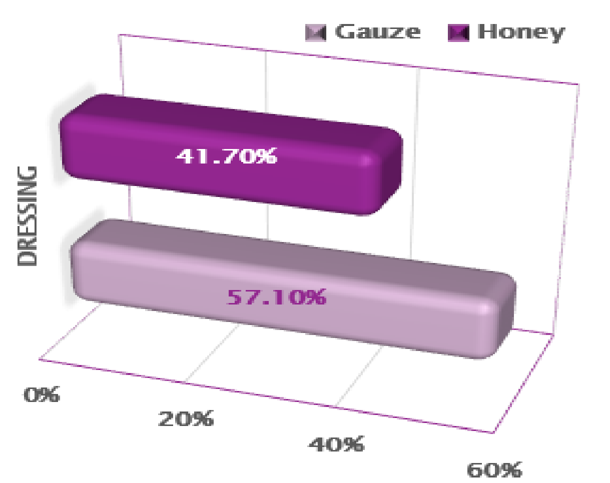


Chart 26. Distribution by DT in complicated G.A cases

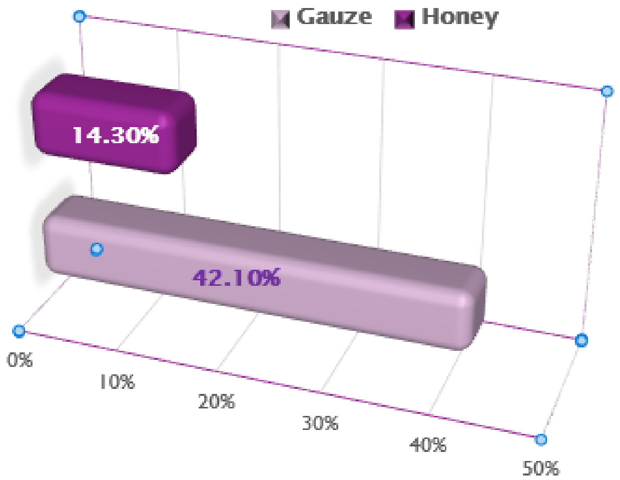


Chart 27. Distribution by DT in complicated G.B cases

Table 27. Distribution by DT in complicated G.B cases

DT	Number of cases	Complications	
		N	%
Gauze	19	8	42.1
Honey	21	3	14.3
Total	40	11	

B. Acute Postoperative Complications

For **all** of our patients, the procedures were carried out **without incidents**.

Although the demanding **dissection** and the **separation** of the **CS** from **CC** in **Koff** procedure, can be a **bloody manoeuvre**, causing significant postoperative **haematoma**, we didn't encounter such problem in ***our study.***

In addition, **none** of the reviewed children has shown any postoperative surgical complication within the **first 10 days** after repair, such as **bleeding**, **hematoma, edema** and **wound infection**.

These findings stressed our team's high surgical skills. They have handled the loose and fragile penile tissue susceptible to edema and infection delicately and brightly.

C. Late Postoperative Complications

Despite the advancement in the surgical field, even the most commonly used hypospadias correction techniques continue to challenge surgeons with post-operative complications most commonly **meatal stenosis (MS)**, **urethro-cutaneous fistula (UCF)**, and **wound dehiscence (WD)**.

In our series, **62.2%** of patients **(N=56/90)** had successful surgeries (free of complications); whereas **37.8% (N=34/90)** cases have encountered at least 1 postoperative surgical **complication,** including **46%** (**N=23/50**) in **Group A** and **27.5%** (**N=11/40**) in **Group B**, revealing a **better** outcome of the **Koff procedure** despite the statistical insignificance (**p-value** = **0.084**).

The overall complications rate was **47.8%,** corresponding to **43 complications** in the **34 complicated patients**, distributed as follows; **32 complications** in the **23 boys** from **Duplay's** group versus **11 complications** in the **11 boys** from **Koff's** group. The **superiority** of **Koff**'s procedure was **highly evident.**

Secondary procedures were needed in **28.9% (N=26/90)** to correct **UCF** in **4** patients and **WD** in **22** patients. Specifically, **32%** in **Group A (16/50)** and **25%** in **Group B (10/40).**

The **commonest** complication was **WD** presented in **24.4%** (**N**= **22/90**) patients, the second was **UCF** shown in **14.4%** (**N**=**13/90**) patients, and the third was **MS** found in **4.4%** (**N**= **4/90**) patients.

We **didn't objectify** any other complication besides **WB, UCF,** and **MS** in both groups. And none of the boys from Koff's group developed a complication before the 6th month postoperatively.

Exhaustive details are as outlined in the Table and Charts next pages.

Table 28. Distribution of complications regarding the SP and the time period

Complications	Time period	Group A N	Group A % /50	Group B N	Group B % /40	p-value	Total N	Total %/90
Total patients with successful procedures	-	27	54	29	72.5	0.084	56	62.2
UCF (13 patients who had 17 UCF)	1st month	1	2	0	0	1.000	1	1.1
	>6th month	11	22	1	2.5	0.011	12	13.3
	Total	12	26	1	2.5	0.006	13	14.4
MS	1st month	2	4	0	0	0.501	2	2.2
	>6th month	2	4	0	0	0.501	2	2.2
	Total	4	8	0	0	0.067	4	4.4
WD	1st month	0	0	0	0	-	0	0
	>6th month	12	24	10	25	0.913	22	24.4
	Total	12	24	10	25	0.913	22	24.4
Total complications	-	32	64	11	27.5	-	43	47.8
Total patients with at least 1 complication	-	23	46	11	27.5	0.084	34	37.8

N: Number of cases

%: Percentage

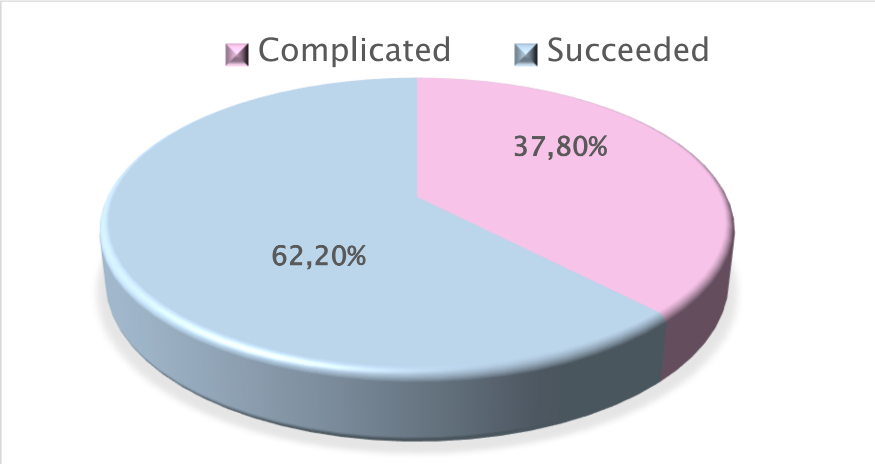


Chart 28. Distribution of postoperative complication and success rates

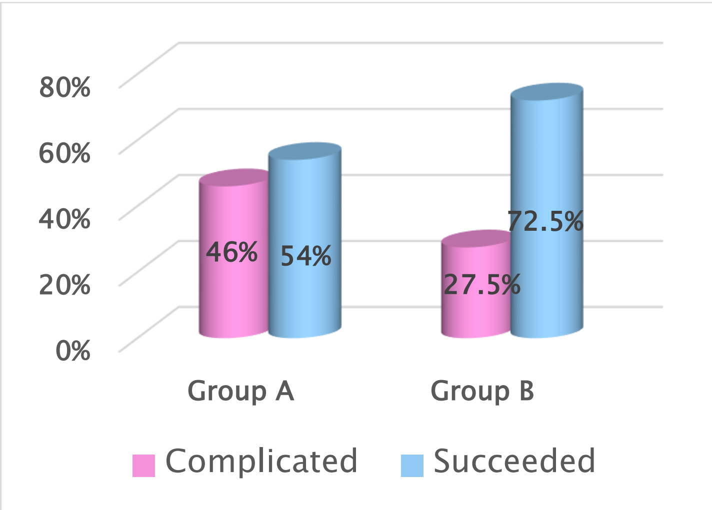


Chart 29. Series' comparison concerning the success and complication rates

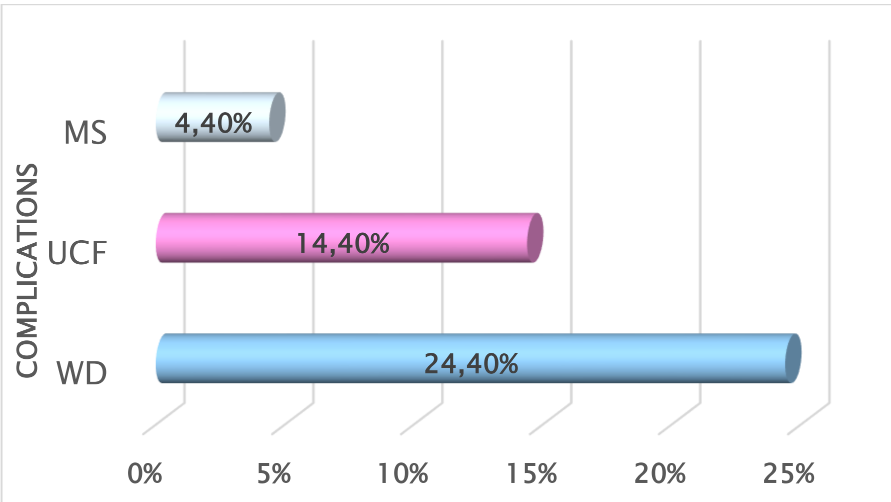


Chart 30. The postoperative complications stratification

a. Meatal Stenosis (MS)

As illustrated in the Chart next page, all of the **4 MS cases** in our series were seen in the **Duplay's** group (**8%, N=4/50**).

Two of them were reported within the **1st month** after hypospadias surgery; they responded well to **4 consecutive meatal dilations** (one per week). Both patients didn't experience any other complications.

Whereas another **one** was diagnosed in the **6th month** after primary surgery, he was handled similarly, and no other complication was pointed out.

Finally, the last **one** was developed **18 months** after 1st repair in **concomitance** with the patient's **2nd UCF**, and **6 months** after his **1st UCF**. It was managed similarly.

None of our **40** patients who were operated on with the **Koff** procedure has exhibited a **MS** or needed a urethral calibration all along the follow-up period.

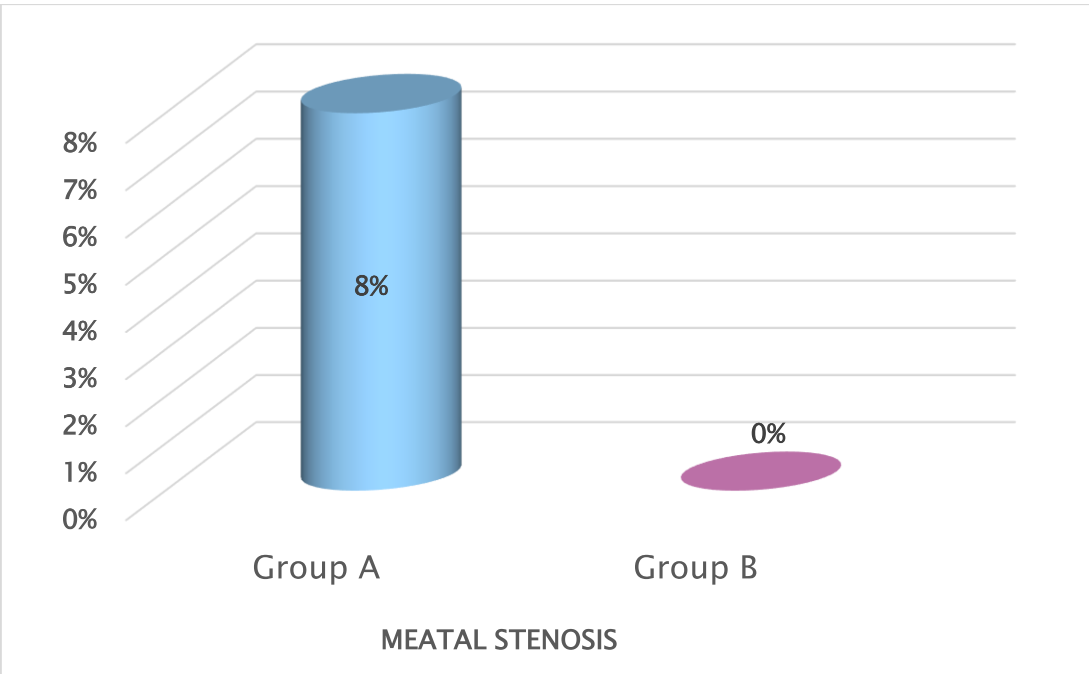


Chart 31. Series' comparison according to the MS rate

b. Urethro-Cutaneous Fistula (UCF)

As summarized in the Chart next page, UCF was an important occurrence in our patients. Elaborated data are described hereunder:

The **Duplay** technique in **our series** was associated with a **26% risk** of **UCF** (**N=12 patients** out of **50** have presented **16 UCFs; 4 patients** had **double UCF**), usually occurring **after 6 months** of the primary hypospadias procedure.

*Only **one** of these patients has developed **one UCF** as early as **4 weeks** after surgery, he didn't show any other complication during the follow-up, and to date, his UCF still not closed.

***Six** patients have exhibited **isolated UCF**:

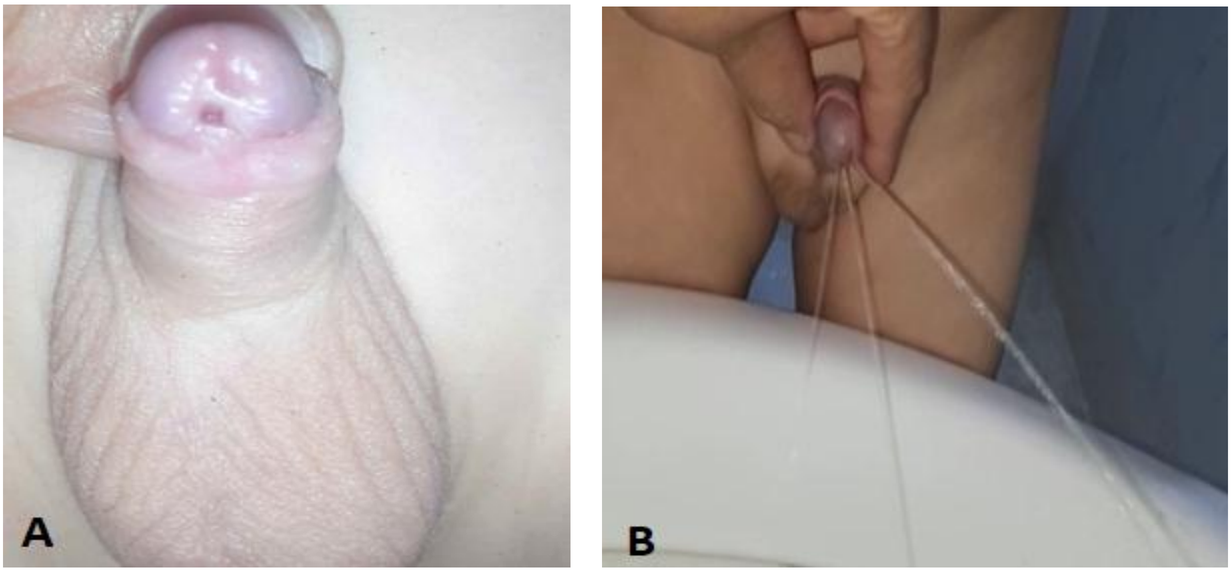
- **3** of them have presented **one UCF** that took place within the **6^{th} month** postoperatively. They were managed conservatively; UCF are not healed yet.
- **One** of them has shown **one UCF** occurred **1 year** after 1^{st} hypospadias repair. He underwent a successful **surgical closure**.
- Another **one** had **2 simultaneous UCF 1 year** later that required **surgical repair**.
- Whereas the last **one** has got and still has **2 UCF**.

*Of the patients with a **UCF 1 year** after the primary repair, **four** were also among those who presented with **wound dehiscence** (WD):

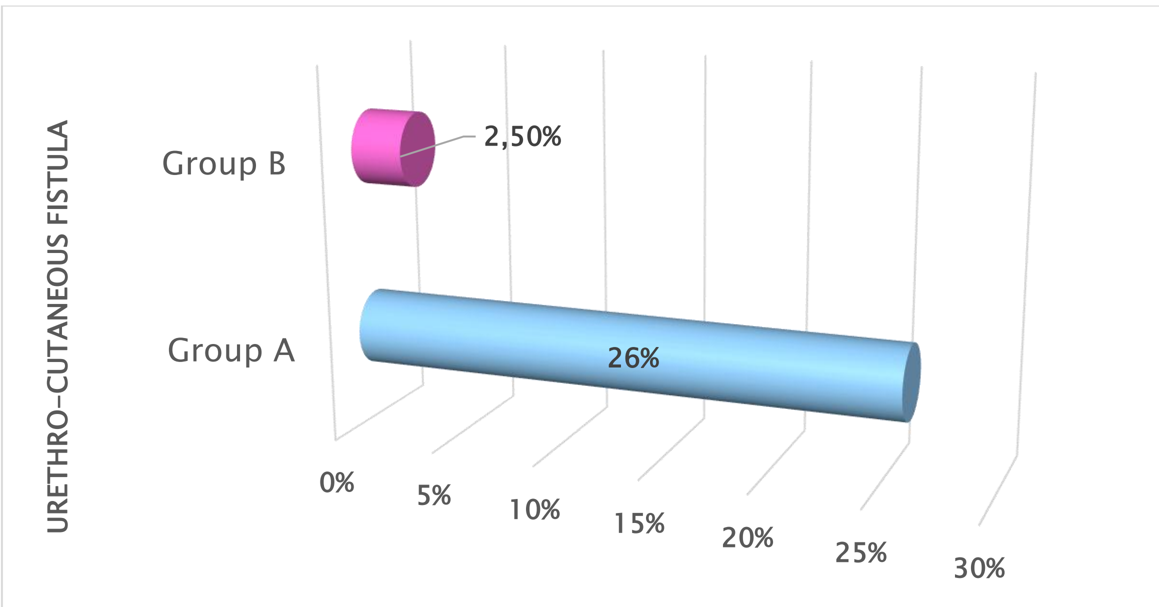
- **Two** of them had only **1 UCF** that was **self-healed**.
- **One** of them had **1 UCF closed surgically**.
- The last **one** had **2 UCF simultaneously**, both easily **closed spontaneously**.

*Finally, **one** patient had **2 UCF 1 year** after primary repair that were **managed surgically**; he also had a simultaneous MS.

In **Koff's** group, there was **only one** patient out of **40** (**2.5%**) who has developed an **isolated UCF** after the **6th month** postoperatively. The UCF was managed **conservatively** and still present to date.



<u>Figure 61.</u> *Patients of our series with **(A)** 1 UCF **(B)** 2 UCF and triple stream*



<u>Chart 32.</u> Series' comparison regarding the UCF rate

c. Wound Dehiscence (WD)

WD was the **commonest** complication in ***our series***. Exhaustive details are as listed below:

Of **50** patients who were operated on with the **Thiersch-Duplay** procedure, **12,** which counts for **24%,** developed **WD.** They usually took place **1 year after** the primary hypospadias procedure.

*__Two__ patients had isolated **WD 6 months** after primary repair, managed with **Duplay**.

*__Six__ patients developed **WD 1 year** post-surgery, without any other complication: **3** reoperated with **Duplay**. **2** repaired with **Mathieu**. **1** underwent **MAGPI.**

*Of the patients with a **WD more than 1 year** after primary repair, **four** were also among those who presented with **UCF**: **2** required re-intervention with **Mathieu**, and **2** reoperated with **Duplay**.

Of **40** patients who were operated on with the **Koff** procedure, **25 % (N=10/40)** presented with **WD**. No other complications were reported.

*__One__ showed a **WD** only **5 months** postoperatively, reoperated with **MAGPI** procedure.

*__One__ had a **WD** on the **9th month** after primary repair, fixed with **modified koff** technique.

*8 patients exhibited **WD 1 year** after 1st surgical repair:

4 managed with **Duplay, 3** repaired with **Mathieu**, and **1** fixed with **MAGPI.**

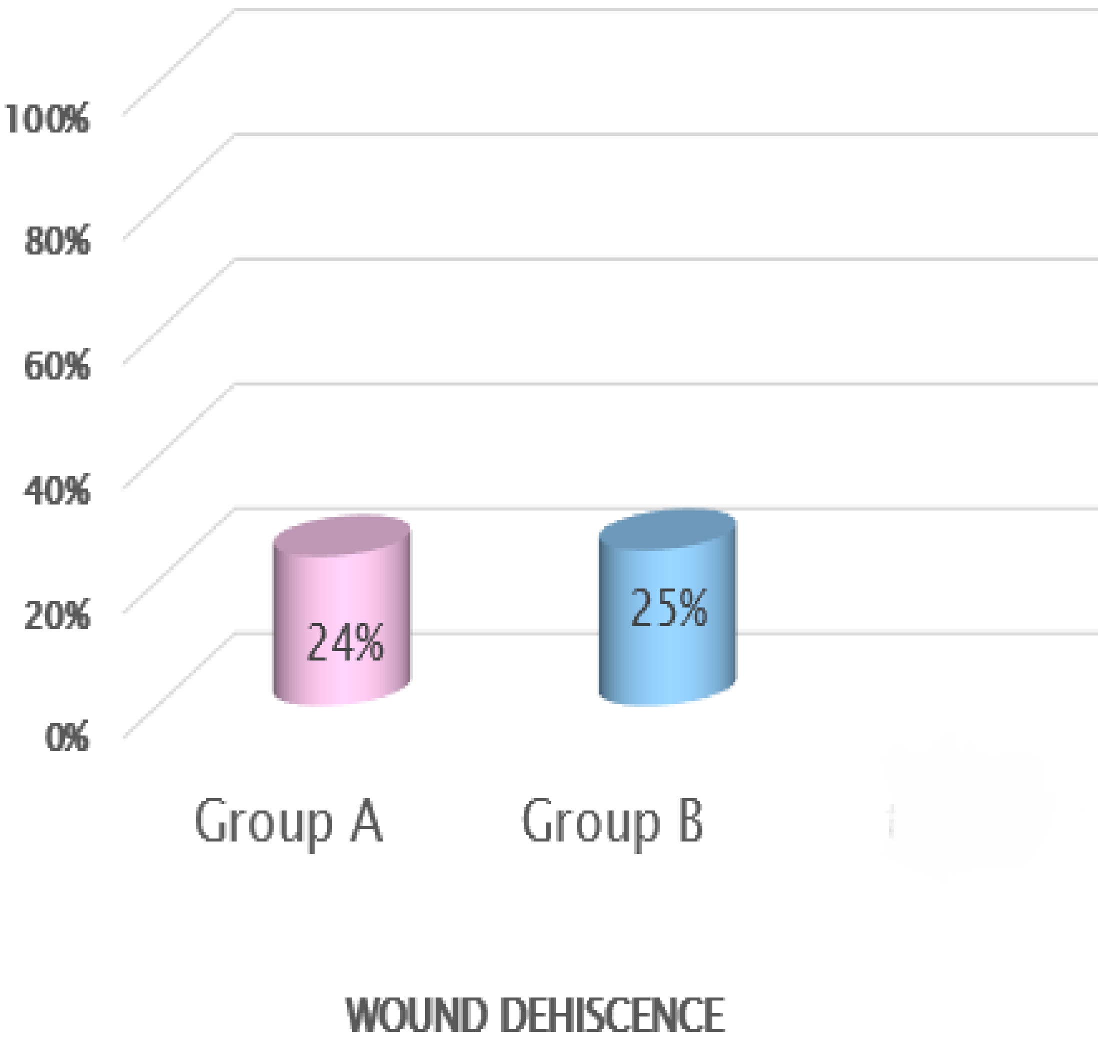


Chart 33. Series' comparison in terms of WD rate

3. September 2020 Check-up

A. Patient Availability

Follow-up results were gathered by reaching out to patients and their parents by **phone calls** (photos and videos were sent via WhatsApp application).

We succeeded to contact a **total** of **74** out of **90** patients (**82.2 %**), while the remaining **16/90** patients (**17.8 %**) were out of touch.

Group A:

Among the **50** cases who underwent the **Thiersch-Duplay** procedure,

78 % (N=**39**) were **Reachable,** whereas **22 %** (N=**11**) were **Unreachable**

Group B:

Among the **40** cases who underwent the **Koff** procedure,

87.5 % (N=**35**) were **Reachable,** whereas **12.5 %** (N=**5**) were **Unreachable**

As we notice, more patients were lost to follow-up in the **Duplay** group than those in the **Koff** group. However, we have no reason to assume **unreachable** patients have not presented complications requiring their return for follow-up, as they could have exhibited a complication but seek for care in another hospital, for example.

B. The Total Number Of Surgeries

Circumcision and **MS dilations** were **excluded** from the count.

The 1st **hypospadias repair**, all **redo surgeries** and **UCF surgical closure** were included.

Elaborated data are described hereunder:

Group A:

Of **39 reachable** patients who were operated on with the **Thiersch-Duplay** procedure,

64.1 % (N=**25**) had **one** surgery

12.8 % (N=**5**) had **two** surgeries

15.4 % (N=**6**) had **three** surgeries

7.7 % (N=**3**) had **more than 3** surgeries

Group B:

Of **35 reachable** patients who were operated on with the **Koff** procedure,

74.3 % (N=**26**) had **one** surgery

17.1 % (N=**6**) had **two** surgeries

8.6 % (N=**3**) had **three** surgeries

None of them had **more than 3** surgeries

As summarized in the Table and Chart next page, the vast **majority** of our boys received only **1 surgery** which was the very 1st hypospadias surgical repair, and that for **both groups**. But only in **Duplay's** group, we had patients with **more than 3 surgeries**. However, the difference between the **2 groups** was **not statistically significant** in terms of **total number of surgeries** (**p-value=0.364**).

Table 29. Series' comparison concerning the total number of surgeries

	Group A		Group B		
Total number of surgeries	N	%	N	%	**p-value**
1	25	64.1	26	74.3	0.364
2	5	12.8	6	17.1	
3	6	15.4	3	8.6	
>3	3	7.7	0	0	
Total	39	100	35	100	

N: Number of cases

%: Percentage

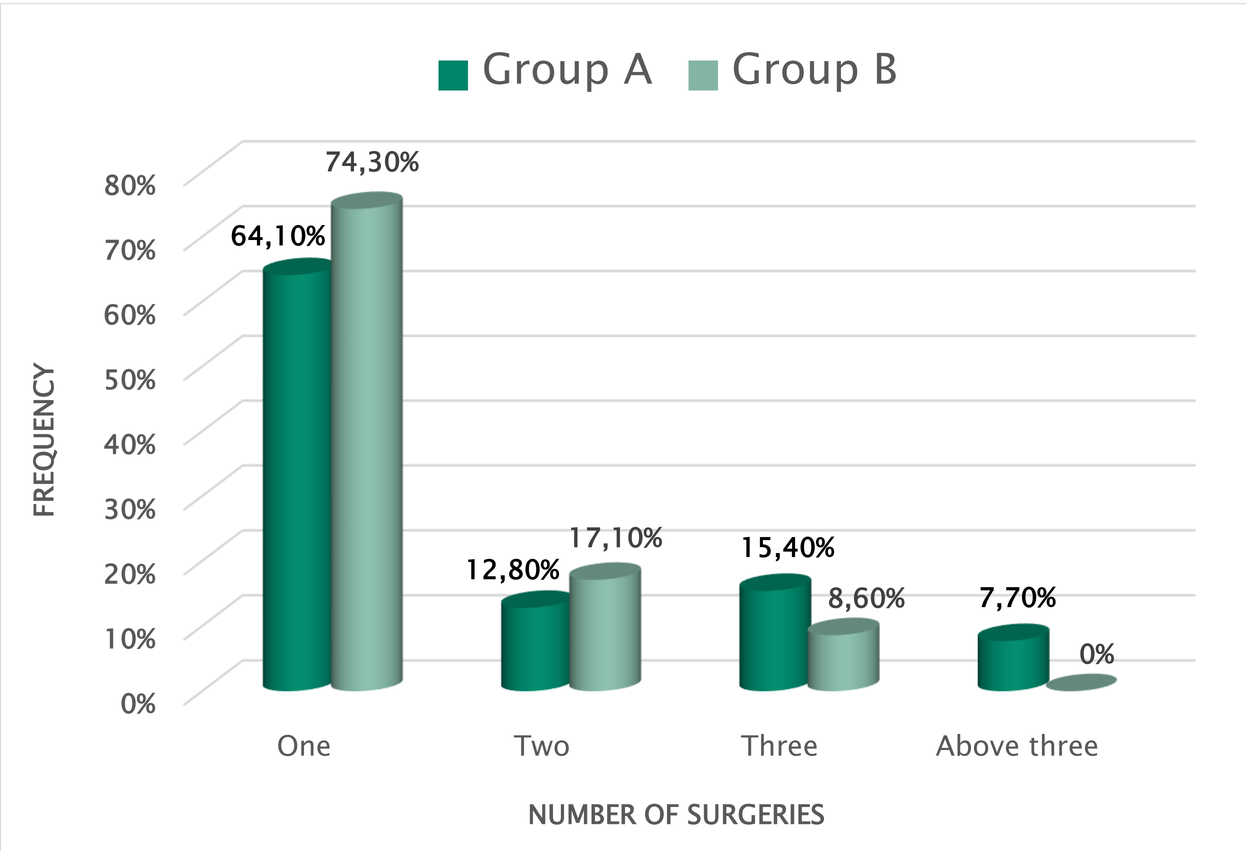


Chart 34. Distribution by the number of surgeries and the type of repair

C. Cosmetic Appearance

In that regard, we reached to the parents by phone calls. Through the WhatsApp application, 3 **photographs** were taken for each patient, one on the ventral surface, another of the glans, and the last one laterally. When the patient is not circumcised yet, pictures were taken with the prepuce retracted.

The cosmetic appearance was assessed on the following **criteria**: apical meatus, excess residual skin, and presence of VPC.

A **total** of **59** cases out of **74 reachable** patients (**79.7 %**) showed **Sufficient** cosmetic results, while **15/74** (**20.3 %**) patients' parents were **unsatisfied**.

The reasons for dissatisfaction were **non-apical meatus** in **13/74** (**17.6 %**) cases and **excess ventral or dorsal skin** in **5/74** (**6.8 %**) cases.

Note that **3 patients** had **both** non-apical meatus and excess skin.

Although both conditions were a **handicap** for **cosmetic appearance**, no subsequent functional abnormality occurred.

Exhaustive details are as listed below:

Group A:

Among the **39 reachable** patients who underwent the **Thiersch-Duplay** procedure,

76.9 % (N=**30**) were **'very satisfied'** of the overall of their children penile appearance, with urethral meatus on the glans tip, no VPC, and no excess skin.

Whereas the remaining **23.1 %** (N=**9**) cases were accounted to have an **Insufficient** cosmetic appearance, the main reason being:

A non-**apical meatus** in **20.5 %** (N=**8**) cases, and an **excess ventral or dorsal skin** in **7.7 %** (N=**3**) cases.

<u>NB:</u> **2** patients had both **non-apical meatus** & **excess skin.**

None of these patients showed a **VPC.**

Group B:

Among the **35 reachable** patients who underwent the **Koff** procedure,

82.9 % (N=**29**) were **'very satisfied'** of the overall of their children penile appearance, with urethral meatus on the glans tip, no VPC, and no excess skin.

Whereas the remaining **17.1 %** (N=**6**) cases were accounted to have an **Insufficient** cosmetic appearance, the main reason being:

A non-**apical meatus** in **14.3 %** (N=**5**) cases, and an **excess ventral or dorsal skin** in **5.7 %** (N=**2**) cases.

NB: 1 patient had both **non-apical meatus** & **excess skin.**

None of these patients showed a **VPC.**

Also demonstrated in the Tables and Charts next pages, **both** techniques gave excellent cosmetic results **(p-value=0.575)**, with **better** outcome in **Koff** group.

For the most part, the **non-apical meatus** was the cause of the judged **insufficient** cosmetic results in **both groups**. However, there wasn't a significant difference between the 2 groups with regard to the **meatal location (p-value=0.552),** nor concerning the **excess skin (p-value=1.000).**

Table 30. Series' comparison according to the cosmetic appearance

	Group A		Group B		
Cosmetic appearance	**N**	**%**	**N**	**%**	**p-value**
Sufficient	30	76.9	29	82.9	0.575
Insufficient	9	23.1	6	17.1	
Total	39	100	35	100	

N: Number of cases

%: Percentage

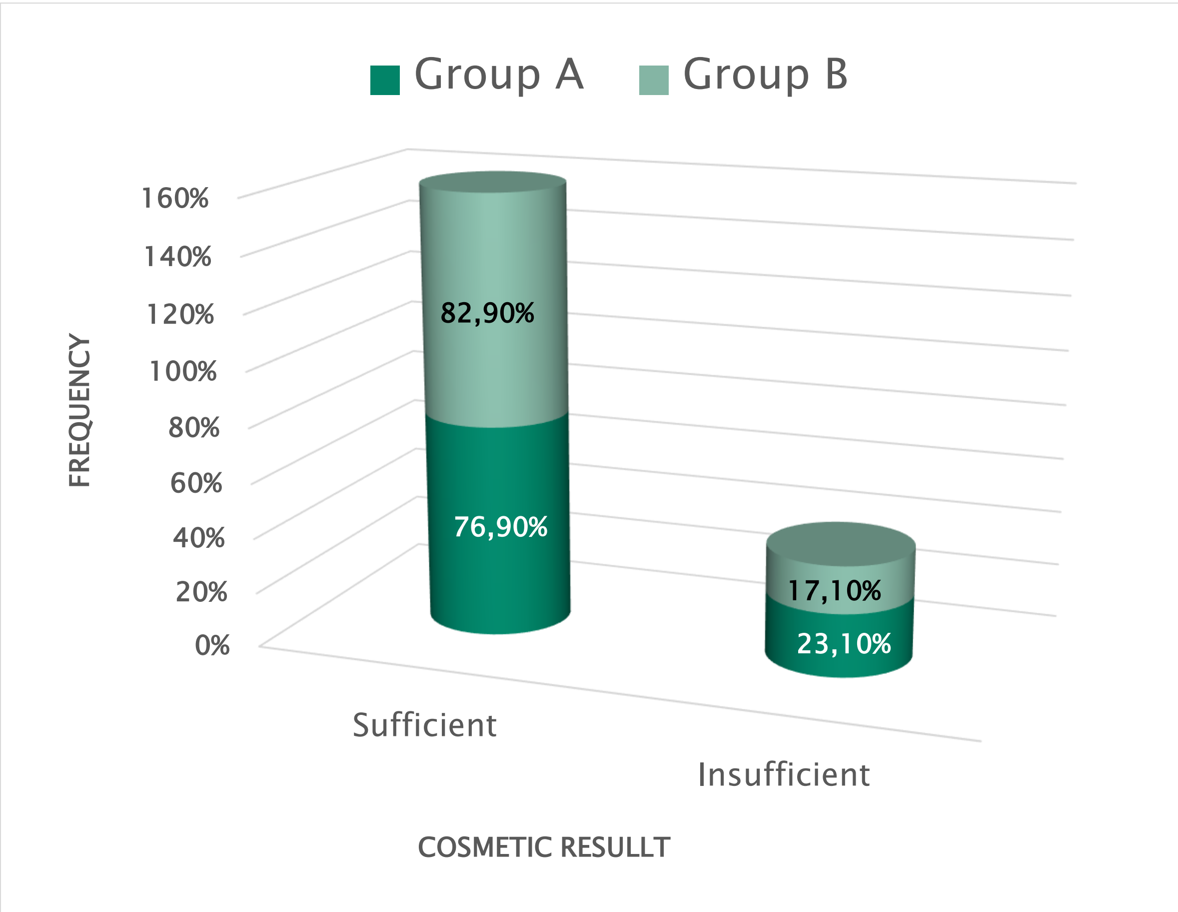


Chart 35. Distribution by the cosmetic appearance and the operative procedure

Table 31. Series' comparison regarding the PO meatal location

	Group A		Group B		
Apical meatus	N	%	N	%	**p-value**
YES	31	79.5	30	85.7	0.552
NO	8	20.5	5	14.3	
Total	39	100	35	100	

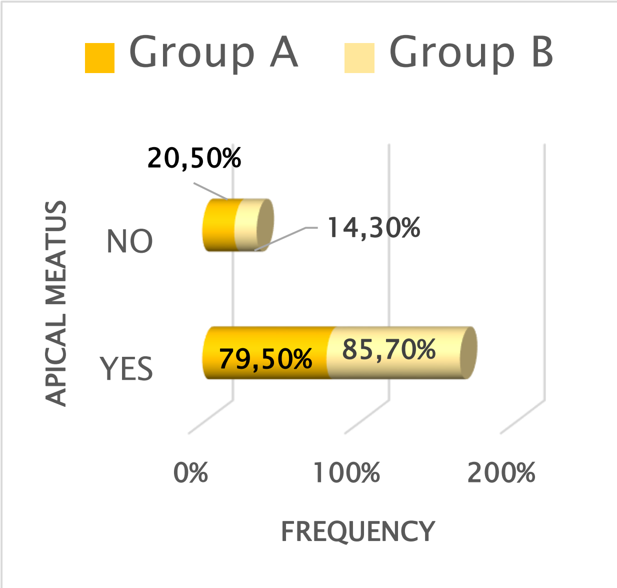


Chart 36. Distribution by the PO meatal location and type of repair

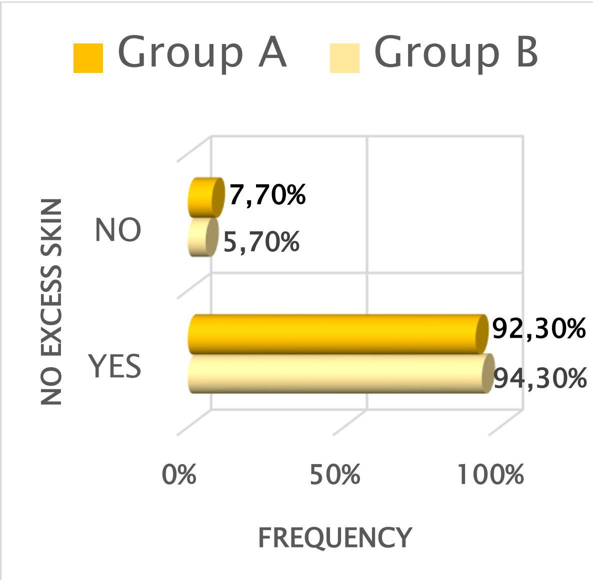


Chart 37. Distribution by the PO excess skin and operative procedure

Table 32. Series' comparison in terms of PO excess skin

	Group A		Group B		
No excess ventral or dorsal skin	N	%	N	%	**p-value**
YES	36	92.3	33	94.3	1.000
NO	3	7.7	2	5.7	
Total	39	100	35	100	

Figure 62. Photographs showing one of our **Duplay** group patients with satisfactory cosmetic results (2018)

Figure 63. Photographs showing one of our **Duplay** group patients with satisfactory cosmetic results (2019)

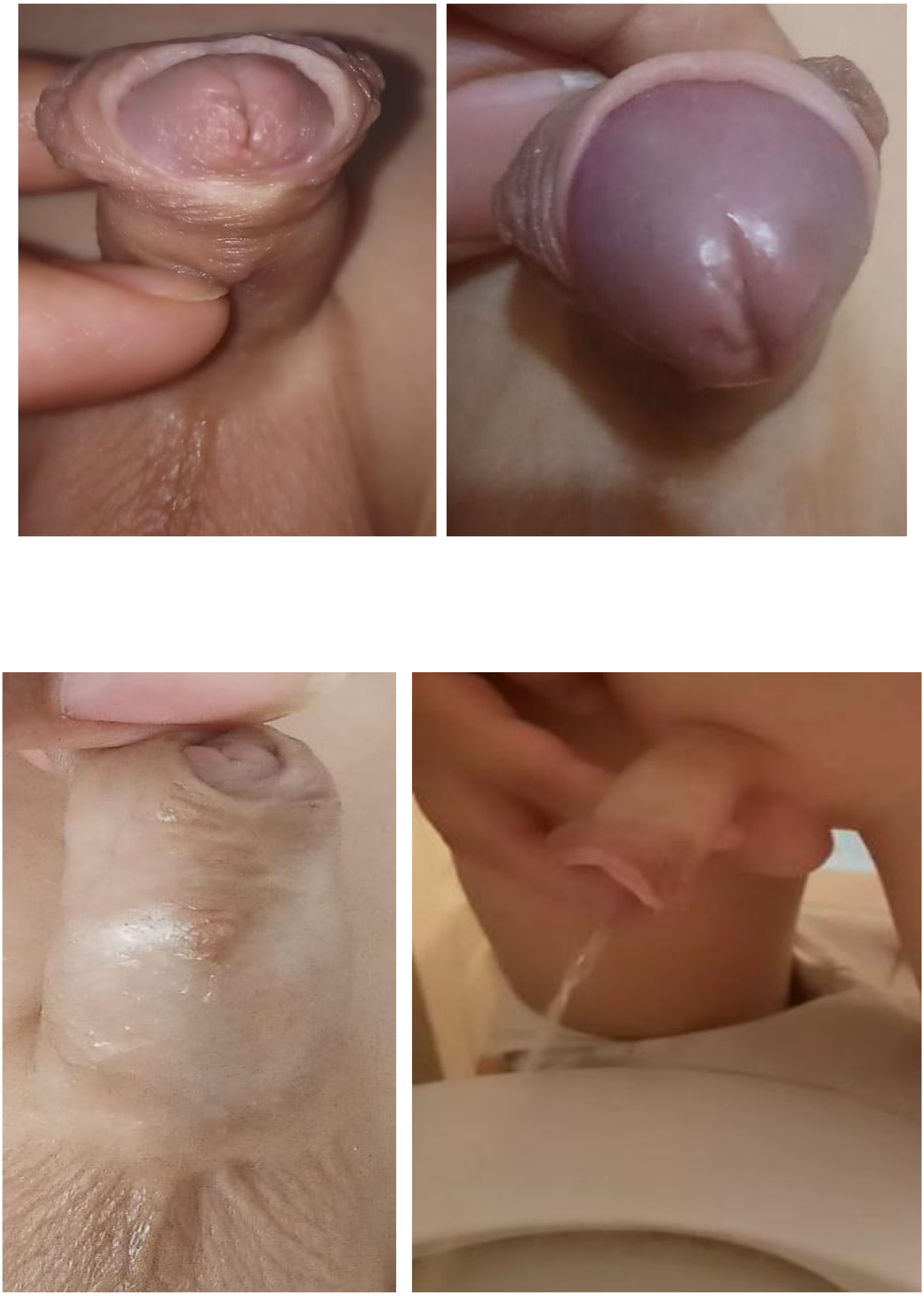


Figure 64. Photographs showing one of our **Koff** group patients with satisfactory cosmetic results (2018)

Figure 65. Photographs showing one of our **Koff** group patients with satisfactory cosmetic results (2018)

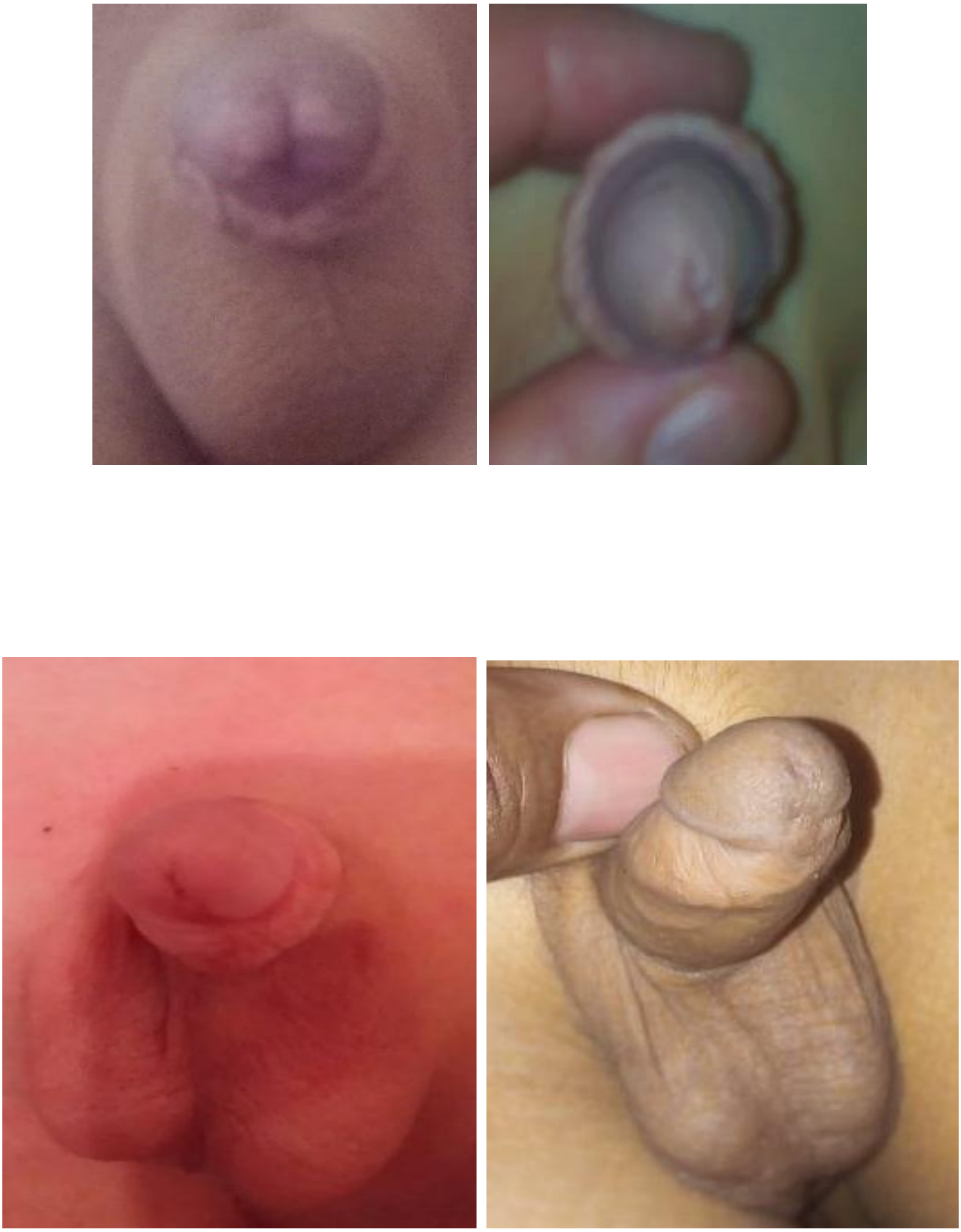


Figure 66. Photographs showing some of our **Koff** group patients with the urethral meatus positioned satisfactorily onto the distal glans (2016; 2016; 2017; 2018)

Figure 67. Photographs showing one of our **Duplay** group patients with a non-apical meatus (2017*)

Figure 68. Photographs showing one of our **Duplay** group patients with a non-apical meatus (2018)

Figure 69. Photographs showing one of our **Koff** group patients with a non-apical meatus (2017)

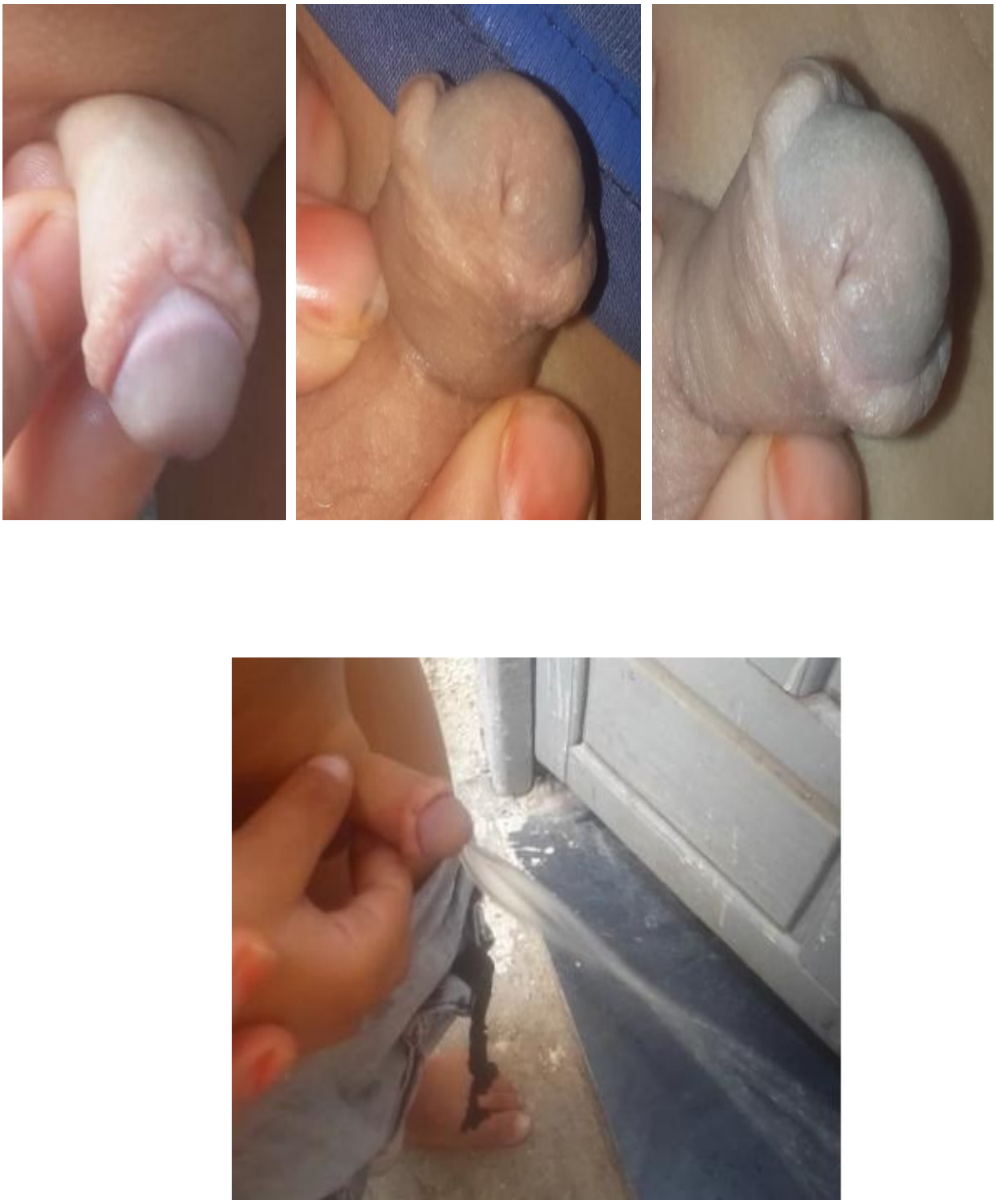


Figure 70. Photographs showing one of our **Koff** group patients with a non-apical meatus (2018)

Figure 71. Photographs showing one of our **Duplay** group patients with excess skin (2019)

Figure 72. Photographs showing one of our **Koff** group patients with excess skin (2016*)

D. UCF

In our series, a **total** of **8** cases out of **74 reachable** patients (**10.8 %**) had an ongoing **UCF**, while the remaining **66/74** (**89.2 %**) had an intact ventral penile aspect. Detailed results deemed to be as the following:

Group A:

Of **39 reachable** patients who were operated on with the **Thiersch-Duplay** procedure, **UCF** was **Present** in**17.9 %** (N=**7**) cases.

Group B:

Of **35 reachable** patients who were operated on with the **Koff** procedure, **UCF** was **Present** in only **1** child, which counts for **2.9 %**.

As outlined in the Table and Chart next page, the **UCF** was **mostly significantly** developed in boys who underwent the **Thiersch-Duplay** repair when compared to Koff repair. **(p-value=0.059)**

Table 33. Series' comparison concerning the post-operative UCF

	Group A		Group B		
UCF	N	%	N	%	**p-value**
Present	7	17.9	1	2.9	0.059
Absent	32	82.1	34	97.1	
Total	39	100	35	100	

N: Number of cases

%: Percentage

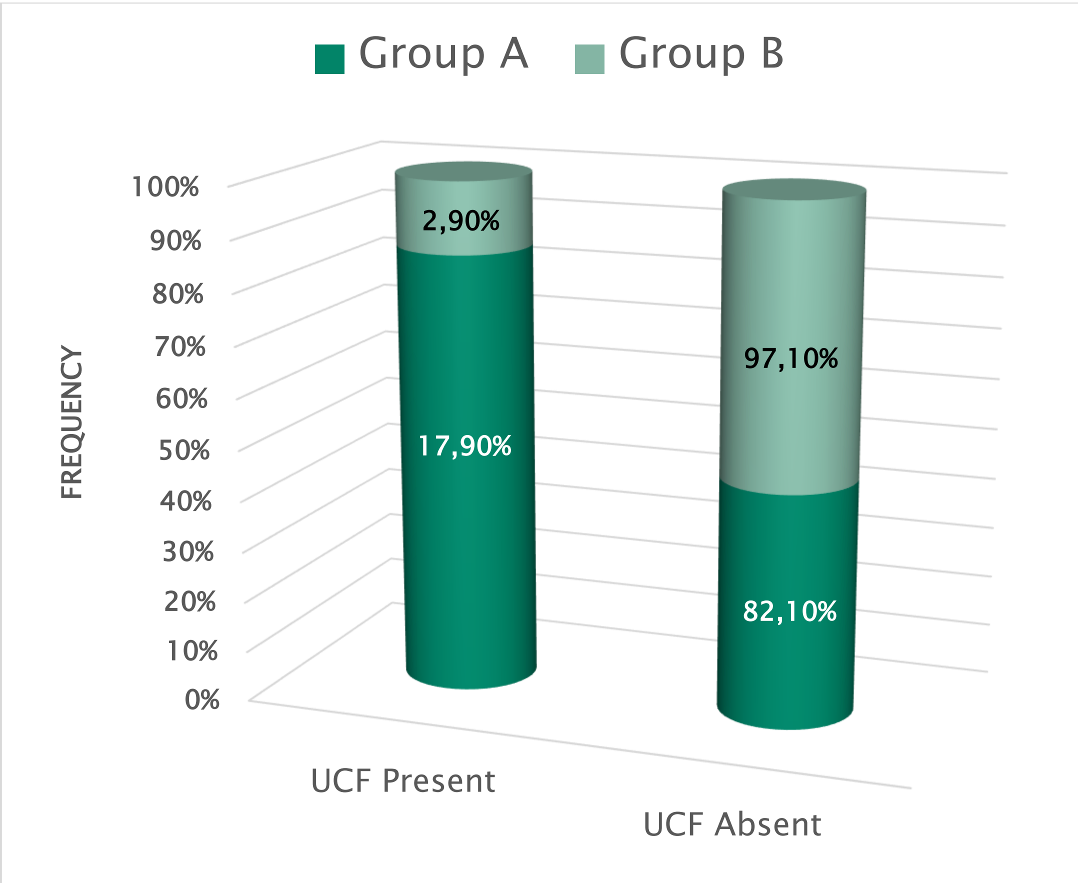


Chart 38. Distribution by the post-operative UCF and type of repair

<u>Figure 73.</u> Photographs showing one of our Duplay group patients with 1 UCF and a double stream (2017*)

<u>Figure 74.</u> Photographs showing one of our Duplay group patients with 2 UCF and a triple stream (2019)

E. Urinary Stream (US)

A **video** of the child while urinating was recorded and sent by the parents, so that to assess the **quality of micturition** based on the caliber/force of urinary stream and its direction.

Overall, a **total** of **71** cases out of **74 reachable** patients (**95.9 %**) had a **satisfactory US** in a forward direction, while the remaining **3/74** (**4.1 %**) patients had **spray/reduced** US.

Elaborated data are described hereunder:

Group A:

Among the **39 reachable** patients who underwent the **Thiersch-Duplay** procedure,

92.3 % (N=**36**) had **Single, strong and straight** US

7.7 % (N=**3**) had **Reduced/Spray** US

Group B:

The US was perfectly **linear**, **single,** and **strong** in all cases of the **35 reachable** patients who were operated on with the **Koff** procedure, with no splashing or deviation.

As illustrated in the Table and Chart next page, the vast **majority** were **satisfied** with their US in **both groups. (p-value=0.242)**

Table 34. Series' comparison according to the PO urinary stream

	Group A		Group B		
Urinary stream (US)	N	%	N	%	**p-value**
Single strong and straight	36	92.3	35	100	0.242
Reduced/Spray	3	7.7	0	0	
Total	39	100	35	100	

N: Number of cases

%: Percentage

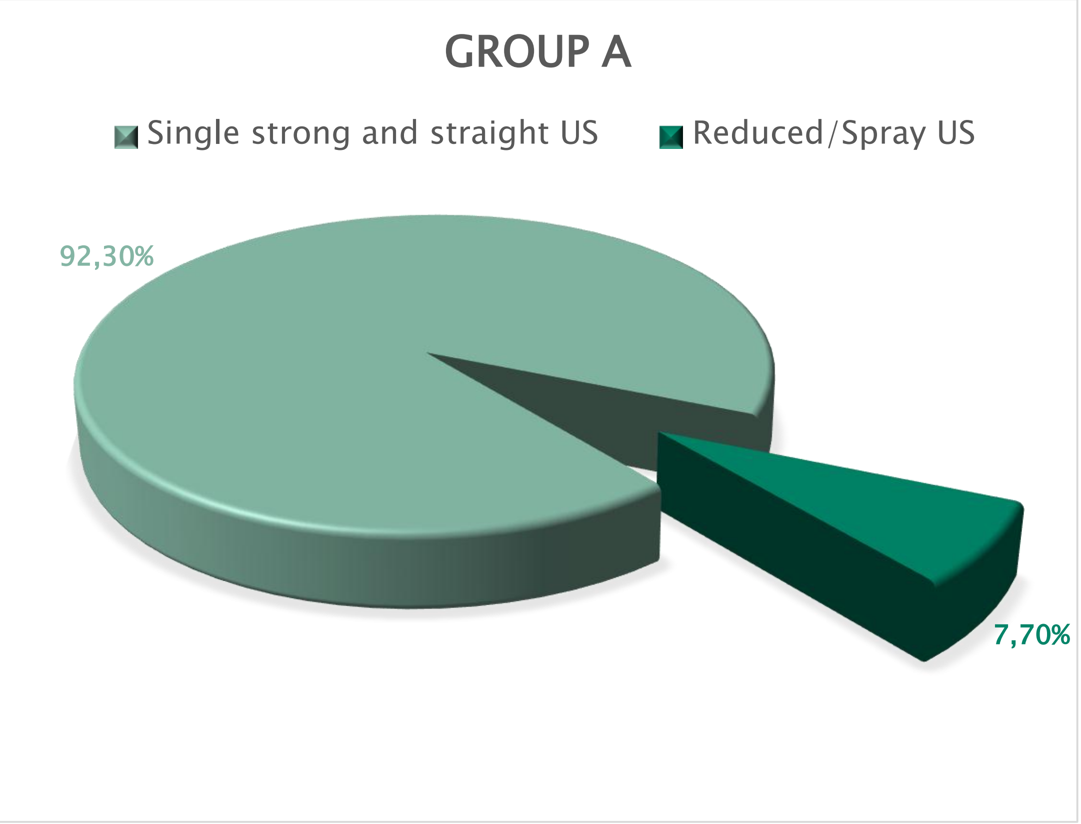


Chart 39. Distribution by the PO urinary stream in group A

Figure 75. Photographs showing two of our Duplay group patients voiding with satisfactory stream (2017*;2019*)

Figure 76. Photographs showing two of our Koff group patients voiding with satisfactory stream (2017; 2018)

DISCUSSION

"Beauty – the adjustment of all parts proportionately so that one cannot add or subtract or change without impairing the harmony of the whole"

–Leon Battista Alberti

I. COMPLICATIONS RATES ANALYSIS BASED ON DIFFERENT CONFOUNDING FACTORS

1. Age at Repair

Hypospadias surgical repair can be performed at any age. The American Academy of Pediatrics [130] pointed out the age range of **6-18 months** to perform surgery of the male genitalia. Nowadays, this is commonly adopted. After this period, the ideal age for surgery has been reported to be **2.5-4** or **4-5** years.

This recommendation's rationale is mainly **psychological,** i.e., gender identity doesn't seem to be defined until after 18 ms. Also, it minimizes the emotional effect of this traumatic experience and subsequent behavioral problems, because the boy would not be able to remember the intervention. [131]

Moreover, most infants develop good tolerance to anesthesia and surgery by the age of 6 months. [132]

However, there are conflicting reports regarding whether **increasing age** at surgery leads to a **higher surgical complication rate**.

Scant reports supported these recommendations and advocated that surgery in cases aged **6-18 months** led to a **lower rate** of complications:

Ziada et al. (2011) [133] prospectively reported on 61 patients with distal hypospadias who underwent primary repair using the TIP technique.

They classified their patients by age into 3 groups. No complication was noted in the group aged less than 2 years. Whereas they observed 3 complications **(17.6%),** including repair dehiscence, MS and hematoma in the group aged **2.2 - 3.7 years**. And 3 cases **(15.8%)** of UCF in the group aged **4 years or older**. The UCF incidence was statistically **significantly higher** in this group **(p=0.032)** when compared to younger groups.

Yildiz et al. (2013) [134] performed a study on **307** patients with distal and mid-penile hypospadias who underwent the TIP procedure. They concluded that the **age** and **surgical technique** should be considered when planning hypospadias surgery, since the **complication rate increases** with patient **age.**

However, in their study, **only** the rate of **UCF** was **significantly higher** in those aged **10-14 years**. There were no significant differences among the age groups in terms of MS and GD development. Thus, age was not a significant factor in the occurrence of these complications (**p>0.05**).

Carmack et al. (2016) [135] have approached the question from an **ethical** point of view, suggesting delaying aesthetic genital surgeries in cases of minor hypospadias without functional impairment until the **patient himself** is at an appropriate age to **give informed consent** to this intervention permanently modifying his own genitals.

They argued that most childhood hypospadias surgeries are performed to anticipate future problems related to function and cosmesis, rather than extant physical and/or psychosocial issues that are adversely affecting the child's well-being.

They cited a study reporting 95% of **non-operated** adult patients were **satisfied** with their **penis appearance**, and none of them described paternity problems. It should be noted that only **one** of them has a **severe** variety, and only **7** patients have deep **chordee**.

On the other hand, they reported a 2nd study showing **significant repercussions** of **proximal** hypospadias on the quality of life of **non-operated** adults.

They also described a natural tendency to avoid stigmatizing children because of their penis appearance or inability to urinate standing up like other children. This tendency denotes a **normative perspective** and sets aside the obligation not to expose the child to potentially **unnecessary risks**.

However, these same authors noted that if we look at adolescents' perception of their **body image**, we see that it is overall better if the patient does not remember the intervention, and therefore if it is carried out at an early age.

Garnier et al. **(2017)** [136] conducted a retrospective study on **464** patients with hypospadias undergoing primary repair, **150** boys <**2 years** and **314 over 2 years**. The hypospadias severity and surgical techniques were compared between the 2 groups.

In their series, the overall **complication rate** was almost **2 times higher** when the intervention is performed **after the age of 2 years (p=0.002).** Thus, age >2 years was a **significant predictor** of complications. This is in part because their study included a significant number of children aged 5 to 16 years, and the non-surgical complications were taken into account. They noted that some periods appeared to be associated with a specific complication, i.e., **healing** problems were more **common** in boys aged >**13 years** (1.5 vs. 28.5%; **p=0.06**).

Duarsa et al. **(2020)** [132] reported a nationwide retrospective study of children diagnosed with hypospadias and managed with multiple surgical techniques in 12 hospitals in Indonesia. The authors classified the age of the **591** collected patients into **5 categories** showing major differences in age in which they were brought to the hospital. Most of their patients aged **more than 4 years (60.4%)**. They demonstrated a direct implication of **age** as a **significant factor (p=0.015)** for the development of **UCF**.

On the other hand, there are reports stating that age at surgery **does not increase** the **risk** of urethroplasty complications:

Weber et al. **(2009)** [137] assigned **77** boys aged **6-17 years** to one of two groups to assess whether repairing hypospadias **before** or **after 18 ms** affects:

- The **surgical outcome**: evaluated using the **PPPS** by non-involved urologists.
- The health-related quality of life (**HRQoL**) and **gender-role behavior**: assessed by a psychologist who interviewed the patients.
- The **psychological adjustment**: evaluated with a questionnaire for parents.

The distribution of hypospadias according to **severity** was **similar** in both age groups. **No statistically significant difference** was found, neither between the **scores** (PPPS=7.31 vs. 6.54; **p=0.88**) nor between the **reoperation rates** (31.8% <18 ms vs. 30.9% >18 ms; **p=0.94**) of the 2 groups. Moreover, group differences **didn't reach significance** in **HRQoL** and **psychological adjustment.**

Bush et al. **(2013)** [138], retrospectively reviewed **669** patients undergoing TIP repair, and found neither younger nor older age increased odds of complications **(p=0.22)**. Thus, full-term healthy boys with hypospadias can undergo corrective surgery at any age after 3 months with no difference in urethroplasty outcomes. Note, however, that they only focused on the surgical complications of urethroplasty, with a follow-up of only a few months.

Braga et al. **(2016)** [139] conducted a retrospective review of consecutive patients who underwent TIP repair; **405** of them had distal hypospadias. Age at surgery was categorized into < 1 year (40/405) and > 1 year (365/405). The **complication** rates were **similar** across various age groups **(p=0.29)**.

Lu et al. **(2017)** [140], in their nationwide, population-based study, found **no significant association** between **increased age** and a **greater risk** of secondary surgery or **complications**. This may be, in their view, the consequence of a general delay in pediatric hypospadias surgery in Taiwan. Indeed, among the **89** patients who underwent repair surgery, approximately **60.6%** received the primary urethroplasty **after** the age of **18 months**.

Splinter et al. (2019) [141] have reached the same conclusion in their investigation, involving the charts of **764** children undergoing hypospadias repairs with different surgical techniques. They showed that **age at repair** was not a **predictor of complications (p=0.26)**. Specifically, the overall complication rates were **26.1%, 30.5%, 25.8%** within the groups aged <1y, 1-3 y, >3y, respectively. **UCF** formation was **not impacted** by age **(p=0.27),** while patients over 3 years of age had **increased stricture** formation **(12%; p=0.02).**

Unsurprisingly, the age in *Our series* was certainly **higher** than recommended, which shows that early awareness of the disease is still low. We are a developing country where the age of admission to the hospital tends to be higher than in developed countries. This can be attributed to ignorance, financial issues, or a clinically insignificant variety of hypospadias (distal with minimal deformity). Therefore, the patients are operated on whenever they are brought to the hospital.

In *Our study*, patients with **more complications** were obviously **older** than patients without complications. However, age was **not** a **significant predictor** of complications **(p-value = 0.605)**. This is in part because our study included a considerable number of children aged 2 to 5 years.

Several potential **explanations** might justify this relationship: [134]

-First of all, **erection** occurred more frequently with the **increasing age**, resulting in postoperative bleeding and **dehiscence**, and affected the postoperative complications notably, especially for **UCF**.

-In addition, adolescent patients have different skin and hair flora, leading to perioperative **infection** and subsequent complications.

-Also, after the age of 2 years, urethral surgery may interfere with the normal **toilet-training process**.

Moreover, some surgeons prefer to operate on more younger patients, between **4 and 9 months old**. At that age, the penis is of **sufficient size** to achieve success comparable with that obtained by waiting until age 2-5 years (as the penis grows less than 1 cm during the first 3-4 years, and the **trophic** conditions of the **skin** allow a high degree of safety during operation). [131]

Also, it is widely known that younger children's **healing ability** is stronger than the older due to endogenous testosterone effect in the peri-pubertal period on the dermis properties, structural changes in the urethral plate, and the differences in cytokines production with age. [142]

Still more important, in case of **complications** that require reintervention **further correction** can be carried out **before the 2nd year of life**.

Finally, we believe that the issue of timing for hypospadias repair must be considered seriously. Not only as a limiting factor itself due to possible age-related tissue **healing limitations** and **psycho-social** development, but also with regard to the **autonomy of the patient.**

Table 35. PO complications and their correlation with age at repair

Referrence	Patients number	Surgical repair	Age at repair ms=months; y=year	Complications	
				N	%
Weber et al. (2009)	77	Various techniques	< 18 ms 22	7	31.8
			> 18ms 55	17	30.9
Ziada et al. (2011)	61	TIP	6-24 ms 25	0	0
			2.2-3.7 y 17	3	17.6
			>4 y 19	3	15.8
Yildiz et al. (2013)	307	TIP	6-18 ms 90	3	3.3
			1.5-5 y 76	8	10.5
			5-10 y 68	7	10.2
			10-14 y 73	17	23
Bush et al. (2013)	669	TIP	3-5 ms 173	22	9.6
			6-11ms 250	27	10.8
			>12 ms 246	35	14.2
Braga et al. (2016)	518	TIP Distal 405	<1 y 40	4	10
			>1 y 365	15	4.1
Garnier et al. (2017)	464	Various techniques	<2 y 150	39	26
			>2 y 314	129	41
Splinter et al. (2019)	764	Various techniques	<1 y 211	55	26.1
			1-3 y 482	147	30.5
			>3 y 132	34	25.8
Duarsa et al. (2020)	591	Various techniques	0-1y 15	0	0
			1-2 y 39	4	10.2
			2-3 y 61	4	6.5
			3-4 y 118	19	16.1
			>4 y 355	53	14.9
This study	90	Duplay, Koff	<2 y 12	3	25
			2-5 y 62	25	40.3
			>5 y 16	6	37.5

2. Primitive Ectopic Meatal Location

In the early years, glanular/coronal and sub-coronal hypospadias were often **not repaired**, because the repair complications often overshadowed the benefits of the surgical correction.

Many studies have reported an association between EML and the risk of complications, advocating that the degree of the operative difficulty being high with the most proximal meatus.

According to their experience, ***Stock and Hanna*** [143] have reported the EML as the major factor determining success and complications. In comparing their **early series**, which included **512** children operated on with Duplay for distal hypospadias (coronal/sub-coronal), with their **2nd series** of **265** children with mid-penile/proximal hypospadias, they concluded that **more proximal** locations were associated with more complications **(8.6%)** than **more distal** repairs **(2.9%).**

Same results were claimed by ***Uygur et al.*** **(2002)** [144], who analyzed the factors that could affect the incidence of complications during **distal** hypospadias repair in **422** patients. Indeed, complication rates were **significantly higher** if the meatus was in more proximal location (**26%; N**=43/164 cases with distal penile variety compared to **9%; N**=3/35 with glanular variety).

Bush et al. (2013) [138] in their retrospective study of **669** patients undergoing TIP repair, EML was found to increase the rate of complications, and it was considered as an **independent risk factor** for urethral complications. [**OR 1.79, 95% CI 1.34-2.40)**]

Braga et al. (2016) [139] defended that hypospadias severity, representing EML and degree of VPC, was the **only factor significantly associated** with the development of postoperative complications. The authors reported that midshaft/proximal hypospadias cases were associated with more complications than distal defects (**16% vs. 4.7%; p<0.01**).

Another study conducted by ***Nozohoor* (2017)** [39]has confirmed that the **degree of hypospadias** is the **most decisive risk factor** for the frequency of **complications** after surgical repair, showing a **statistically significant** association between the two factors.

The complication rate for any complication during the entire follow-up period increased from **11%** among patients with **balanic** hypospadias to **67%** among those with penoscrotal/perineal hypospadias. However, the groups with the most severe degree were very small (Penoscrotal, n=6 and Perineal, n=3).

Splinter et al. (2019) [141] have reached the same conclusion in their investigation, involving the charts of **764** children undergoing hypospadias repairs with different surgical techniques. They showed that **hypospadias type** (**p=0.003**) and **surgical repair technique** (**p<0.001**) were marked **predictors of complications**.

Specifically, the overall complication rates were **16.3%** with **glanular/coronal** vs. **50.7%** with **scrotal-perineal**.

Many other studies have reported high complication rates with more proximal locations of the meatus but **without** a **statistical significance**.

Winberg **(2020)** [145], for instance, has studied **76** boys who underwent primary hypospadias repair with Mathieu and TIP methods. He presented results that joined those stated before although the number of complications **did not differ significantly** between the groups with different hypospadias **degrees.**

Duarsa et al. **(2020)** [132] conducted a nationwide, retrospective study of children diagnosed with hypospadias in 12 hospitals in Indonesia. Of **591** cases managed with multiple surgical techniques, the **type of hypospadias** was **not significantly correlated** to the development of **UCF (p=0.102**).

In *Our study*, the overall risk of **complications** after anterior hypospadias repair **did not significantly correlate** to the hypospadias **degree,** even after adjusting to the **surgical technique** (**G.A: p-value=0.464 / G.B: p-value=0.753**). Therefore, surgery in boys with **mild asymptomatic** hypospadias might be **questionable**. It may cause complications with a frequency comparable to those for which an operative intervention is assumed necessary. By that *Our study* shed light on whether all boys with any degree of hypospadias should undergo reconstruction.

Moreover, we noted more complications with the **glanular** variant **(58.3%)** than distal penile (45.2%) in **group A**, suggesting that **Duplay** procedure may be more convenient to the **distal penile** form. Whereas we observed more complications in the **distal penile (33.3%)** variant than glanular (16.7%) in **group B**, suggesting that **Koff** procedure may be more suitable to **glanular** form.

Our results were basically in accordance with outcomes reported in the literature, so that while comparing our series with aforementioned series, it became apparent that surgical **complications** were **more often encountered** in **proximal** than in distal repairs. It is suspected that this is justified because the longer defect length needs **better tissue** and **richer vascular** supply to repair, and **healing** is relatively **difficult.** [142]

However, the slight insignificant difference may be explained by the fact that although efforts were expended on defining the **degrees of hypospadias**, the **bias** in those degrees' **interpretations** remains. [145]

Table 36. PO complications and their correlation with hypospadias degree

Referrence	Patients number	Surgical repair	EML	Complications N	Complications %
Uygur et al. (2002)	422	Various one stage repair techniques	Glanular 35	3	9
			Coronal 130	15	12
			Sub-coronal 93	17	18
			Distal penile 164	43	26
Bush et al. (2013)	669	TIP	Distal 491	36	7.3
			Midpenile 44	8	18.2
			Proximal 61	15	24.6
Braga et al. (2016)	518	TIP	Distal 405	19	4.7
			Midpenile 59	18	16
			Proximal 54		
Nozohoor (2017)	113	Various techniques	Balanic 79	9	11
			Distal 25	10	40
			Penoscrotal 6	4	67
			Perineal 3	2	67
Splinter et al. (2019)	764	Various techniques	Glanular/Coronal 283	46	16.3
			Subcoronal 49	16	32.7
			Distal penile 307	82	26.7
			Mid-shaft 85	41	48.2
			Proximal penile 28	14	50
			Scrotal-perineal 73	37	50.7
Duarsa et al. (2020)	591	Various techniques	Glanular 24	0	0
			Subcoronal 68	9	13.2
			Distal penile 211	33	15.6
			Proximal 264	36	13.6
Winberg (2020)	76	Mathieu TIP	Glanular/Coronal 23	9	39.1
			Subcoronal/Distal 47	24	51
			Proximal 6	4	66.6
This study	90	Duplay, Koff	Glanular 24	9	37.5
			Subcoronal 11	3	27.3
			Distal penile 55	22	40

3. Surgeons Qualification [145]

Most previous studies have reported that **complications** are **inversely related** to surgeon volume, especially for procedures that depend greatly on **technique**.

Indeed, the surgeon's expertise is highly involved; for instance, "when to operate" is the surgeon's choice, and it varies between surgeons since the interpretation of the degree of hypospadias might differ as well.

The surgeon also chooses the **age** at reconstruction, then selects the **method of repair,** and for this, standardization is still missing in the literature.

When the surgeon starts to operate, his or her **skill** and experience are crucial for the outcome. Also, different surgeons use different **suturing materials** and **techniques**; they also prescribe different **schemes of antibiotics**.

Beyond this, the use of **catheters**, their **route** and their **duration**, **the dressings**, and the follow-up plan, differ between surgeons. For all these aspects, there is still no consensus; it's the surgeon's call.

Few reports with contradictory findings have been delivered:

Uygur et al.(2002) [144], while studying the factors affecting outcome in anterior hypospadias surgery, they have investigated the **surgeon's experience** by dividing the 18 years of their study into three 6-year intervals; the success rate for each interval was determined separately, then compared to the others. The complications were **highest 33%** during the **first 6 years**, but decreased to **12 %** during the **last 6 years**.

Horowitz and Salzhauer (2006) [146] reviewed prospectively collected data for all primary single-stage hypospadias repairs performed by **one pediatric urologist** with various techniques during his **first 5 years in practice**, using **fistula rates** as the outcome measure. There were **231** operations, with an **annual decline in fistula** rates from **23% to 6%,** which the authors attributed to a learning curve.

Another population-based analysis, conducted by ***Lee et al.***(2013) [147] on predictors of re-do surgery after primary hypospadias repair using a national database that includes more than 90 participating institutions. The authors demonstrated that surgeon experience has a **direct impact** on complication rates.

They hypothesized that patients who undergo repair by **low-volume surgeons** have a **significantly higher secondary surgery rate**. To note that **surgeon volume** was measured by the number of distal hypospadias surgeries performed yearly. The authors stated that **every additional 10 distal repairs** that a surgeon performed yearly were associated with a **29% decreased risk** of complications.

Another retrospective review by ***Rompré et al.(2013)*** [148] evaluated outcomes for primary distal and proximal TIP repairs by a **single surgeon** during the first **9 years** of practice after fellowship. There were **303** cases; **complications diminished after 75 cases**, which were considered within a learning curve.

Lu Y-C et al.(2015) [140] have reported the same results. On a total of **75** newborns who received single hypospadias surgery, they analyzed the impact of surgeon characteristics (**gender**, **specialty**: urology vs. pediatric surgery, **age**, **years since license certification**, the **number** of board **certifications,** and **caseload volume**) on the outcomes of hypospadias surgery.

To note that **Surgeon volume** was calculated by the number of primary hypospadias repairs performed by each surgeon in the 11-year study period.

They concluded that surgeons with **high volume caseloads** (> 10y) had a **significantly lower** likelihood of performing **reoperation** than low-volume surgeons (1-3y).

Sanchez et al.[149] have advocated that the **reoperation rate** was **significantly higher** in the group with multiple involved surgeons who performed a mean of **2 urethroplasties a year**-the most active with **5.2 cases per year**- compared to the second group led by a surgeon performing **20.8 cases a year** (62.5% vs. 22.9%, **p<0.001**). They explained the result by the caseload increase allowing the surgeon to acquire greater experience and adjust management.

These studies seem to confirm the intuitive idea that a **surgeon's postoperative results** with hypospadias repair **improve with experience**. This concept is also supported by current international guidelines. [150]

In contrast, ***Spinoit et al.*** **(2014)** [151] have showed different results in their multivariate analysis from a cohort of **474** patients. They proved that the surgeon was **not a significant predictive factor** for re-intervention (**p=0.096**).

Bush et al.**(2015)** [152] join Spinoit's team with their recent experience that reviewed urethroplasty complications of distal hypospadias fixed with TIP, performed by consecutive junior surgeons in independent practice, and compare them with the results of their mentor (with >20 years of experience).

With the **number of repairs** ranging from **25- 68** by **junior** surgeons versus **136** by the **mentor**. With similar mean follow-up for all surgeons. Urethroplasty **complication** (**UCF, dehiscence**) rates were **statistically the same** between the former fellows, and between them versus the mentor, ranging from **5-13%.**

Also, it was found that **junior** surgeons in their first **5 years** of experience achieved **similar results** for distal TIP hypospadias repair with a **complication rate similar** to the average found by systematic literature review. Even though their participation during training largely comprised **observation** and surgical **assistance**, with **discrete performance** of key steps.

This difference in results may be because ***Horowitz and Salzhauer***, and ***Rompré et al.*** results were not compared with those of the mentors. Besides, urethroplasty complications might also be influenced by surgeon decision-making regarding **technique**. While ***Bush et al.*** and ***Rompré et al.*** involved only TIP repairs, ***Horowitz and Salzhauer*** used a variety of methods. It is possible that reliance on fewer techniques might increase experience with regard to these particular techniques.

Our study joins **Bush's** results by demonstrating **no statistically significant difference** in complications rates between the two categories of surgeons. These outcomes proved a **successful**, satisfying **transfer** of surgical skills and expertise within our **training program**, in which our professors make sure that junior surgeons- in their initial years of independent practice- will be able to perform distal hypospadias repair and achieve the same results as an experienced mentor. To accomplish that goal, they:

- Review their own results continuously to be certain that they are correctly performing and teaching procedures.
- Determine key steps, and evaluate outcomes for each technique.
- Ask their mentees to report back to them their initial hypospadias repair results to be certain that the lessons taught were learned.

Table 37. Outcomes of junior surgeons compared with their mentors

Referrence	Patients number	Surgical repair	Surgeon qualification	Complications N	Complications %
Bush et al. (2015)	361	TIP	Mentor **136**	11	8
			Junior surgeon **A 38**	2	5
			Junior surgeon **B 37**	5	13
			Junior surgeon **C 68**	4	6
			Junior surgeon **D 25**	2	8
			Junior surgeon **E 57**	4	7
This study	90	Duplay, Koff	Mentors **41**	14	34.1
			Junior surgeons **49**	20	40.8

4. Anesthesia

A. General Anesthesia (GA)

GA has been the mainstay of anesthetic technique for hypospadias repair. It provides **uninterrupted performance** of the repair without concern for patient **movement** or sensation of **pain**. However, the Food and Drug Administration (**FDA**) issued a warning in 2017 on **general anesthetic** medications (inhalational and intravenous), stating that **repeated** or **lengthy** (>3 hours) use in children younger than **3 years** may affect the **development of children's brains**. [153]

Neurotoxic effects of **GA** demonstrated in animal studies include **apoptotic neuronal cell death**, **decreased neuron density**, and **decreased neurogenesis.** These effects may be more pronounced in young infants. [154]

Further, endotracheal intubation may result in serious airway complications, such as **tracheal rupture** or **pharyngoesophageal injury** in young infants. Even worse, the failure of airway management in infants has been associated with catastrophic complications, like cardiac arrest and death. [155]

B. Spinal Block (SB)

Although many surgeons are most familiar with GA, experts in pediatric anesthesiology have concluded that **spinal anesthesia** is an **ideal alternative** as it usually requires little or no sedation, and is most easily implemented in children younger than 12 months of age, who are likely to be the most vulnerable to putative neurotoxic insults. [156]

Further, pediatric **urology** procedures in young children are often **elective**, **non-repetitive, short** in duration (**won't last more than 3 h**), and limited to the pelvis, which makes them ideally suited for **SA.**

With **spinal block (SB),** also known as **intrathecal** or **subarachnoid block**, the local anesthetic is deposited directly into the **CSF**, resulting in anesthesia to the **T8-9 dermatome** and **below**. [157]

The **major benefit** of **SB** is cardiorespiratory **safety** as it can be performed in children with few if any of the adverse effects that are seen in adults, such as **hypotension, bradycardia,** and **respiratory insufficiency** leading to oxygen desaturation and the need for airway intervention.

It is likely explained because infants possess a relatively **underdeveloped autonomic nervous system** and a relatively **high** per-kilogram **CSF volume**.

Additionally, "**high spinal**," or unintentionally excessive height of **SB** level, has been shown to be extremely **rare** (0.6%).[158]

Moreover, in trained hands, **SB** can **shorten OR time**, provide **excellent pain control**, and allow **patients-parents** immediate **reunion** after surgery. [157]

A study conducted by ***Apiliogullari et al.*** **(2009)** [159] concluded that **SB** provided by hyperbaric bupivacaine is adequate for **distal hypospadias** repair as a reasonably **short procedure** that requires sensory block limited to the sacral dermatomes.

Whitakeret al. (2017) [157], as well as *Ebert et al.* (2018) [160], have demonstrated through their studies that many of the typical pediatric urological procedures performed may ideally and safely be conducted under **SB.**

Besides avoiding the potential **negative effects of GA** on future neurocognitive development, SB obviates the need for **ETT** placement and **airway management.** It also decreases the use of any systemic agents whatsoever; **narcotics** and intravenous **corticosteroids**. Moreover, in scenarios where the benefit of surgery must be weighed against the risk of GA, SB may allow a paradigm shift in the **timing of surgery**.

On the other hand, not all pediatric urologists are on SB' board, some of them have reported many reasons for their **reluctance** to use **SB**: [156], [161]

- It can be **technically challenging** to perform, which will **increase** the **preoperative time** (usually **4 min** with a dedicated team**)** and may lead to a **failure of spinal needle placement** due to **increased movement**, **smaller size** of the child and thus smaller target for needle placement.
- It may be **converted** to **GA** in up to **10%** of young children owing to the added difficulty of having an **awake agitated child** during surgery (**coughing, crying,** and **moving)**; the older the child, the more likely he is to be fussy despite an excellent block, making impossible to the operation to proceed safely.
- It produces an excellent **sensory block**, but an **inadequate motor blockade** leading, but rarely, to leg movement that can interfere with operative conditions.
- It's a "**single-shot**" technique which means that the **duration** of anesthesia is **limited** (but increases with age). Generally, it can be provided for **70-80 min** in

most patients. But when adjuncts as **epinephrine** or **clonidine** are added to local anesthetic, the block can be **extended** to as long as **110-120 min**.

C. Caudal Block (CB)

A caudal technique is usually performed with the child either **semi-prone** or on **one side**. A strict **aseptic** technique is used, and a fine needle is passed through the skin and the **sacrococcygeal ligament**, a ligamentous membrane in the midline of the lower back overlying the sacral hiatus. This allows injection of local anesthetic or other analgesic drugs into the **sacral part of the epidural space** where nerves that supply the penis are. [162]

CB allows for **lower requirements of inhaled and systemic anesthetics**, offers **reduced agitation** on emergence in older children, which may help reduce **unintended self-trauma** to the operative site, and provides reliable **analgesia,** often making it a better choice for lower torso surgery in pediatrics, especially in patients with severe comorbidities. [163]

However, the safety of **CB** for **hypospadias repair** in children remains an area of **controversy**. Several studies have demonstrated that it is not innocuous.

The potential **CB-related** complications ranging from a dural puncture, accidental intravenous or intra-marrow injection of local anesthetic, overdosing, impaired micturition and infection, are considered **unusual**. Whereas, **epidural haematoma** is relatively common. Long-term complications, such as nerve damage or paralysis, are very **rare**.[164]

Some recent studies have theorized that **CB** may be a **risk factor** for complications after hypospadias repair, such as **UCF** formation, **GD**, and **MS**.

A randomized controlled study by ***Kundra et al.*** (2012) [165] showed that **CB** was

associated with a **higher UCF rate**. Of the **53** patients undergoing primary hypospadias repair, **19%** developed **UCF** and incidentally, **all** of these patients received **CB.**

The authors described as well **better analgesia** for a **longer duration** with **PB** when compared with **CB**. However, more important factors were not controlled by the authors as the **surgical technique** that has been implicated in UCF formation by previous studies. [166], [167] This calls into question the findings of Kundra' study.

Their proposed **mechanism of action** has not been previously described. They have supported that **CB** promoted intraoperative **penile engorgement** by **sympathetic block** and **vasodilation** of the **penile sinuses**, causing **venous pooling** and resultant tissue **edema**. The latter could result in **tension** on surgical **sutures** and **inadequate** or **delayed** wound **healing**.

However, to extrapolate and conclude that venous congestion of the penis would impair post-operative healing and lead to more complications remains a speculative assumption that has not been adequately tested.

We extensively searched the literature to find evidence of epidural anesthesia or analgesia causing **edema** in humans and **found none**. Moreover, it could be argued that a **decrease in peripheral edema** might be expected in infants, given the **increase** in **cardiac output** and a **decrease** in **systemic vascular resistance** demonstrated with epidural administration of **bupivacaine.** [168]

Histopathologic studies suggest that **urethral** tissue has a more **prolonged inflammatory period** when compared to dermal tissue due to the **spongiosum** appearing to be an inadequate base for cellular proliferation. This may, in part, explain why surgeries on the penis or urethra may be more prone to **aberrant wound healing**. Therefore, promoting adequate **angiogenesis** and minimizing trauma which may stimulate pro-inflammatory cytokines, is key to minimizing complications following surgeries on the penis or urethra. Thus, effective analgesia for a prolonged period will result in reduced postoperative inflammatory response and resultant edema. [169]

Considering these histopathological principles, possible hypotheses may be proposed and may be interrelated:

- Firstly, the **vasodilatory** effect of the **CB** may increase blood flow to the tissues and thus **reduce** tissue **ischemia** and **facilitate healing** [165].
- Secondly, previous clinical trials have identified that **CB,** when compared to **PB,** is associated with **reduced postoperative blood loss** in hypospadias surgery and **superior analgesia**. [170]

By reducing blood loss, **CB** may reduce the risk of **hematoma** formation. Further, superior analgesia may improve healing. The impact of patient pain and stress in impairing wound healing and recovery is well documented. [171]

Taicher et al. (2017) [172] conducted the **largest** non-randomized observational study (**2001-2014**) **(N= 395)** comparing **CB** and **PB**.

Their experience proved that **CB** was **associated** with an **over 13-fold increase** in the odds of developing postoperative surgical **complications** in boys undergoing hypospadias repair even after adjusting for meatal location.

We would note that these results came from a **single surgeon** series, and the **type of surgical repair'** impact wasn't included in its scope of analysis.

Similar results were reported by ***Belaunde et al.*** **(2017)** [173] in their retrospective clinical database constructed for **192** patients who underwent distal hypospadias repair by a **single surgeon** for the period **2008-2013**. They revealed a **higher risk** of developing **complications** in patients who underwent **CB** than in patients who underwent **PB**. This study's limitations included not adjusting the results to the **severity** of hypospadias nor to **surgical technique**.

On the contrary, a growing body of literature suggests that surgical **complications** are mainly linked to important **intervening confounders**, such as the **severity** of the disease and the **surgical techniques**. Thus, the noted differences could have simply been a result of chance.

In addition, available clinical studies to date against **CB** are mostly **retrospective**, limited to **single-center** experiences and limited by **small sample sizes** and patient **selection biases** involving indications for CB, and have not characterized the anesthetic intervention itself as an independent factor contributing to the incidence of postoperative complications.

Zaidi et al. (2015) [174] reviewed retrospectively **19 years of data** containing a large series of cases of children who underwent primary single-stage hypospadias repair. They noticed that the type of regional block administered **was not associated** with post-operative complications.

Braga et al. **(2017)** [139] conducted a retrospective review of patients who underwent **TIP** repair between **2004-2015**, to study the impact of **CB** vs **PB** on the rate of **UCF**, and **GD**. Of **518** patients, complications developed in **37** (7%): 21 UCF (19-CB, 2-PB); 16 GD (13-CB, 3-PB).

Their findings corroborate their hypothesis that the risk of surgical complications is more likely driven by the **complexity** of the hypospadias (meatal location/VPC) rather than the type of regional block used.

This analysis revealed similar results in a subgroup including only patients with **distal hypospadias** [14/271 (5.2%) vs. 5/134 (3.7%); **p=0.52**].

Splinter et al. (2019) [141] in their investigation, involving the charts of **764** children undergoing hypospadias repairs, showed **no association** between **anesthesia techniques** and **surgical complications**. Specifically, after **CB, PB**, and **GA only**, the overall complication rates were **28%, 31%,** and **27%,** respectively.

In contrast, they defended that **hypospadias type** (**p=0.003**) and **surgical repair technique** (**p<0.00**) were marked **predictors of complications**.

Ngoo et al. (2020) [175] conducted the first prospective study that demonstrated an association between **PB** and **increased revision surgery** rates. Revision surgery was defined as reoperation for UCF, GD, strictures or MS. In contrast to published data, they have found a **beneficial effect of CB** when compared to **PB** for revisional surgery rates.

To address the aforementioned circumstances, a **meta-analysis** of the current literature was performed by ***Zhu et al.*** **(2019)** [176], who identified comparative studies of **CB** versus peripheral nerve block (including **PB** and **pudendal** block) or **no caudal block**, to estimate the **analgesic efficacy** and relative **complications** of **CB** for hypospadias repair in children.

Data from **298** patients in 4 RCTs and from **1726** patients in 7 observational studies were included. The **CB** did **not** appear to be **associated** with surgical **complications**.

In ***Our department***, our pediatric urologists, with their colleagues anesthesiologists, are still loyal to **GA**. Since **GA** was the predominant technique used in *Our study*, it was expected to have much greater numbers of surgical complications among the subjects who were operated on under **GA**, which was the case for **Koff's group**. However, the slightly higher rates under **SA** in **Duplay's group** have impacted the overall rates.

In *Our study*, we didn't encounter any complication for both of our 2 patients who received CB. However, regarding the few reports on **minimal effect** of **CB** on surgical **complication** rates, it's thought that they are most likely due to **publication bias**, ie, **unexpected outcomes** are much more likely to be **published** and more likely to be accepted for presentation at scientific meetings. [141]

Finally, we share the same thoughts with the aforementioned studies indicating that common anesthetic techniques have **minimal, if any, impact** on surgical complications among children undergoing hypospadias repair.

We believe that **collaboration** in the OR is the **key to success**. It is important that pediatric urologists and pediatric anesthesiologists work together to **balance** the **benefits and risks** of anesthesia. We also encourage to individualize care and utilize the anesthesia technique that one deems best suited for a given child.

5. Suture Materials and Suturing Techniques

A. Suture Materials [118]

The effect of **suture materials** on urethroplasty complications remains controversially debated. Whereas general **agreement** exists upon the use of **absorbable** sutures, surgeons are still divided over the use of materials with an **early** or **delayed absorption** rate.

Indeed, the **ideal** suture material should be **fine**, **waterproof**, **last long** enough to allow **sufficient healing**, but be **resorbed** in a time sufficient to avoid **excessive scar** formation and **fibrous tissue**. For instance, in our study, we used:

- **Polyglactin (Vicryl):** This is a **synthetic**, **braided** and **absorbable** suture, which elicits **little tissue reaction** and is usually absorbed between **56** and **70 days**. It provides wound support for **30 days**.
- **Polydioxanone (PDS):** This is a **synthetic**, **monofilament,** and **absorbable** suture. It will hydrolyze slowly **(180 days)** with **good tensile strength** for up to **56 days**. The tensile strength is ideal for penile straightening procedures that are subjected to tissue expansion during postoperative erections.

Some authors like ***Ulman et al.*** [177] suggested that the use of sutures with a **delayed absorption** rate might **reduce** the incidence of **UCF** by ensuring a prolonged approximation of the neo-urethral edges; add to that, because of capillarity, the monofilament suture **attracts less**, or **no**, fluid and **urine** into the **tissues** compared with polyfilament suture, which leads to **less fistula** formation.

Their study reviewed **97** children with **distal** hypospadias treated using Mathieu procedure. In the 1st group of **36** patients, neourethra was constructed using **6/0 Vicryl**. While in the 2nd group of **61** patients, **7/0 PDS** was used.

Urethral or meatal stenosis was not observed in any patient. There was no infectious complication. **UCF** rate was **significantly higher** using **VICRYL** (16.6%) compared to **PDS** (4.9%) (**p<0.01**).

While others, like ***Di Sandro and Palmer*** [178] studied the complication rates after hypospadias surgery, with stratification according to the type of suture used for the urethral anastomosis in **117** boys during a **7-year** period.

They argued that the use of sutures with a **very delayed absorption rate** could **increase tissue reaction** causing a long-standing inflammation, which explained the **4-fold** increase in **neo-urethral stricture** rate [6.8% vs. 23.6% (**P < 0.02**)] after hypospadias repair with **PDS** sutures they found, compared with **chromic or polyglycolic acid suture.**

There was **no significant difference** in the incidence of **UCF**, and in some patients, the PDS sutures remained present in the urethra, without absorption, up to **7 months** after the initial repair. They suggested that the extreme delay in in-vivo absorption of PDS should preclude its use as an interrupted suture in small-caliber urethral anastomoses.

Notably, ***Di Sandro and Palmer*** did not mention the **suture materials' size**, since a **longer** absorption time is partially balanced by a **thinner** suture. Indeed, the **absorption rate** depends both on suture **material** and suture **size. PDS** allows using **thinner** and, therefore, **less traumatic** sutures, maintaining the same absorption time of **thicker polyglactin** or polyglycolic acid sutures. We believe this could be advocated as a major advantage of **PDS.**

On the other hand, ***Cimador et al.*** **(2004)** [179] retrospectively evaluated **336** hypospadias repairs over a **10-year period.** They stratified the patients into 2 groups according to the suture materials used for urethroplasty. **Vicryl** was used in **254** patients, whereas **PDS** was used in the remaining **82** patients.

A **successful** one-stage repair was achieved in **82%** of the **Vicryl** group and in **83%** of the **PDS** group (**p = 0.97**).

The authors reported **no statistically significant differences** in **UCF** and/or **stricture** rates in the 2 groups, even considering each procedure separately.

Similarly, ***Guarino et al.*** **(2009)** [180] compared the results of **distal** hypospadias repair (TIP) in**100** boys using **polyglytone** vs. **PDS** to evaluate the potential benefits of using a suture with a rapid absorption time.

They documented the **absence of statistically significant differences** in terms of acute skin **infection**, **skin dehiscence,** and **UCF** rates suggesting that the tensile strength of polyglytone is adequate.

They jugged both sutures to be adequate for hypospadias repair, but a rapid absorption monofilament may allow a much more rapid disappearance of the skin sutures. In the long term, this outcome means an almost complete absence of **suture tracks**.

Shirazi et al. **(2012)** [181] conducted a study to quantify the impact of different suture threads (including Chromic, Vicryl, PDS, Rapid Vicryl, Monocryl) on **histological parameters** of the penis and urethra following hypospadias repair in **rats**.

They demonstrated that **Monocryl** (poliglecaprone 25) was associated with a **higher** percentage of **vessel density**, a higher **volume** of the urethral **lumen,** and **lower** lymphocyte **infiltration**. While the volume of the urethral **epithelium** was highest in the **PDS** group compared to the other operated groups.

However, there was **no significant difference** regarding **collagen deposition** and **fibroblast infiltration** among the operated groups.

They concluded that the **Monocryl** and **PDS** groups showed **better results**.

Differing from *Di Sandro and Palmer,* ***Spinoit et al.*** **(2015)** [151] in their retrospective analysis where **polyfilament** was used in **331** boys (69.8%), **monofilament** in **95** (20%), and **both combined** in **4** (0.8%), demonstrated on the initial **univariate** analysis that **polyfilament** suture material was associated with **significantly more re-intervention (OR 2.12** [1.16-3.86]**, p=0.015)**.

However, the **multivariate** analysis showed this association **no** longer to be **statistically significant**. Still, the bulk of the 95%CI (0.94-3.43) **favors monofilament**.

B. Suturing Techniques

Interrupted vs. Continuous:

Whilst the use of absorbable sutures for hypospadias repair has been universally accepted, there is **no general agreement** on the **suturing techniques** (**interrupted** or **continuous**). The choice is mainly dictated by the **surgeon's preference**.

The effect of various suturing techniques has been best studied in **bowel anastomosis,** and it has been found that the use of an **interrupted**-suturing technique results in a **decreased complication** rate as compared to continuous suturing [182].

In their study, ***El-Sherbiny et al.*** **(2004)** [183], performed urethroplasty using **double-layer subcuticular 7/0 polyglactin** sutures in **all** patients; running sutures were used in 57 (43%) patients and interrupted in 76 (57%).

They found in a **univariate** analysis that suturing technique was a **significant risk factor** that could affect the outcome of hypospadias repair. They suggested that the use of a **running** suture was **significantly associated** with a **higher UCF** rate (23%) as compared to an interrupted suturing technique (9%). Nevertheless, in the **multivariate** analysis, they found that the suturing technique had **no independent significance.**

In agreement with what was previously reported by *Elsherbiny et al.*, another analysis by ***Sarhan et al.*** **(2009)** [184] found that the use of **running** sutures was associated with **a higher** complication rate than **interrupted** sutures. Still, the difference was **not statistically significant** (**p=0.531**). Note that running sutures were used in 408 (81.6%) patients and interrupted in 92 (18.4%).

Snodgrass et al. **(2010)** [185], in their review, also found **no** statistically significant **difference** in urethroplasty complication rate based on suture materials and suturing techniques. They compared the likelihood for either **UCF** or **GD** between patients repaired with **chromic** versus **polyglactin sutures,** and between **one-layer interrupted** stitches **through epithelium** vs. **two-layers running subepithelial** stitches.

To compare the effect of **interrupted**- and **continuous**-suture in TIP urethroplasty on **complication rates**, ***Gupta et al.*** **(2017)** [186] performed a prospective randomized study comprising **100** boys operated on by **2 surgeons** using similar operative and perioperative principles; urethroplasty was done with **6-0 Vicryl subcuticular** suture in **2 layers** over an **8-10 F catheter**. Neourethral coverage with **preputial dartos flap** was also used in all cases.

The authors concluded that the type of suture technique had **no statistically significant effect** (**p=0.5**) on the occurrence of **complications** (UCF, GD, superficial wound infection, MS, and urethral stricture).

Subcuticular vs. **Full-thickness:**

Typically, a **subcuticular** technique is employed during longitudinal closure of the neourethra when performing tubularization technique. Healing then provides a "**watertight**" anastomotic suture line that, at least theoretically, decreases the risk of UCF formation.

However, ***Hakim and Coworkers*** [187] reported that the technique, either **subcuticular** or **full thickness,** did **not significantly affect** the results, provided that the suture used was of polyglactin composition.

In contrast, ***Ulman and Colleague*** [177] studied groups that differed not only in suture materials, but also in suturing technique, they documented a **statistically significant lower UCF rate** (4.9% versus 16.6%) for **subcuticular** (in the group in which PDS was used) compared with **full-thickness** technique (in the group in which VICRYL was employed).

Therefore, ***Ulman et al.*** concluded that using a **subcuticular** suture technique utilizing **PDS** suture material **improved** the **outcomes** in urethroplasties, but were unable to differentiate the contribution of each one.

A similar comparison has been carried out by ***Chung et al.*** **(2012)** [167], who suggested that the **suture materials** and **suturing techniques** have **no significant effect** on the outcome.

They conducted a retrospective study between1990 and 2010, included **294** patients, operated on with several operative methods by a single surgeon.

The incidence rates of surgical complications (particularly UCF) according to the type of <u>**suture materials**</u> were **20%** with **polyglactin 910**, **24.3%** with **chromicized catgut**, and **24%** with **PDS**, respectively (**p=0.684**).

The incidence rates of surgical complications (particularly UCF) according to the <u>**suturing techniques**</u> were **28%** and **26.1%** for **interrupted** and **continuous** suturing methods, respectively (p=0.538); and were **27.3%** and **27.1%** for **full-thickness** and **subcuticular** suturing methods, respectively (**p=0.809**).

In *Our department*, we perform urethroplasty procedures by using either **PDS®** or **Vicryl®**, yet, we **prefer PDS** 6/0 to VICRYL.

This choice was based on the fact that **PDS** is a monofilament and could be extruded easily **thinner** than VICRYL. Therefore, we reasoned that PDS would be **less traumatic**. In addition, its **absorption** rate greatly exceeds that of polyglycolic acid (PgA), which could prevent **glans dehiscence** that might indicate **too rapid suture dissolution**. [179]

Our present study also supports the findings of the majority of the studies to date. We found **no statistically significant difference** in complication rate using a different suture **material** (**VICRYL** vs. **PDS)** or **technique** (**Interrupted** vs. **Running)** for anterior hypospadias repair, despite the **higher** complication rate amongst cases repaired with **PDS** sutures compared with **VICRYL** sutures.

Finally, we suggest that **suture materials** and **suturing techniques** do **not affect** the **complication rate** in the Thiersch-Duplay urethroplasty procedure. And given the lack of any randomized trial demonstrating the **superiority of any suture material**, choice of sutures remains the surgeon's preference.

6. Dressing

The election of an **appropriate wound dressing** is one of the most controversial aspects of hypospadias surgery. In fact, there may be as many different types of dressing as there are types of surgical repair.

An **"ideal"** penile dressing should maintain the phallus in an **upright (zenith) position**, be **nonadherent** to the surgical wound, slightly **absorbent**, gently **compressive** but **nonischemic**, and yet **elastic** and **soft** to allow for slight swelling.

Baskin. [131] has recommended a "**sandwich**" dressing for **distal** hypospadias repair with urinary diversion, consisting of a layer of **Telfa** followed by **gauze** folded 3 times on the penile ventrum and secured with a medium transparent **Tegaderm** sheet of sticky plastic.

The author stated that it allows more **diffuse pressure** by pressing the penis upward against the abdominal wall to maintain it straight and extended. And it is easily removed at **home** after **48 hours**.

On the other hand, 2 prospective randomized trials [188], [189] showed **little** or **no advantage** to the dressing application to the operated hypospadias.

Patients were randomly assigned to receive either **transparent film** dressing, **elastic wrap** dressing, or **no dressing**. Antibiotic ointment was used to coat the penis in those receiving "no dressing."

The authors demonstrated that the method of postoperative care (dressing versus no dressing) did **not affect** surgical **success rate** or **wound healing**.

Jawale. [190] in his studies, has pointed the poor wound healing as a crucial factor that may lead to repair failure. He discussed the link between **nutrition** and **wound healing** and concluded that the poor nutritional status, if not corrected, can **delay** the wound healing process.

In his experience, he started a **high protein diet** for the child before, during, and after surgery in the form of eggs or protinex powder. He described the difference in healing as dramatic. Thus, **nutritional screening** must be an integral part of the overall clinical assessment of hypospadias patients.

Natural honey's benefits on open wound healing have been known for centuries, but the scientific foundations have been fully revealed and proven recently. [191]–[193] It has been confirmed to be safe and more effective than many expensive synthetic and biological dressings. [194]–[196]

Some authors consider it to be **the ideal** dressing material for all **non-infected wounds**, including burns, decubitus wounds, traumatic ulcers, malignant ulcers [191], and recently used in **infected wounds** such as Fournier's gangrene after debridement. [197]

Honey is considered naturally sterile and has several properties: [198], [199]

- **Antimicrobial effect**: Thanks to the catalase, hydrogen peroxide and low pH (pH=3.6), a group of bacterial inhibitory substances called **inhibin** prevent honey from being contaminated. The applied dressing can never sterilize the wound, but it can prevent the colonization of microorganisms by creating a thin barrier to disconnect the wound from the air.
- **Chemical debridement and anti-edema effect**: Honey's high viscosity ensures the absorption of edema fluid built-up in the tissues, and thus the blood supply increases.
- **Epithelization and granulation accelerating effect**: by forming a moist environment.
- **Analgesic effect**: occurs when the nerve endings in the wound are cut off from the air.
- **Nutritional regulating effect**: The high sugar content made of honey a good source of energy in wounds with increased catabolism.

Considering all of these effects, we have incorporated honey in *Our department's* dressing policy since **2015**. We noticed a higher tendency to **improve** the surgical outcomes and decrease the complication rates.

As confirmed by a ***retrospective study*** [200] conducted in *Our department* on **40** posterior hypospadias patients from **2009 to 2017**. Out of **29** cases who applied honey dressing, **24.13%** developed **complications** compared to **27%** out of **13** who used **simple gauze** dressing.

Our present study represents an extension to the same results, and joins a study conducted on **rats** by the "**Marmara University**" [201], which investigated the effects of honey on graft; in intension to contribute it to hypospadias surgery, where wound healing is critical, and scarring is not desired.

For this purpose, epithelization, infection, and scar formation were evaluated during the healing period. Full-thickness biopsies were performed from the graft site to investigate acute and chronic inflammation, fibrosis, and vascular proliferation.

The authors reported that the wound healing **period** was **shorter** in the **honey** dressing group, and **no infection** or **necrosis** was observed. While in the classic dressing group, 1 case developed graft necrosis and 1 exhibited a subcutaneous infection. **No significant histological difference was found** in terms of regeneration as a result of the microscopic evaluation.

II. LATE POSTOPERATIVE COMPLICATIONS

For pediatric urology surgeons, the topic of late post-operative complications after hypospadias repair, their associated risk factors, and their management has always been an exciting subject matter to be studied and discussed.

This may be justified because of how challenging and occasionally humbling it can be the **redo failed hypospadias** surgery due to the significant **scarring** and the **paucity of genital skin**; thus, leaving the surgeons with less-than-ideal material with which to reconstruct the failed repair.

The management, however, should be performed after a period of healing over **6 months**, with the exception of **urethral** or **meatal stenosis**, which requires more **emergent attention**. [202]

1. Meatal Stenosis (MS)

MS is a relatively **common** but **avoidable** unfavorable result that can be quite troublesome, causing harm to the bladder and thus the upper urinary tract. It can also lead to UCF development. [203]

The most common presenting **symptom** is **difficulty in urinating**. Difficulties were defined as **frequent micturition**, **prolonged** urination, a **thin** stream, difficulties **starting** urinary flow, **keeping the flow** going, **directing** the stream into the toilet, **spraying** of the urinary stream, and **straining** or **arching** of the back during voiding. [204]

Clinical diagnosis is generally based on **meatal calibration** (inability to pass an 8Fr sound through the neomeatus in <1-year-old children and 10Fr in those aged >1 year). **Radiological** investigations are **unnecessary** unless a proximal extension of the stricture is suspected. Calibration is a method for postoperatively **assessing the**

dimensions of the neourethral meatus, or **disclosing subclinical forms** (obscure obstructions), especially in children who are **not toilet-trained**. [205]

Thiersch-Duplay urethroplasty

In 1997, ***Stock and Hanna*** [143] reported the largest documented series of Thiersch-Duplay repairs. Combining the principles of Heineke-Mikulicz meatoplasty to widen the meatus dorsally at 12 o'clock with Thiersch-Duplay tubularization of the urethral plate, they noted a low **complication rate** of **2.1%** in **512** children with **anterior** hypospadias. Of **11** complicated cases, **2 MS** were reported, which counts for **0.4%.** They were repaired **surgically.**

Mege et al. **(1999)** [206] retrospectively studied **321** patients treated according to a modified Duplay method. Only **58** patients were reviewed with a mean **follow-up** period of **71 months**. The long-term results showed an overall complications rate of **25.9% (15/58),** including **MS** in **1.7%** of cases **(1/58)**.

Ravasse et al. **(2000)** [207] conducted a study including **100 anterior** hypospadias, 50 fixed with Mathieu and **50 with Duplay** procedure, the same operator performed all the cases. All urethral sutures were performed with inverted running sutures. Urine drainage was ensured by Foley catheter for 48 h.

The follow-up period was **6 months** to **4 years**. **3** children **(6%)** in the **Duplay** group had to be reoperated because of urethral **complications,** including **1** patient **(2%)** with **MS.**

Bouhafs et al. **(2002)** [208] reported on **585** hypospadias cases operated on with a modified **Duplay** technique. Of a total of **65** complications (**11%**), **MS** was a little more frequent; present in **4.3%** of cases which counts for **25** patients.

The authors recommended the plate to be **14 to 15 mm wide** to prevent MS.

Merrot et al. **(2003)** [119] have spanned a 10 years-period retrospectively to gather a total of **849** patients with **primary anterior** hypospadias. A **Thiersch-Duplay** procedure was undertaken in **457** patients and a modified Mathieu procedure was performed in 392 patients. In both groups, the **follow-up** period ranged from **21 months** to **10 years**. The overall late **complications** were **34/457** patients (**7.4%**) managed with the **Duplay** procedure, compared to 7/392 patients (1.7%) managed with the Mathieu.

They reported that the **Duplay** procedure was associated with **3.3% MS,** which counts for**15** patients. **13** of them needed a **meatoplasty**; compared to 0.5% treated successfully with simple dilations in the Mathieu group. This difference was statistically significant (**p<0.05).**

Acimi **(2011)** [120] has reviewed a total of **245 distal** hypospadias corrected by a single surgeon within 9 years period. 132 patients underwent repair by TIP and **113** by **tubularized urethral plate** (**Duplay**). The mean **follow-up** period was **84 months** (21-120 months). The reported complication rate in the **Duplay** group was **15%,** including **8** patients (**7%**) with **MS.**

The author demonstrated that the MS rate was **significantly higher** for Snodgrass group than Duplay group (**p=0.001**). 4 patients needed a **meatotomy**. *Acimi* suggested that when the distal hypospadias is associated with a **deep** balanic **groove**, it should be corrected by the **Duplay** procedure.

Grosos et al. (2014) [209] have conducted a retrospective review between1992 and 2006 of **578** patients; **517** of them had **distal** hypospadias and were all operated on with **Thiersch-Duplay** technique -without TIP- followed by a spongioplasty. The mean **follow-up** period was **25.6 months** (6ms -17 years). **90**/517patients (**17.4%**) had **inadequate urethral healing**, including **44** cases with **MS (8.5%).** These results were rather similar to *Our study*.

Koff urethral mobilization and advancement

Hamdy et al. (1999) [210] employed UMA in **46** children with **distal** hypospadias. **MS** occurred in **3** children **(6.5%),** all of whom had the mobilized urethra **tunnelled** through the glans.

Paparel et al. (2001) [211] have evaluated the **Koff** urethral mobilization in **26** patients between 1999 and 2001. All cases were performed by the same surgeon. The mean **follow-up** period was **4.64 months** (1-24 months).

In a total rate of complications of **23% (6/26), 5** patients **(19.2%)** presented with a late **MS** requiring a secondary **meatotomy**;

The authors recommended a **careful selection** of cases to avoid secondary MS, which seems to be related to **ischemia of the distal hypoplastic urethra.**

Awad et al. (2007) [212] have compared the TIP urethroplasty and **anterior urethral advancement (AUA)** for **distal** hypospadias repair. A total of **140** boys were divided into 2 groups. 68 patients were treated with TIP and **72** patients with **AUA**. There was no significant difference between both groups with respect to age & meatal sites. Note that they **mobilized the glans** instead of tunneling it.

The **4** patients **(5.5%)** who developed **MS** responded well to urethral **dilatation** twice weekly for 3 weeks without anesthesia. The authors reported no significant difference between the 2 groups concerning **MS** (7.3% in TIP group).

Hammouda et al. **(2008)** [213] studied **46** children with **anterior** hypospadias who were managed with **UMA** from 2004 to 2007. The mean **follow-up** period was **25 months**. **No** case of **MS** was observed.

Thiry et al. (2014) [126] reviewed **158** children with **distal** hypospadias (**115 primary** cases and 43 redo cases) who underwent surgical repair using the **Koff** technique by the same surgeon. To our knowledge, this series is the **largest** ever published with the **most extended follow-up** period (up to **165 months**).

16 patients in primary cases **(13.9%)** presented with a **complication**, including **MS** that was the commonest, present in **4/16** cases **(3.5%).** Probably owing to **distal urethral ischemia** related to **insufficient distal CS,** especially when the mobilized urethra is not reattached to the ventral aspect of the CC.

Hassan et al. **(2015)** [214] conducted a prospective study on **30** patients with **primary anterior** hypospadias repaired with **UMA.**

3 patients developed **MS**; although every effort was made to avoid it through adequately incise and dissect the glans deeply down to the CC and mobilize glanular wings adequately laterally. The authors suggested that the **small glanular size** plays a role in the development of MS.

Hashish et al. **(2017)** [215] used the UMA technique in **20** patients with **primary distal** hypospadias. **5** patients **(25%)** had significant late postoperative **complications**, including **3** patients **(15%)** with **MS.** All of whom responded well to daily **dilatation** with 8 Fr Nelaton's catheter.

The authors claimed they started urethral **dissection distally** from the ectopic meatus with adequate **tissue around** it to prevent MS.

Haider et al. **(2019)** [216] included a total of **60** patients with **anterior** hypospadias in their study to evaluate the effectiveness of UMA technique.

MS was labelled in **4 (6.6%)** who had a narrow urinary stream; they were managed with urethral **dilatation** weekly for 2 to 3 weeks.

In ***Our study,*** the rate of **MS** was insignificantly **higher** with **Thiersch-Duplay** procedure (**8%**) when compared to **Koff** procedure (**0%**) (**p-value=0.067**).

The MS was **gradually dilated**, once a week for a month, and successfully resolved. None of the 4 patients needed a meatotomy or meatoplasty.

These findings were consistent with the results reported by ***Acimi*** **(2010)** [120] and ***Grosos et al.*** **(2014)** [209]**,** who demonstrated a high incidence of MS among the hypospadias repairs with Duplay procedure.

These results may be related to a few technical issues such as tubularizing a poor UP with a **narrow lumen,** questioning the adequate indication of the **Duplay** technique in these cases. [217], [218] [219] Or urethral plate's tubularization **too far distally**. [220] Or maybe the **glanuloplasty** was done a bit too **tightly,** in fact, **glanular flaps** should be sutured so as not to cause **compression** over the underlying **urethra,** and one should always attempt to create a **wide meatus**. As it may be a matter of a bad choice of **transurethral catheter'** size that could increase the **tension** exerted for **glans wings approximation.** [221]

The **0% MS** found within the **Koff** group patients is **relatively rare** compared to statistics reported in the literature [211] [222]. Indeed, *our team* follows a few strategies to avoid MS; including:

- **Not** trying to bring the meatus back to the **apex of the glans** when performing the urethral advancement because it's believed that a meatus that is too anterior often tends to stenosis due to **ischemia of the distal end** of the urethra. [211]
- A meatoplasty extending into the meatus dorsal part, thus widening its caliber.
- And mobilizing the glans instead of tunneling it, to create an ample bed to receive the urethra and to create a more normal conical glans shape.[214]

To manage MS, some authors [223] suggest regular **periodic calibration** to be routinely performed during 1 year postoperatively as an integral **part of the technique**. While others [224] think that **3 months** is sufficient if it is started early. Another team regard calibration/dilatation as **unacceptable** because of **the** unpleasant **pain** and possible **injury of the neourethra** during dilatation.

In *Our department*, we believe that this procedure is difficult to be practiced systematically given the large number of patients treated for hypospadias. So, we use it as a treatment in **diagnosed MS** and not for prevention.

Table 38. Studies' comparison concerning MS and its correlation with SP

Referrence	Patients number	Surgical procedure (SP)*	Total patients with complications		Total patients with MS	
			N/*	%	N/*	%
Stock & Hanna (1997)	512	Duplay 512	11	2.1	2	0.4
Mege et al (1999)	321	Duplay 58	15	25.9	1	1.7
Ravasse et al (2000)	100	Duplay 50	3	6	1	2
Bouhafs et al (2002)	585	Duplay 585	65	11	25	4.3
Merrot et al (2003)	849	Duplay 457	34	7.4	15	3.3
Acimi (2011)	245	Duplay 113	17	15	8	7
Grosos et al (2014)	578	Duplay Distal 517	90	17.4	44	8.5
Hamdy et al (1999)	56	UMA 46	-	-	3	6.5
Paparel et al (2001)	26	Koff 26	6	23	5	19.2
Awad et al (2007)	140	AUA 72	5	7	4	5.5
Hammouda et al (2008)	55	UMA 46	-	-	0	0
Thiry et al (2014)	158	Koff primary 115	16	13.9	4	3.5
Hassan et al (2015)	30	UMA 30	-	-	3	10
Hashish et al (2017)	20	UMA 20	5	25	3	15
Haider et al (2019)	60	UMA 60	-	-	4	6.6
This study	90	Duplay 50	23	46	4	8
		Koff 40	11	27.5	0	0

2. Urethro-Cutaneous Fistula (UCF)

UCF is the most feared but anticipated complication after hypospadias surgery. It occurs **anywhere** through the neourethra, often at the **coronal** level.

The **coronal** UCF develops and persists due to **distal narrowing of the urethra** in the glanular region. This relative narrowing and **lack of extensibility** of glanular urethra cause **backpressure**. If too high the pressure, the neourethra might **breakdown** at the coronal region and the urine would take the easy way out and produce a UCF. The **junctional** area is also prone to UCF because of the **changing tissue type** from normal to neourethra, making it a **delicate** area. [225]

Speculations regarding the upcoming of UCF have concerned post-operative local **infections**/urinary extravasation, local **hematoma**/**ischemia**/ **necrosis**, **increased pressure** due to anastomotic **narrowness** or stricture, the effect of **suturing manner** and **materials,** the **surgeon's skills,** as well as the poor **healing abilities** of the patient [177], [218].

The choice of a particular **surgical technique** is a key factor; a failure to invert all epithelial edges at urethroplasty, devitalization of tissue, and failure to add appropriate second-layer urethroplasty coverage may lead to UCF. [226]

A study reported that the **timing of UCF diagnosis** in 26 patients was a median of **3 months**. However, **23% presented at >2 years** after their primary repair. The authors stated that the follow-up needed to diagnose 90% and 99% of initial UCF would be 8 and 20.5 years, respectively [227].

Treatment depends on the number, location, and size of the UCF; however, the temptation to simply close it is dangerous, as **recurrent UCF** are quite common. Often it is more advisable for UCF that arise at, or distally to, the coronal sulcus to repeat the whole urethroplasty by opening the bridge between the meatus and fistula, mobilizing the **inner urethral edges**, and closing in two layers with good **glans**

approximation. UMA might also be considered for treating persistently recurrent hypospadias UCF. Note that healing is **spontaneous** in about one-third of cases, provided they are small-sized, and there is **no distal obstruction.** [166] [228]

Thiersch-Duplay urethroplasty

Paulus et al. (1993) [229] reviewed **220 distal** hypospadias repairs that have been operated on over 10 years. Of **89** cases underwent **Duplay's** technique, **8** exhibited complications **(9%),** including **8 UCF** in **7 children** (one double) (**7.9%**), compared to 131 cases with MAGPI procedure who presented only 3 complications, including **1 UCF**.

Stock and Hanna (1997) [143], in their large series of **Thiersch-Duplay** repairs, also observed **5** cases with **UCF (1%)** that were repaired **surgically.**

They suggested the use of the Heineke-Mikulicz meatoplasty in patients with a stenotic meatus and the **glanuloplasty** as described by **Zaontz** to allow the Duplay repair to achieve excellent cosmetic and functional results.

The **Zaontz** technique involves de-epithelialization of the skin at the lateral margins of the glanular grooves to permit approximation and healing.

Mege et al (1999) [206], apart from MS, they found **UCF** in **3.5%** of cases.

Ravasse et al. (2000) [207] have shown in the same study that among the **Duplay** patients, besides MS, **1** patient exhibited a **UCF (2%).**

They concluded that covering the urethroplasty by a **foreskin subcutaneous connective tissue** pedicled flap **reduces** the UCF rate of **Duplay** urethroplasty to the same value as that observed after Mathieu urethroplasty, although it classically used to be higher.

Bouhafs et al. **(2002)** [208] noticed **46 UCF** out of **585** operated boys **(7.5%)**. To limit the risk of UCF, *Bouhafs* suggested reconstructing the urethra in an interrupted fashion, using magnification to ensure better security.

Merrot et al. **(2003)** [119] found that the **Duplay** procedure with spongioplasty was associated with **19/457 UCF,** which counts for **4.1%. All** their patients needed a **surgical closure** that was successful, compared to significantly lower rates within the Mathieu group (1.3%) which counts for 5/392 patients.

Acimi **(2011)** [120] has as well found that the **Duplay** technique led to **UCF** in **9/113** patients (**8%**). To note that he covered the neourethra by putting together, on the midline, pre-cavernosa tissues.

Despite there was **no statistically significant difference** between the 2 techniques (**p=0.08**), the rate of UCF formation seemed **higher** in the patients treated by the **Duplay** vs the Snodgrass (3%). This may be due to the urethral plate's midline incision, which lowers the tension on the sutures' edges. Only **3** UCF **resolved spontaneously** after 10-30 days; the others needed a **surgical correction**.

In the author's opinion, when the groove is less deep or non-existent, the Snodgrass technique is more appropriate. It gives an excellent cosmetic appearance and has a low rate of UCF formation.

In their study, ***Grosos et al.*** **(2014)** [209], besides MS they have also reported a **UCF** rate of **9.1%** that was significantly more frequent in the first post-operative year.

Duarsa et al. (2020) [132] collected **591** hypospadias cases from 12 centers. Most repairs (**44.16%**) were performed by using the **Thiersch-Duplay** technique**. UCF** was found in **80** patients (**15.27%**) out of the **total patients** with **41** of them underwent **Duplay** procedure. However, the authors demonstrated that the **urethroplasty** technique **wasn't significantly related** to UCF development (**p-value=0.226**).

Koff urethral mobilization and advancement

Paparel et al. (2001) [211] have reported only **one** case of **UCF** out of 26 cases **(3.8%),** which disappeared **spontaneously** a few months later. These results, defend the full penile urethral mobilization as an effective **alternative** procedure whose main advantage is to **avoid the use of any non-urethral tissues** to reconstruct the hypospadiac urethra.

Awad et al. (2007) [212] found, among their **72** patients, **one patient** who developed a big **UCF** (1.3%) in which the **urethra was retracted** to its primary site due to **poor post-operative management** and **wound infection** followed by **WD** and cut-through. The authors concluded that both techniques (TIP and AUA) could treat distal hypospadias with a high success rate. Still, the urethral advancement technique appears to be a good choice due to its simplicity, short operative time, and lower UCF rate with good cosmetic results.

Hammouda et al. (2008) [213] didn't record any post-operative **UCF** in their 46 patients, as there was no anastomosis between the urethra and the neo-urethra, which can be a potential site for leakage and UCF formation.

Hassan et al. **(2015)** [214], out of **30** patients, they didn't observe any **UCF**. They stated that the UMA procedure has the advantage of avoiding the need for a second layer of tissue covering during the repair. Moreover, there is a meager chance for the development of UCF, the post-operative management is simple, and a brief hospital stay is sufficient.

Hashish et al. **(2017)** [215] reported only **one** patient with **UCF** out of 20 **(5%)** requiring **surgical closure** 6 months after the operation. They explained it by a probable urethral injury during the surgery.

Therefore, ***Hashish et al.*** defended the necessity of a **meticulous mobilization** of the distal urethra, **wide glanular dissection,** and **wide lateral mobilization** of glanular wings to ensure a safe and successful Urethral advancement repair. They confirmed that the technique could be used regardless of the urethral plate's, the glanular groove, or the glans characteristics.

On the other hand, ***Hamdy et al.*** **(1999)** [210], ***Thiry et al.*** **(2014)** [126], and ***Haider et al.*** **(2019)** [216] observed **no** post-operative **UCF** after the UMA procedure. They suggested that the UMA technique is an effective alternative as technically there is an extremely low chance of UCF formation, which is the most common reason for redo surgery after hypospadias repair with other techniques.

In *Our study,* the reported incidence of the **UCF** was found to be **14.4%** (13/90 patients) which is consistent with the global incidence reported in the literature. It was observed with **MS** in **1 case** and with **WD** in **4 cases**. It was **doubled** in **4 cases**.

A **statistically significant difference** in the UCF incidence was noted between the **Koff** team, with the **less frequent UCF rate (2.5%),** and the **Duplay** team **(26%)**. **(p-value=0.006)**

In the *current study*, the UCF rate in the **Duplay** group was **26%**, **higher** than most reviews.

Gapany et al. (2007) [230] conducted a retrospective review of prospectively collected data of **85 tubularized plate urethroplasties**, a **UCF rate** of **25.9%** has been reported. Later, they modified their approach by systematically padding the urethral suture with a layer of **vascularized subcutaneous preputial tissue**, as described by Snodgrass. They noticed out of **57** hypospadias repairs, **UCF** occurred in **2** cases, **one** of which closed **spontaneously** within 6 months.

Thus, their UCF rate had dropped to **3.5%**. They concluded that the added layer led to a much better outcome.

Similar results were reported by *Sherbiny et al.* [183]**,** who conducted a study including 54% of primary cases with neourethra covered by a **subcutaneous dartos flap,** 24% covered by approximated CS (**spongioplasty**), and in the remaining 22% the double-layer urethroplasty was thought to be sufficient, and **no cover** was provided. The complications were **significantly more common** in repairs with **no neourethral coverage**.

The patients in *Our study* who underwent the **Duplay** procedure had a **ventral dartos flap**, applied as a barrier layer to cover the formed urethra in **76%** cases (N=38/50), 9 of them (**23.7%**) had **12 UCF.** Whereas the remaining **24%** (N=**12/50)** had their neourethra covered by putting together, on the midline over the suture line, the approximated corpus spongiosa as a second barrier for waterproofing (**spongioplasty**), using mostly a **6/0 PDS running** sutures, 3 of them which counts for **25%** presented with **4 UCF.**

This interposition was thought to be very important to reduce the UCF incidence; however, it **didn't show any benefit** in *Our series*, and there was no significant difference between the ventral dartos flap and spongioplasty in terms of UCF occurrence. **(p=1.000)**

Similarly to *Our data*, ***Snodgrass et al.*** **(2010)** [185] demonstrated that there was **no difference in UCF rates** between patients **with** (dartos flaps) and **without barrier flaps**.

UMA has several advantages over other techniques, mainly because of a **very low incidence of UCF**, an effect which is logical due to **obviating** the reconstruction of a **neourethra.** Also, it **does not need** other **tissues for coverage.**

Only **1 UCF** was reported in *Our series*, which compares well with other series from the literature. It may be explained by an **unrecognized/unsutured urethral injury** during mobilization resulting in a subsequent **UCF** formation.

Thereby, to **prevent** UCF development, surgeons have to be of a **high degree of expertise** to meticulously **dissect** the urethra without causing **injury,** using magnification and delicate instruments, because an **extensive dissection** of the urethra may lead to **ischemia** and potential **injury.**

Also, the healthy distal end of urethra must be fixed to the tip of glans penis after **excision of unhealthy distal urethra**.

<u>Table 39.</u> Studies' comparison concerning UCF and its correlation with SP

Referrence	Patients number	Surgical procedure (SP)*	Total patients with Complications		Total patients with UCF	
			N/*	%	N/*	%
Paulus et al (1993)	220	Duplay 89	8	9	7	7.9
Stock & Hanna (1997)	512	Duplay 512	11	2.1	5	1
Mege et al (1999)	321	Duplay 58	15	25.9	2	3.5
Ravasse et al (2000)	100	Duplay 50	3	6	1	2
Bouhafs et al (2002)	585	Duplay 585	65	11	46	7.5
Merrot et al (2003)	849	Duplay 457	34	7.4	19	4.1
Acimi (2011)	245	Duplay 113	17	15	9	8
Grosos et al (2014)	578	Duplay Distal 517	90	17.4	47	9.1
Duarsa et al (2020)	591	Duplay 261	–	–	41	15.7
Hamdy et al (1999)	56	UMA 46	–	–	0	0
Paparel et al (2001)	26	Koff 26	6	23	1	3.8
Awad et al (2007)	140	AUA 72	5	7	1	1.3
Hammouda et al (2008)	55	UMA 46	–	–	0	0
Thiry et al (2014)	158	Koff primary repair 115	16	13.9	0	0
Hassan et al (2015)	30	UMA 30	–	–	0	0
Hashish et al (2017)	20	UMA 20	5	25	1	5
Haider et al (2019)	60	UMA 60	–	–	0	0
This study	90	Duplay 50	23	46	12	26
		Koff 40	11	27.5	1	2.5

3. Wound Dehiscence (WD)

WD is a discouraging complication after hypospadias surgery. All urology surgeons have definitely experienced the child who, despite what appears to be a well-performed operation, ultimately manifests this unexpected complication.

Glans dehiscence (GD)

The prevalence of **GD** ranges from **0-8%.** In the only specific study of this complication conducted by ***Snodgrass et al.*** **(2011)** [231], GD's risk was **not affected** by **age** at surgery, pre-operative **testosterone** administration, or **glanuloplasty suture materials**.

However, the risk of **GD** after **tubularized plate repair** was **3.6**-fold greater in patients with **proximal** hypospadias compared with distal hypospadias and **4.7**-fold greater for **repeat procedures** (14%) than for primary repairs (4%). Suggesting it may be a result of local **ischemia** or **inflammation** after surgery.

Most **GD** are apparent at the initial post-operative visit at a median of **2 months**. A few **partial dehiscences** resulting in a **larger neo-meatus** could progress to **complete dehiscence** by the second follow-up.

Most patients are treated **conservatively** for **GD**. Indeed, although a **coronal regression** is likely to have a **gloomy cosmetic** appearance, this complication might **improve urinary function**, as it **reduces outflow resistance** and, therefore, the risk of urinary **obstruction**. However, a meatal retraction can become pronounced with penile growth resulting in **splaying** of the **stream**; and to void the bladder, the boy has to sit. [204]

Several techniques can be used for **repeat reconstruction** of the distal urethra. The indications for the **correction** of **GD** are similar to those for extremely distal hypospadias, namely **spraying**, **deviation of urinary stream**, and **unsightly glans appearance**. [232]

Neo-Urethral dehiscence (UD)

Repair breakdown may occur secondary to **devascularization of local tissues** or flaps used in urethroplasty, resulting from **excessive use of electrocautery**, **unidentified vascular pedicle injury** during repair, or **hematoma formation.** It may also result from **urethroplasty** and/or **glanuloplasty** under **tension**, as it may be linked to a local penile infection [233].

Regardless of the cause, repair breakdown requires **debridement** of devitalized, necrotic tissue before going for any surgical repair. **Re-suturing** of the raw area is **not advisable** [234]

Treatment for **UD** will depend on the **length** and **extension** of the neourethral defect, the amount of **scar tissue** encountered, and **local skin** availability. [235]

Thiersch-Duplay urethroplasty

Paulus et al. **(1993)** [229] in their review, of **89** cases who underwent **Duplay** technique, **1** boy only (**1.1%**) showed **UD** and reoperated upon according to **Mathieu's** procedure. Compared to **1/131** with **GD** not reoperated and **1/131** with **UD** reoperated with success by the same technique in the **MAGPI** group.

Stock and Hanna **(1997)** [143], in addition to MS and UCF, have as well objectified **4** cases of **breakdowns** of the distal neourethra **(0.8%).**

The authors suspected the glans' conical shape and the absence of glanular groove to be responsible for that.

Mege et al. **(1999)** [206], besides MS and UCF, have reported **UD** in **20.7%** of cases (**12/58**).

In ***Ravasse et al.*** (2000) [207] series, only **1** child over **50** presented with **UD** (**2%**) in the Duplay group.

Bouhafs et al. (2002) [208] noticed **7** cases with **meatal retraction (GD)** out of **585** operated boys (**1.2%**).

Merrot et al. (2003) [119] found that the **Duplay** procedure was associated with **6/457 WD,** which counts for **1.3%,** all of whom required a **reintervention**.

None of ***Acimi's*** (2011) Duplay patients [120] presented with a **WD.**

In their review, ***Grosos et al.*** (2014) [209], besides MS and UCF, have also reported a **WD** rate of **3.2%,** which counts for **16/517**. Similarly to ***Our study,*** they found that WD was significantly more frequent in the 1st post-operative year.

Koff urethral mobilization and advancement

Hamdy et al. (1999) [210], ***Paparel et al.*** (2001) [211], and ***Awad et al.*** (2007) [212] haven't reported a single case of **WD** within their series.

In their review, ***Hammouda et al.*** (2008) [213] achieved a slit-like orthotopic meatus with conically shaped glans and straight penis in all but **one** sub-coronal case (**2.2%**) with **mid-glans meatal retraction**.

They advised beginning the urethral **mobilization proximally**, where the urethra is entirely surrounded by **spongiosal tissue**, not distally, where the spongiosal tissue splays away laterally.

They recommended as well **three-fold** penile urethral **mobilization** that allows **tension-free** urethral anastomosis, **deep interballanitic** incision, and **wide** dissection of the **glans laterally**; in order to avoid complications such as **curvature**, **glanular disruption,** and **meatal retraction** or **MS**.

The authors confirmed that contrarily to plate tubularization that is best limited to patients with a deeply grooved urethral plate, the UMA may be performed with the best results regardless of the presence of an **unhealthy**, **narrow** urethral plate, **shallow** glanular **groove**, and **flat** or **small glans**.

Thiry et al. (2014) [126] noticed the presence of **2/115 GD** (**1.7%**);

Hassan et al. (2015) [214] out of **30** patients, recorded in **one** patient only a **disruption** of the most distal of the **glans** approximation sutures, leading to a minor detachment in the glans. **2** patients exhibited **meatal retraction (6.7%)**, wherein the urethra migrated proximally but still within the glans; only **one** of these patients required a **reintervention**. The authors believed that it's due to a **lack** of **tension-free anastomosis** because of non-respect to the urethral **mobilization ratio.**

Hashish et al. (2017) [215] reported **3 (15%)** patients out of 20 who had **meatal retraction** required no further surgical intervention as the meatus remained within the glans.

The authors stated that they avoided problems such as **glanular disruption**, **MS,** or **retraction** by performing a **wide lateral mobilization** of the **glanular wings**, which allowed sufficient glanular tissue in each glanular wing to be secured well to each other. Also, care must be taken to ensure that the glans closure is **not tight** around the urethra. Furthermore, they found that the fear of devascularization due to urethral mobilization seems to be absent.

Haider et al. (2019) [216] reported as well, only **2/60 patients (3.3%)** with **retraction** of the **urethra**, for which redo surgery was carried out; in both cases, with MAGPI procedure. The authors concluded that the UMA technique might be adopted safely for anterior hypospadias correction since it had good functional as well as excellent cosmetic outcome.

In ***Our study,*** of the post-operative surgical complications, **WD** was the **most** readily **diagnosed 24.4%** (**N=22/90**). This rate was higher than reported in the literature.

WD occurrence was **quite similar** between the **Koff** group and the **Duplay** group. **(p-value=0.913),** which **refutes** the common **theory** consisting of the **koff** technique resulting in **higher rates** of **WD** when compared to **Duplay** technique.

All these cases required reoperation, which failed in **7** cases of the **Duplay** group, and **3** cases of the **Koff** group.

Basically, it is difficult to compare ***Our results*** to most other published series concerning either **Duplay** or **Koff** repairs, given the **lack** of a **standardized definition** for **Dehiscence**, and the failure of many reports to describe **sutures used** and **glanuloplasty technique**. Accordingly, it's suggested that future reports concerning hypospadias techniques include this information so that other surgeons can compare and contrast their own experience and results. [231]

The separate observation that the **penis and glans** are sometimes **smaller** in **proximal** cases, and nearly **4-fold increased GD risk** in patients with **proximal** hypospadias, suggest that **anatomical** and/or **host factors** (wound healing) might be involved in the development of this post-operative complication.

This is a fascinating theory, especially that **glans size** might be a **modifiable factor to decrease GD** occurrence. We can use **testosterone** therapy preoperatively to address this concern; it has been observed to increase glans circumference, thus providing **more substance to hold sutures**, which could decrease **tension** on the glans wings approximation. [236]-[238]

Actually, we don't have any recorded information about the glans size in *Our series*, and to date, no published data include normal glans width or circumference and no established criteria indicating when pre-operative hormonal stimulation might best be used.

The Koff technique, though, is not widely used in *Our department* by fear of subsequent **dehiscence** development.

Actually, we believe that **GD** and **meatal retraction** may result from **inadequate preparation** of the **glanular bed** to accommodate the urethra leading to a tight glans wrap that exerts tension on the glanular closure. Thus, it may be avoided by performing a **wide mobilization** of the **glans wings** further laterally if necessary.

Also, it may be linked to **stenting,** which applies **mechanical pressure** over **the suture line** with its subsequent **ischemic effect** and the possibility of compromising **wound healing** in its early phases. [215]

Some authors suggested anchoring the mobilized urethra to the corpora to avoid any glanular traction. [126]

Table 40. Studies' comparison concerning WD and its correlation with SP

Referrence	Patients number	Surgical procedure (SP)*	Total patients with Complications		Total patients with Dehiscence	
			N/*	%	N/*	%
Paulus et al (1993)	220	Duplay 89	8	9	1	1.1
Stock & Hanna (1997)	512	Duplay 512	11	2.1	4	0.8
Mege et al (1999)	321	Duplay 58	15	25.9	12	20.7
Ravasse et al (2000)	100	Duplay 50	3	6	1	2
Bouhafs et al (2002)	585	Duplay 585	65	11	7	1.2
Merrot et al (2003)	849	Duplay 457	34	7.4	6	1.3
Acimi (2011)	245	Duplay 113	17	15	0	0
Grosos et al (2014)	578	Duplay Distal 517	90	17.4	16	3.2
Hamdy et al (1999)	56	UMA 46	-	-	0	0
Paparel et al (2001)	26	Koff 26	6	23	0	0
Awad et al (2007)	140	AUA 72	5	7	1	1.3
Hammouda et al (2008)	55	UMA 46	-	-	1	2.2
Thiry et al (2014)	158	Koff primary 115	16	13.9	2	1.7
Hassan et al (2015)	30	UMA 30	-	-	2	6.7
Hashish et al (2017)	20	UMA 20	5	25	3	15
Haider et al (2019)	60	UMA 60	-	-	2	3.3
This study	90	Duplay 50	23	46	12	24
		Koff 40	11	27.5	10	25

III. SEPTEMBER 2020 CHECK-UP

1. The Total Number of Surgeries

Most **complications** after primary hypospadias repair require **additional surgical correction**, which makes the need for reoperation after hypospadias surgery an **indicator** for surgical outcomes and **medical care quality**.

The rates of complications requiring **re-operation** following a primary repair of **distal** hypospadias are reported to be as low as **2.8%** and as high as **9.4%** across recent US studies. Approximately **7%** of children undergoing **distal** hypospadias repair experience a **re-operation** within **5 years**. [239]

Herbst et al. **(2013)** [240] reported that **more** than a **quarter** of patients who had received primary hypospadias repair required **additional interventions** after what was thought to be **definitive repair**.

One of the long-lasting debates in hypospadiology is whether the **primary surgical technique** has an impact on long-term outcome and **re-operation rate**.

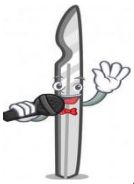
Well, to our knowledge, **no** technique has ever emerged as a **gold standard** as no high-level evidence has ever shown the **superiority** of one technique over another.

A **retrospective analysis** [151] of a large hypospadias database including **474** children undergoing primary hypospadias surgery was reviewed. The patients had **different severity levels** and different **initial repair procedures** (TIP, MAGPI, ONLAY…).

The long-term follow-up indicated that the **surgical technique did not significantly influence the re-intervention rate**.

The authors defended that with **experienced hands**, the **only significant** variable that independently predicts re-intervention is the **severity of hypospadias**, the **only factor we cannot modify nor control**.

Another **population-based analysis** advocated that surgeons with high volume caseloads had a significantly lower likelihood of performing hypospadias **secondary surgery** than low-volume surgeons*.* [140]



A prospective study conducted by ***Snodgrass and bush*** **(2017)** [241] on patients undergoing different hypospadias surgical repairs (TIP, inlay, two-stage graft…) demonstrated that the **complications doubled** in boys undergoing **a 2nd hypospadias** urethroplasty compared with those undergoing **primary repair**. This finding emphasizes the need for hypospadias surgeons to '***get the job right the first time***.'

The risk of additional complications increased to **40% with three** or **more reoperations**. These findings support the theory that **previously operated tissues** have **less robust vascularity** than assumed in a primary repair, and suggest that **adjunctive therapies** are needed to improve wound healing in re-operations.

The study also noticed that **40%** of the re-operative urethroplasties followed **distal repairs,** emphasizing that there is **no 'minor' hypospadias**.

These results may explain why in ***Our series,*** only in **Duplay** group we reported patients with **more than 3 surgeries**.

In *Our series*, the observed reasons for the **first reoperation** were mainly **WD** and **UCF**.

Our results joined the previously published reports and confirmed thathypospadias **re-operation** was **not significantly correlated** with the **type of primary surgical repair** (**p-value=0.364**).

However, *Our study* was limited because a **5-year follow-up** as a maximum in the best cases may not be **long enough** to cover all our patients' reoperations; some may occur beyond the study period.

To note that despite the majority of **Koff** cases were done in **2016-2017**, and thus, they got a longer follow-up period compared to **Duplay** cases, they didn't undergo as many re-interventions as Duplay's boys.

We have to stress that through that **September check-up,** we identified some patients with **new UCF** who are awaiting **further potential surgery** (7/39 Duplay vs. 1/35 Koff). Based on that, the number of surgeries **may get higher** in **Duplay**'s group.

2. Cosmetic Appearance

The basic principles of hypospadias surgery are to reconstruct the urethra to the glans' tip, straighten the VPC, achieve acceptable cosmetic penile appearance, and allow normal urinary and sexual function. These principles are well established, and hundreds of surgical procedures have been described.

In contrast to the numerous studies focusing on hypospadias repair's **surgical techniques** and **complications**, strikingly, there are very limited studies longitudinally reporting on **long-term cosmetic** and **functional** (**urinary, sexual**) outcomes during adolescence and early adulthood.

Besides, one of the conundrums of evaluating this category of outcomes is the **lack of consensus** on the best methodology to apply. Cosmetic and functional results indeed are often **subjective,** and a significant disparity might be present between the judgments of **parents**, operating **surgeons**, and **patients**.

Data in the literature are quite controversial about this point. ***Mureau et al.*** [242] reported that the **surgeons'** evaluation tends to be more **optimistic** than that of the patients, whereas ***Weber et al.*** [243]observed an **opposite** trend.

Scarpa et al. **(2009)** [244] Demonstrated in their study that in **distal hypospadias, subjective evaluation** of overall penile appearance can be as **reliable** as an evaluation made using a **systematic scoring system**. Also, they claimed **excellent concordance** among the subjective assessments of **different observers,** including the child's parents and 3 surgeons (with the operating surgeon). However, **patient satisfaction** seems more affected by **subjective feelings** than the **anatomical result**.

Hoag and colleagues **(2008)** [245], combining medical data from chart reviews and a patient questionnaire of patients repaired for hypospadias as children, found that despite a slightly higher initial major complication rate (57.2%), respondents reported **few long-term complications** (11% **UCF**, **29%** persistent **VPC** and 10% stricture) with **excellent urinary** and **sexual functional results**.

Their patients appeared to be experiencing **minimal** long-term **voiding** and sexual **sequelae**, including **spraying** and **hesitancy** during micturition. Overall, **86%** of patients were quite **satisfied** with their overall surgical result. These findings are in agreement with ***Our results*** (**79.7 %** satisfied parents; **10.8%** UCF).

>>>Thiersch-Duplay Urethroplasty:

- ***Merrot et al.*** **(2003)** [119] reported that their patients' **satisfaction** was **excellent** in both groups (**Duplay** & Mathieu), and **cosmetic** results were considered **satisfactory** by the parents in all 849 patients.

- ***Acimi*** **(2011)** [120]stated that the **cosmetic** and **functional** results were generally **satisfactory** as judged by the parents. However, the **cosmetic** appearance obtained by the **Snodgrass** technique was considered **superior** to the **Duplay**'s. Indeed, the meatus in all **TIP** patients was **vertically oriented** and **normally positioned**. Whereas, with the Duplay technique, it was not always easy to place the meatus at the glans apex.

- ***Thiry et al.*** **(2015)** [246] have assessed long-term **functional, cosmetic,** and **sexual** results of hypospadias repair using a combination of contemporary validated questionnaires (PPPS, HOSE, and IIEF-5 score when older than 16 years old) and a retrospective analysis of flowmetry charts.

The authors included **275** patients older than 12 years treated for hypospadias by an Onlay, Mathieu, **Duplay (N=17),** or Duckett's technique. The mean (range) **follow-up** was 111 **(1-147) months** for **Duplay**.

12.3% (N=34/275) **UCF** were identified; **29%** (N=5/17) in **Duplay's,** which is considered **higher** when compared to ***Our results*** (17.9% **UCF** in **Duplay** group).

They claimed that their patients expressed a **high satisfaction** for every single item of the penile perception scale (**PPPS**), with mean values between 2 (satisfied) and 3 (very satisfied). **82%** were satisfied or very satisfied with the overall evaluation of **penile appearance**.

Fall et al. **(2020)** [247] conducted a retrospective study, including **55** patients operated for hypospadias between 2009 and 2017, with a mean follow-up of **58 ± 33 months.** Urethroplasty according to **Duplay-Snodgrass** was the **most used** technique.

The outcomes were judged good or poor depending on the quality of **penile straightening**, the penile **aesthetic appearance**, the **neo-meatus position**, the **permeability** of the urethra, and the existence or not of **UCF**. They claimed that **81.8%** of patients had a **good outcome,** and **Duplay-Snodgrass** urethroplasty had **better results** than the other techniques used.

>>>Urethral Mobilization & Advancement:

De Sy WA and **Hoebeke** [248] presented a study titled "Trans-glandular urethral advancement for distal hypospadias-16-year experience". In **40** patients, they were able to judge the **appearance** and **function** of their adult penis with a **follow-up** of at least **7** to **16 years** after the intervention. The results were **excellent**.

In conclusion, the authors emphasized that the **fear** of **ischemia** and **retraction** or even **necrosis**, with late secondary **VPC**, after extensive urethral mobilization, is **unjustified**.

Other reports, including that of ***Seibold et al. (2010)*** [249], showed excellent long-term outcomes of **urethral mobilization** techniques. Their study included **99** patients with a **follow-up** of **5 years** or greater. 96/99 patients (**97%**) had an **excellent cosmetic** and **functional** result based on the validated HOSE scoring system. There was **1** case of **UCF** and none of MS. Their findings were comparable to ***Ours*** (**82.9% satisfied** parents; **1 UCF**).

Adorisio et al. (2010) [129] claimed that all of their **90** patients who underwent **urethral advancement** according to **Koff**, modified with a Ψ incision on the tip of the glans, showed **no** residual or de-novo **VPC** during a follow-up period of **8-66 months**. All **cosmetic** results were judged **excellent** with urethral meatus on the tip of the glans.

The authors emphasized the importance of careful **patient selection** for a successful outcome. For them, suitable candidates are those with **distal or mid-shaft** hypospadias, presenting with (**1**) **absence** or low degree of **VPC**; (**2**) distal **UP** well **developed**; (**3**) distance between meatus and tip of glans at most **10-12 mm**; and (**4**) preserved **glanular morphology.**

Al-Nagaar et al. (2020) [128] included in their prospective controlled randomized trial **16** patients with **distal** hypospadias undergoing **primary repair**. **8** of them were allocated for a **Snodgrass** procedure, and another **8** were allocated for an anterior urethral advancement procedure (**AUA**).

The authors reported that **1** patient had **VPC** in **AUA** group. Whereas **1** patient had a **UCF, 1** had an **MS**, and **2** had a **repair failure** in the **Snodgrass** group.

In **AUA** group, the **US** was **straight** in **all** patients, and **parent satisfaction** was **good** in **7** cases and **fair** in **1** case.

In **Snodgrass** group, the **US** was **straight** in **6** patients, and **parent satisfaction** was **good** in **4** cases, **fair** in **2** cases, and **poor** in **2** cases.

In the end, the authors advocated that the **AUA** is a **safer** and **more reliable** modality for distal hypospadias management. It has **better cosmetic** and **functional** results as well as a **shorter operative time** than Snodgrass, which is concordant with ***Our own results***.

3. Urinary and Sexual Functions

The perception of the **urinary flow's quality,** reflecting patient's and/or parents' vague impression, is challenging to interpret. However, one should keep in mind the remarkable adaptation of the child to an impaired urethral flow.

Rynja et al. (2011) [250] reviewed a total of 20 studies investigating micturition, cosmesis and psychosexual functioning in patients who were operated on for hypospadias before the age of 6 years and were older than 14 years at follow up.

They demonstrated that **hypospadias** patients report **more urinary symptoms**, such as obstructive voiding, spraying, and deviated stream than controls. A **low *Q* max**, suggesting an obstructive flow, was found in 13.5% of patients with proximal hypospadias only compared to 2.9% of controls.

Fortunately, low flow rates have been found to improve in most patients by puberty, [251] suggesting that it is possibly an intrinsic feature associated to the malformation itself and may be less of a consequence of the surgical technique.

Thiry et al. **(2015)** [246] disagreed with ***Rynja et al.*** regarding their observation that only patients with proximal hypospadias have lower ***Q*** **max** compared to control patients.

They have reported a retrospective review of post-operative flowmetry results of 136 patients older than 12 years treated for a hypospadias by an Onlay, Mathieu, Duplay, or Duckett's technique between 1990 and 2000.

Overall, individual ***Q*** **max** were **within age-adjusted references**, **independent of the surgical technique**, with a median (range) Q max of 18.8 ml/s (3-45). ***Q*** **max** was **low** in **9.5%** patients, not affected by the surgical technique. **Spraying**, as reported in the HOSE questionnaire, was found in (**29%**) patients.

A recent review was conducted by ***Hoy and Rourke*** **(2017)** [252] of **93 adult** patients who presented to a reconstructive urologist with complications linked to **hypospadias,** including **74** who were **surgically** repaired in **childhood** and 19 non operated.

Their study highlighted the long-term issues that can occur following the correction of hypospadias as a child. It likely **increases** the future risk of **urethral stricture** (47% vs. 11% p=0.004)), **recurrent UTIs** (19% vs. 0% p=0.050), and subsequent **lower urinary tract symptoms** (55% vs. 26% p=0.038), with a trend toward improving patient satisfaction with cosmesis compared to nonsurgical management.

The correct evaluation of **sexual activity** in adolescents and young adults is still a matter of discussion, with no specific instrument having been developed for. However, long-term sexual problems, like erectile dysfunction [253], ejaculatory difficulties [254], lower self-esteem, teasing, and negative genital perception, have been reported in patients with hypospadias [255], [256].

Several studies have found the overall sexual function equivalent to or slightly lower than controls [257].

Rynja et al. **(2011)** [250] reported that hypospadias patients are as sexually active as controls, but are less satisfied with the penile appearance. They also less often have an intimate relationship compared to controls.

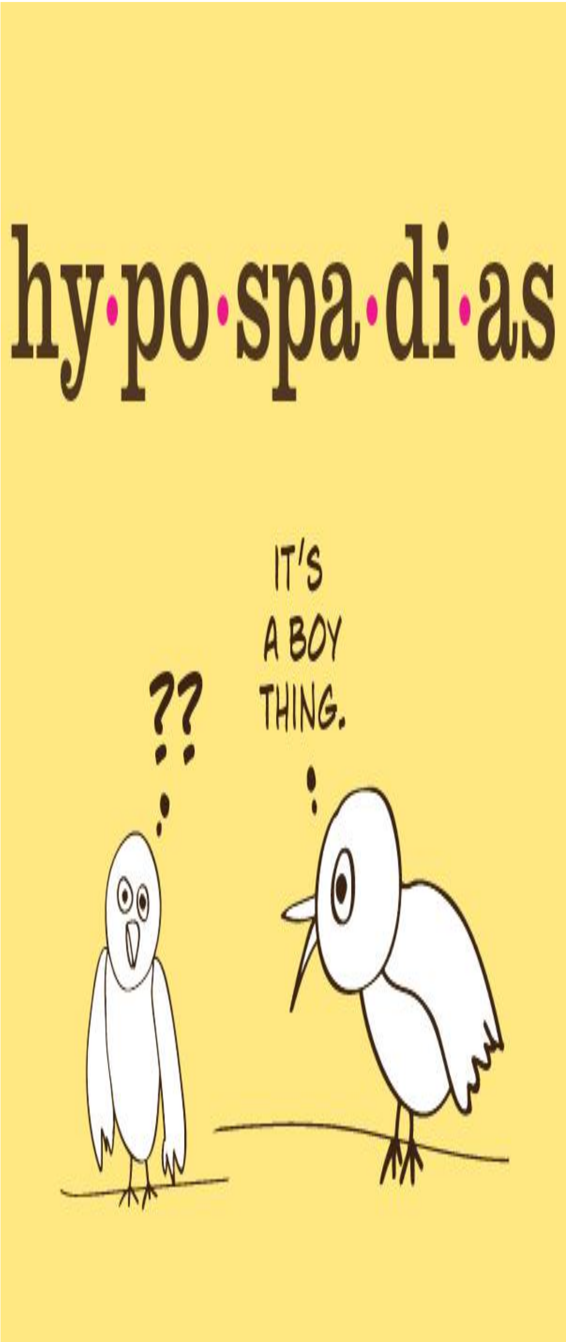
Most independent studies have agreed on the conclusion that there was a significant degree of **functional** and **social morbidity** after hypospadias surgery, probably reflecting patient **dissatisfaction** with the standard of repair.

The **success criteria** evaluated in *Our study* included a **straight penis** with a **slit-like meatus** located on the **tip** of an **acorn-shaped glans** with **single** and **forwardly directed** US of adequate **force** and **caliber**.

Taking into consideration the limitation of a **small number of patients** resulting from not being able to reach out to all 90 patients (**17.8%** were **unreachable**), the results of *Our study* align with aforementioned reports published in the literature and confirms that distal hypospadias repair using **both techniques** (Duplay and Koff) provide **quite equivalent acceptable cosmetic** and **functional results.**

However, in *Our series*, a more **natural apical meatus** was predominantly present with the **Koff** procedure, with a **lower UCF rate** and **better urinary** functional results.

These findings seem to be **very satisfactory**, and highlight the fact that with meticulous care, the cosmetic and functional end results with **Koff** procedure could be almost **indistinguishable from normal**. Thus, this technique deserves **homologation**.



CONCLUSION

"A man and his penis are one"

–William Granzig

Historically the hypospadias literature has been limited to case series involving descriptions of **new surgical techniques** and **surgeon experiences** resulting in **camps** loyal to one practice or another.

However, recently "hypospadiology" has been shifting toward a more **evidence-based approach**, which has allowed for a better understanding of surgical outcomes.

An **ideal** hypospadias repair is expected to have low complication rates, and resulting in a **normal penis** based on **appearance** and **function**.

The surgical management of anterior hypospadias depends on the **surgeon's custom** and is tailored to the child based upon **anatomical variations,** including meatal location, glanular size, and degree of chordee. However, most publications agree nowadays on **one-stage surgery.**

The ***Duplay*** procedure is suited for patients with a **wider urethral plate** that can be directly rolled up to complete the urethral formation.

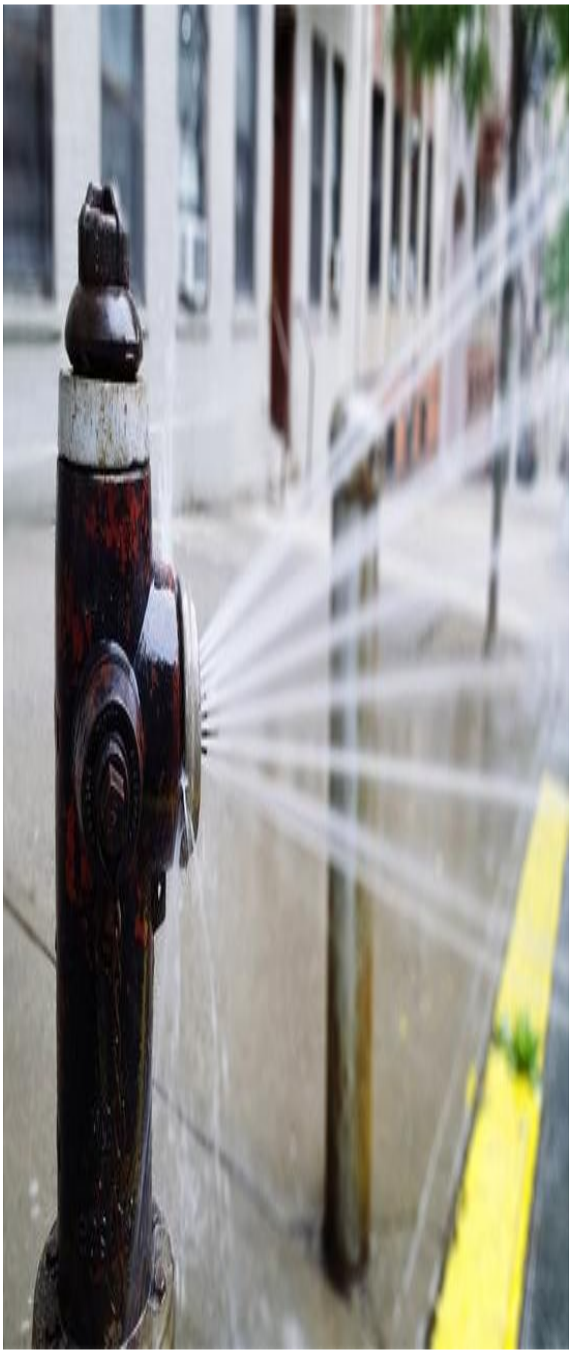
Whereas the ***Koff*** procedure is an alternative to creating a neourethra by **mobilization** and elongation of the existing urethra and **advancing** its meatus distally.

To date, it remains challenging to determine whether the reported **higher complication** rates are **correctly attributed** to the employed **surgical techniques** or if other important **confounding factors** and **selection bias** are at play.

Overall, *Our study* demonstrated that both techniques gave **comparable results** in terms of **Dehiscence.**

However, the **Koff** repair was found to have highly significantly **better** results regarding **UCF** and **MS** rates than Thiersch-Duplay repair.

Furthermore, more **natural apical meatus**, and **better urinary** functional results were predominantly present with the **Koff** procedure.



ABSTRACT

"Have no fear of perfection – you'll never reach it"

– Salvador Dali

Thesis title: Retrospective Comparative Study Between DUPLAY and KOFF Methods in Repair of Anterior Hypospadias (About 90 cases)

Protractor: Professor KHATTALA khalid

Author: FADELI Loubna

Category: Surgery

Number of pages: 299 **Number of figures**: 76 **Number of tables**: 40

Number of charts: 39 **Number of bibliographic entries**: 258

ABSTRACT

Perhaps no surgical concern in history has inspired such widespread and varied opinions with regard to management as has hypospadias. From the earliest recorded hypospadias description to the present, several hundred surgical approaches have been introduced, each with its own merits and demerits.

Hypospadias repair is a complicated surgery even in the best of hands. One-stage surgery is usually preferred for its multiple benefits. Nevertheless, concerns have been raised on the long-term cosmetic and functional outcomes. To date, there is a lack of consensus on which surgical technique offers more favorable postoperative outcomes.

The present work was undertaken to evaluate and compare the outcomes and complications rates of two single-stage techniques widely used to repair primary anterior hypospadias, namely **Thiersch-Duplay** Tubularized Plate Urethroplasty and **Koff** Urethral Mobilization and Advancement.

This study was carried out at our Department of Pediatric Surgery, at Hassan II University Hospital-Fez/Morocco, during a period of four years from January 2016 to December 2019.

Data from medical records of **90 patients** operated on for **primary anterior** hypospadias were **retrospectively** analyzed and **compared**. The patients were divided into **two groups**, **50** patients underwent **Thiersch-Duplay** procedure (**Group A**), and **40** patients underwent **KOFF** procedure (**Group B**).

We compared the two groups in terms of various **complications** and overall success rate, taking into account several **confounding factors**. Patients were called for follow-up on September 2020 to assess the **cosmetic** appearance, the **urinary stream**, and **UCF.**

The surgery was mostly performed on boys presented around the age of **2-5 years** with **distal penile** variety. All cases received **prophylactic antibiotics**, but none had a preoperative hormonal manipulation. Hemostasis was maintained using only a penile **tourniquet**, and all cases were **stented** for 5-7 days, but mostly discharged the next morning.

Neither intraoperative complications nor acute postoperative complications occurred. Whereas **37.8%** (**N=34/90**) cases have exhibited at least one late postoperative surgical **complication,** including **46%** (**N=23/50**) in **Group A** and **27.5%** (**N=11/40**) in **Group B**, revealing a **better** outcome of the **Koff procedure** despite the statistical insignificance (**p-value = 0.102**). We didn't objectify any other complication besides **Dehiscence, UCF,** and **MS.**

Complication rates were **not significantly correlated** with various confounding factors, such as age at repair, ectopic meatal location, surgeons qualification, anesthesia regime, suture materials and suturing techniques, and dressing type.

Both techniques gave **comparable results** in terms of **dehiscence [G.A: 24% N=12/50** vs. **G.B: 25% N=10/40 p-value = 0.913]** and **meatal stenosis [G.A: 8% N=4/50** vs. **G.B: 0% p-value = 0.067].**

However, the **Koff** repair was found to have highly **significantly better** results regarding **UCF** rate than Thiersch-Duplay repair **[G.B: 2.5% N=1/40** vs. **G.A: 26% N=12/50 p-value = 0.006]**.

The **cosmetic** and **functional** results were **satisfactory** in both techniques, but they were **better** in the **Koff** group **[G.B: 82.9% N=29/35** vs. **G.A: 76.9% N=30/39]** although statistical significance wasn't reached **(p-value = 0.575).**

A normal-looking apical meatus was found in **85.7% (N=30/35)** cases in **G.B**, compared to **79.5% (N=31/39)** cases in **G.A (p-value = 0.552)**. Urinary stream abnormalities were seen in **G.A** only **[7.7%; N=3/39].** All patients healed uneventfully, but **2.9% (N=1/35)** of the **G.B** patients who have a **UCF** compared to **17.9% (N=7/39)** of patients in **G.A (p-value = 0.059).**

Overall, our study could not demonstrate the superiority of one technique above another. At the same time, it established the versatility, satisfactory cosmetic and functional results, low MS and UCF rates of Koff urethral mobilization and advancement technique in primary anterior hypospadias repair.

To the best of our knowledge, there is no single procedure that is suitable for all patients. Only individualizing care through utilizing the surgical technique that one deems best suited for a given child could ensure excellent outcomes.

RESUME

Il parait qu'aucune préoccupation chirurgicale, dans l'Histoire, n'a suscité des controverses aussi répandues et variées en matière de la prise en charge que l'hypospadias. Depuis les premières descriptions enregistrées de l'hypospadias jusqu'à présent, des centaines d'approches chirurgicales ont été introduites, chacune avec ses propres avantages et inconvénients.

La réparation de l'hypospadias est une chirurgie très délicate et compliquée même entre les mains des meilleurs chirurgiens. La procédure chirurgicale en un seul temps est généralement préférée pour ses multiples bénéfices. Cependant, de nombreuses involutions ont été décrites quant aux résultats fonctionnels et esthétiques à long terme.

A ce jour, il ne s'est toutefois pas établi de consensus sur la technique chirurgicale idéale qui permet d'offrir les meilleurs résultats postopératoires.

Ce travail a été entrepris pour évaluer et comparer les résultats et les taux de complications entre deux techniques largement utilisées pour réparer l'hypospadias antérieur, à savoir l'urétroplastie selon **Duplay** et l'avancement urétral selon **Koff.**

Notre travail est **une étude rétrospective comparative**, étalée sur une période de 4 ans, du 1er Janvier 2016 jusqu'au fin Décembre 2019, portée sur 90 cas d'hypospadias pris en charge au sein du service de Chirurgie Pédiatrique au CHU Hassan II FES/ Maroc.

Le recueil des données a été réalisé via une recherche exhaustive dans les dossiers médicaux de **90 patients** opérés pour **hypospadias antérieur primaire.** Les patients ont été répartis en **deux groupes**, **50** patients ont subi la technique de **Thiersh-Duplay (groupe A)** tandis que **40** patients ont bénéficié de la technique de **koff (groupe B).**

Nous avons comparé les deux groupes en termes de **diverses complications** et du taux global de réussite, en tenant compte de plusieurs **facteurs de confusion.** Les patients ont été contacté en septembre 2020 pour un contrôle qui vise à évaluer **l'aspect esthétique, le flux urinaire et la FUC.**

La chirurgie a été principalement effectuée chez les garçons dont la tranche d'âge est entre **2-5 ans** avec une **variété pénienne distale.**

Tous les cas ont reçu une **antibioprophylaxie**, cependant aucun d'entre eux n'a eu une hormonothérapie préopératoire.

L'hémostase a été maintenue en utilisant uniquement **un garrot** pénien, et tous les cas ont été **cathétérisés** pendant 5 à 7 jours, néanmoins la majorité sont sortis le lendemain matin.

Il faut noter qu'aucune complication, qu'elle soit peropératoire ou postopératoire précoce n'a été enregistrée. Cependant **37.8% (N=34/90)** des cas ont présenté au moins une complication postopératoire tardive, dont **46% (N=23/50)** dans le **Groupe A** et **27.5% (N=11/40)** dans le **Groupe B,** révélant ainsi un meilleur résultat en faveur de la technique de **Koff**, malgré l'insignifiance statistique **(p = 0.102).** Nous n'avons toutefois objectivé aucune complication autre que **le lâchage**, la **FUC** et la **SM**.

Les taux de complications **n'étaient pas significativement attachés** aux divers facteurs de confusion, à savoir l'âge à la chirurgie, la localisation du méat ectopique, la compétence des chirurgiens, le type d'anesthésie, le matériel et les techniques de suture et le type de pansement.

Les deux techniques ont donné **des résultats comparables** en termes de **lâchage** **[G.A: 24% N=12/50** vs. **G.B: 25% N=10/40 p = 0.913]** et de **sténose du méat [G.A: 8% N=4/50** vs. **G.B: 0% p = 0.067].** Cependant, la réparation selon **Koff** s'est avérée avoir des résultats **nettement favorables** concernant le taux de **FUC** par rapport à Duplay **[G.B: 2.5% N=1/40** vs. **G.A: 26% N=12/50 p = 0.006].**

Les résultats esthétiques et fonctionnels ont été satisfaisants dans les deux techniques, mais ils étaient meilleurs dans le groupe de **Koff [G.B**: **82.9% N=29/35** vs. **G.A**: **76.9 % N=30/39]** bien que la signification statistique n'ait pas été atteinte **(p = 0.575).** Un méat apical d'aspect normal a été trouvé dans **85.7% (N=30/35)** du **G.B**, par rapport à **79.5% (N=31/39)** cas dans le **G.A (p = 0.552).**

Des anomalies du flux urinaire ont été observées dans le **G.A** seulement **[7.7%; N=3/39].** Tous les patients sont guéris sans incident, mais **2.9% (N=1/35)** des patients du **G.B** ont eu une **FUC** contre **17.9% (N=7/39)** des patients du **G.A (p = 0.059).**

En conclusion, notre étude n'a pas pu démontrer de supériorité d'une technique par rapport à l'autre, néanmoins, elle a pu établir des résultats esthétiques et fonctionnels satisfaisants **en faveur** de la technique de mobilisation/ avancement selon **Koff** ainsi qu'un faible taux de SM et de FUC.

Il faut également noter qu'il n'existe pas de procédure chirurgicale adaptée pour tous les patients, autrement, il fallait savoir individualiser les soins en choisissant la technique que l'on juge la plus adéquate pour chaque enfant.

ملخص

تعد جراحة المبال التحتي الأمامي من أبرز الجراحات التي أثارت جدالا واسع النطاق عبر التاريخ، إذ أنها عرفت، ومنذ أولى الحالات المسجلة حتى الآن العديد من الأساليب والتقنيات الجراحية، إلا أن لكل واحدة إيجابياتها وسلبياتها.

فمما لا شك فيه أن إصلاح المبال التحتي الأمامي يعد عملية دقيقة ومعقدة حتى بين أيدي أفضل الجراحين، وتعتبر طريقة "المرحلة الواحدة" الأ فضل بشكل عام لما لها من مزايا متعددة . لكنها مع ذلك، تعرف العديد من المساوئ في ما يخص النتائج الوظيفية والجمالية على المدى البعيد. وحتى الآن ، لا يوجد أي إجماع علمي بخصوص التقنية الجراحية المثلى القادرة على توفير نتائج مرضية بعد الجراحة.

نهدف من خلال هذا العمل الى تقييم ومقارنة النتائج ومعدل المضاعفات بين تقنيتين معتمدتين بشكل واسع لإصلاح المبال التحتي الأمامي، وهما على التوالي طريقة دوبلاي (رأب الاحليل)، وطريقة كوف (تقدم مجرى البول).

هذا العمل هو عبارة عن دراسة مقارنة بأثر رجعي ، امتدت خلال 4 سنوات ، من أول يناير 2016 إلى نهاية دجنبر2019، حول 90 حالة من المبال التحتي الأمامي تم علاجها في قسم جراحة الأطفال بالمستشفى الجامعي الحسن الثاني بفاس/ المغرب. تم جمع البيانات من خلال بحث شامل في السجلات الطبية لـ 90 مريضًا أجريت لهم عملية جراحية للمبال التحتي الامامي، بعد ذلك تم تقسيم المرضى إلى مجموعتين، بحيث خضع 50 مريضًا منهم لتقنية دوبلاي (المجموعة أ) في حين خضع 40 مريضًا لتقنية كوف (المجموعة ب).

قمنا بمقارنة المجموعتين من حيث المضاعفات المختلفة ومعدل النجاح الإجمالي ، مع الأخذ بعين الاعتبار العديد من العوامل المؤثرة. في سبتمبر 2020، تم الاتصال بالمرضى من أجل المتابعة و تقييم النتائج المتعلقة بالمظهر الجمالي تدفق البول، والنواسير.

معظم العمليات الجراحية أجريت على الاطفال الذين تتراوح أعمارهم بين 2-5 سنوات والذين صماخهم يتواجد على مستوى الجزء الامامي من جسم القضيب. تلقت جميع الحالات العلاج الوقائي بالمضادات الحيوية، ولكن لم يخضع أي منهم للعلاج الهرموني قبل الجراحة. ومن أجل ضمان الإرقاء استخدمت مرقاة على قاعدة القضيب، وتمت قسطرة جميع الحالات لمدة 5-7 أيام، و سرح أغلبهم صباح اليوم التالي.

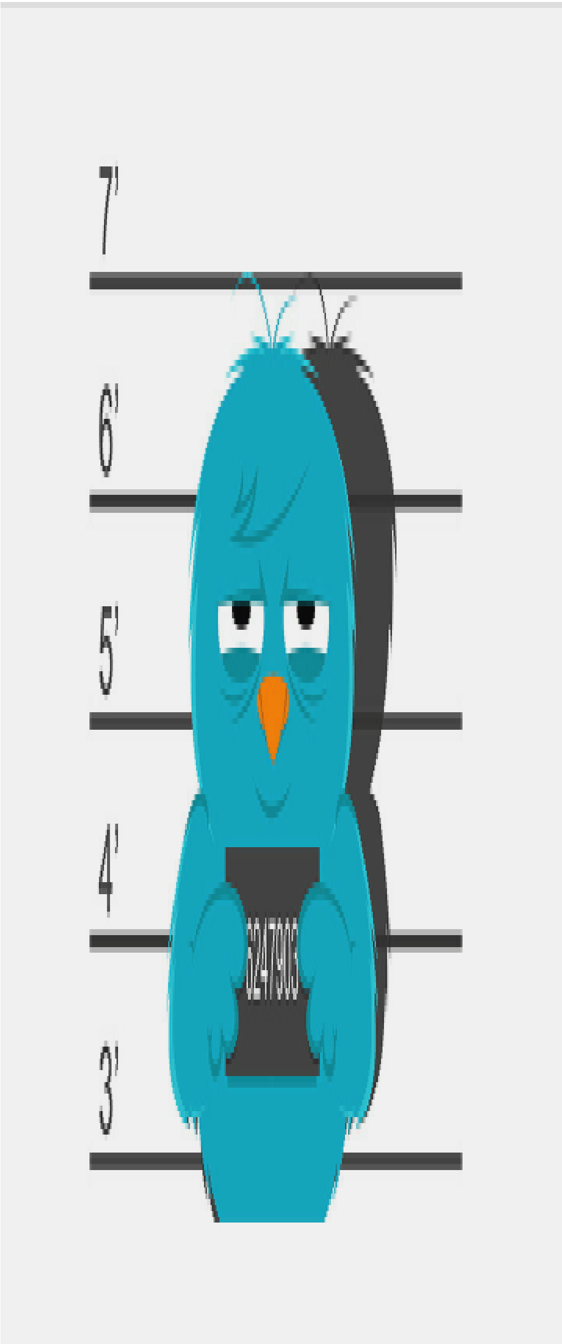
وتجدر الإشارة إلى أنه لم يتم تسجيل أية مضاعفات مبكرة، سواء أثناء الجراحة أو بعدها. الا ان 37.8 % (N= 90/34) من الحالات عرفت على الأقل مضاعفة متأخرة واحدة بعد العملية منها 46% (N= 50/ 23) في المجموعة (أ) و% 27.5 (N= 40/11) في المجموعة (ب) مما يدل على نتيجة أفضل لصالح تقنية كوف على الرغم من عدم وجود دلالة إحصائية (p=102 ,0). بالإضافة إلى أنه لم يتم تسجيل أية مضاعفات أخرى بمحاذاة التفزر، النواسير و تضيق الصماخ. كما أن معدلات المضاعفات لم تكن مرتبطة بشكل كبير بالعوامل المؤثرة على اختلافها، مثل العمر عند الإصلاح، وموقع الصماخ المنزاح، كفاءة الجراحين، نوع التخدير، مواد وتقنيات الخياطة، ونوع الضماد.

كلتا الطريقتين أسفرت عن نتائج مماثلة من حيث التفزر[م أ :% 24 (N= 50/12) مقابل م ب : 25 % (p=913 ,0) (N = 40/10)]، تضيق الصماخ [م أ :% 8 (N= 50/4) مقابل م ب : % 0 (p=067 ,0)]، في حين حققت تقنية كوف نتائج جيدة بشكل ملحوظ فيما يتعلق بالنواسير مقارنة مع دوبلاي [م ب :% 2,5 (N= 40/1) مقابل م أ: %26 (N= 50/12) (p=006 ,0)]

كانت النتائج الجمالية والوظيفية مرضية في كلتا التقنيتين، لكنها كانت أفضل في مجموعة كوف [م ب :82,9% (N= 29/35) مقابل م أ: %76,9 (N= 39/30)] على الرغم من عدم الوصول الى الدلالة الاحصائية (p=575 ,0). تم الحصول على صماخ قمي طبيعي المظهر بنسبة % 85.7 (N= 35/30) في المجموعة (ب) مقابل %79,5 (N= 39/31) في المجموعة (أ) (p =552 ,0). كما لوحظ وجود شذوذ في التدفق البولي في المجموعة (أ) فقط [7.7% ؛ N= 3/39].جميع المرضى تم شفاؤهم بشكل طبيعي إلا أن % 2,9 (N= 35/1) من مرضى المجموعة (ب) عرفوا ظهور نواسير مقارنة مع % 17,9 من مرضى المجموعة (أ) (p=059 ,0).

في الختام، لم تستطع دراستنا إثبات تفوق إحدى التقنيتين على الأخرى، لكن في الوقت نفسه، تمكنت من ابراز وجود نتائج مرضية اكثر لصالح تقنية كوف على المستوى الجمالي، الوظيفي وانخفاض نسبة تضيق الصماخ و النواسير.

كما تجدر الاشارة إلى أنه، لا يوجد إجراء واحد مناسب لجميع المرضى، إذ يبقى نهج الطابع الفردي في الرعاية الصحية، من خلال استخدام التقنية الجراحية التي تعتبر الأنسب لكل طفل على حدة، السبيل الأفضل من أجل ضمان نتائج ممتازة.



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-Thomas Carruthers

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[258] “Photos taken in our Pediatric Surgery Department. CHU HASSAN II-FEZ.”

Six little monkeys jumping on the bed,

One fell off and bumped his head,

So Mama called the Surgeon and the Surgeon said,

Don't worry mam I can put him together again;

The brilliant Surgeon waved his magic wand,

The injured little monkey was Divinely repaired.

Royaume du Maroc المملكة المغربية

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Université Sidi Mohamed Ben Abdellah

كلية الطب والصيدلة
ⵜⴰⵙⴷⴰⵡⵉⵜ ⵏ ⵜⵎⵓⵙⵙⵏⵉ ⴷ ⵜⵎⵙⵙⵉⵍⵜ
FACULTÉ DE MÉDECINE ET DE PHARMACIE

سنـــة 2021 أطروحة رقم 21/190

دراسة مقارنة بأثر رجعي بين تقنية دوبلاي وكوف في جراحة المبال التحتي الأمامي

(بصدد 90 حالة)

الأطروحة

قدمت و نوقشت علانية يوم 2021/05/28

من طرف

الآنسة فضيلي لبنى

المزداد في 1994/10/16 بخنيفرة

لنيل شهادة الدكتوراه في الطب

الكلمات الأساسية

المبال التحتي الأمامي - دوبلاي - كوف - مضاعفات

اللجنة

السيد يوسف بوعبد الله.. الرئيس
أستاذ في جراحة الأطفال

السيد خاليد ختالة.. المشرف
أستاذ في جراحة الأطفال

السيدة سناء أبورزاق.. الأعضاء
أستاذة في علم أمراض الأطفال

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