CLASSIFICATION AND EVALUATION OF HYPOSPADIAS: REVIEW ARTICLE

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Abstract:
A standard grading system of hypospadias is important for family counseling, surgical planning, and self/peer assessment of results and complications. Anatomical classifications based on meatal location have been commonly used as an indicator. Classification after chordee release and using the division level of corpus spongiosum are important recent contributions. Duckett classified hypospadias according to meatal location after release of curvature into anterior, middle, and posterior hypospadias. Orkiszewski used pubic bones as a reference. GMS Score scaled the anomaly based on the properties of Glans, location of Meatus, and degree of Chordee. The Hypospadias International Society (HIS) recommends the MCGU Score incorporating Meatal location, Chordee, Glans size, and the Urethral plate quality.

Keywords: Hypospadias**,** HIS, GMS.

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Introduction:

Hypospadias is one of the most common congenital anomalies in boys, occurring in 1 in 150 to 300 live births (**1, 2**).

Many hypotheses have been proposed regarding the etiology of hypospadias, including genetic predisposition, inadequate hormonal stimulation prenatally, maternal-placental factors, and environmental factors. Thus, it seems possible that the etiology of hypospadias is multifactorial (**3**).

Risk factors include preterm birth and intrauterine growth restriction have been associated with an increased risk for having a newborn with hypospadias (**4, 5**).

Familial predisposition is seen in hypospadias, with 7% of cases having affected first-, second-, or third-degree relatives. The chance that a male sibling of an affected boy will have a hypospadias is 9–17%. Hypospadias is equally transmitted through the maternal and paternal sides of the family, with an estimated heritability of 57–77 % (**6**). In only 30% of hypospadias is a clear genetic cause found (**7**). Hypospadias have been described in over 200 syndromes. The two most well-known are the Wilms' tumor, aniridia, genitourinary malformations, and mental retardation (WAGR) and the Denys-Drash syndrome (genitourinary malformations and susceptibility to Wilms' tumor) (**8**).

Most hypospadias occurs as an isolated condition but can associated with anomalies as uni/bilateral cryptorchidism and micropenis suggesting a deficiency of hormonal influences during embryogenesis. Androgens and estrogens both play a critical role in genital development, and in case of imbalance, different entities can be seen within the spectrum of congenital penile anomalies like hypospadias, micropenis, and ambiguous genitalia (**9**).

Cryptorchidism is found in approximately 7% of patients with hypospadias. This increases to nearly 10% with more proximal hypospadias (**10**). The concern for DSD is particularly high in a boy with hypospadias and a nonpalpable testis (**11**).

Classification of Hypospadias:

This condition is characterized by proximal displacement of the urethral opening, ventral penile curvature, and a ventrally deficient hooded foreskin (**3**).

The location of the urethral meatus can be within the glans, at the corona, the shaft of the penis, the scrotum, or the perineum. Several patients with hypospadias also have Bifid Scrotum, penoscrotal transposition or small penis. Hypospadias has impacts on both urinary and sexual function (**12).**

This classification system can be misleading, as some variants of distal hypospadias are associated with proximal spongiosal hypoplasia and penile curvature, which may require a more involved surgical reconstruction, while some apparent severe cases of proximal hypospadias present less of a surgical challenge when favorable anatomy is present (**13**).

So, Meatal position alone is a very crude way to classify severity of hypospadias and does not take into account the degree of tissue dysplasia. Factors such as size of the penis, size of glans and urethral plate, level of division of the corpus spongiosum, presence of a curvature, and anomalies and position of the scrotum also have a significant influence on the outcome of surgical correction. Therefore, a definite classification can only be completed during surgery (**14).**

Proximal penile, penoscrotal and scrotal types represent 20% of all cases. It is a significant surgical challenge to achieve cosmetically and functionally acceptable outcomes in these patients (**15**).

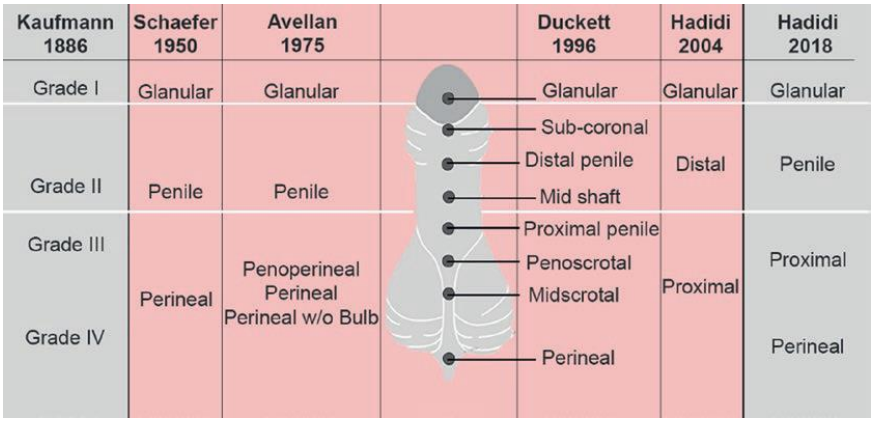

Fig1: Different classifications of hypospadias, according to location of meatus. (Quoted From: Ahmed T. Hadidi, Classification and Assesment of Hypospadias; HypospadiasSurgery an Illustrated Guide, Ahmed T. Hadidi· Amir F. Azmy (Eds.), 2004; Ch9, 239).

Embryology and Anatomy of Urethera and Prepuce:

The mechanism of urethral development is debated. In 1954 Glenister proposed the "ectodermal ingrowth theory," in which the stratified squamous lining of the glanular urethra originates independently via retrograde ectodermal margin with the endodermal penile urethral plate, which is forming simultaneously as a result of antegrade fusion of the urethral folds (**16**). Alternatively, another evidence supports an entirely endodermal origin for the urethra, as the urethral plate formation is contiguous from the penile urethra into the glans and undergoes differentiation to form the stratified squamous layer (**17**).

External genital development occurs in two phases, a hormone-independent phase and a hormone-dependent stage, beginning at the eighth week of gestation. Expression of the sex-determining region of *Y* chromosome (SRY) gene product between 7 and 8 weeks of gestation results in masculinization of the undifferentiated gonad, testosterone production, regression of female structures, and elongation of the genital tubercle (**18**). Androgen receptors have been localized to the penile skin, inner prepuce, urethra, and stromal cells of the corpus spongiosum during the early gestation period, suggesting a major role for androgens in urethral development (**19**).

Prepuce development coincides with and is dependent on normal urethral development. At approximately 8 weeks of gestation, preputial folds first appear on the distal penile shaft at the base of the corona(**16**).

These folds first fuse dorsally, then with further penile growth, join ventrally to envelop the developing glans. This process is limited by the developing urethra. Ventral fusion is not completed until the urethral folds fuse, typically around 20 weeks of gestational age (**18**).

Based on the predominant morphology characteristics and abnormalities the analyzed prepuces was classified into 6 groups of A-"monk's hood" or "1 humped" (43 cases, 24.7%), B-"cobra eyes" (80, 45.9%), C-"normal" (intact) (4, 2.3%), D-"flat" (24, 13.8%), E-"v"-shaped (16, 9.2%), and F-"collar-scarf" (7, 4.0%). Cobra eyes and monk's hood prepuces had the most **favorable** vascular pattern for the creation of flaps, the prepuces while the "flat" and "v"-shaped prepuces had the most **unfavorable** vascular pattern (**20**).

The blood supply of the penile skin is symmetrical (**21**). The superior and inferior external pudendal arteries arise from the femoral artery. They are attached to the Scarpa fascia, which extends to the base of the penis. At this point they divide into four branches as superficial penile arteries. Two enter the superficial penile fascia (Colle's fascia) dorsolaterally and two enter it ventrolaterally. Numerous collaterals between these four arteries create a fine subcutaneous arterial plexus up to the preputial ring **(22)**.

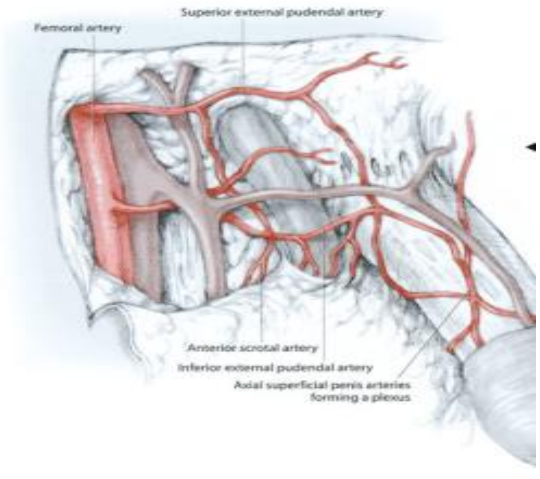

Fig 2: Arterial blood supply of the penile skin and prepuce. (Quoted From: Zacharias Zachariou. Blood Supply of the Penile Skin; HypospadiasSurgery an Illustrated Guide, Ahmed T. Hadidi· Amir F. Azmy (Eds.), 2004; 73-77).

Behind the sulcus in the distal part of the penile shaft, small vessels penetrate the Buck's fascia, making an anastomosis with the dorsal penile artery. Beyond the preputial ring on the inner surface the terminal branches become minute. Variations of the superficial penile arteries are possible with dominance of one side pair. The blood supply to the frenulum is also symmetrical and arises from the dorsal penile artery, which branches at the level of the sulcus with small

arteries that curve around each side of the distal shaft to enter the glans and the frenulum ventrally (***23)***

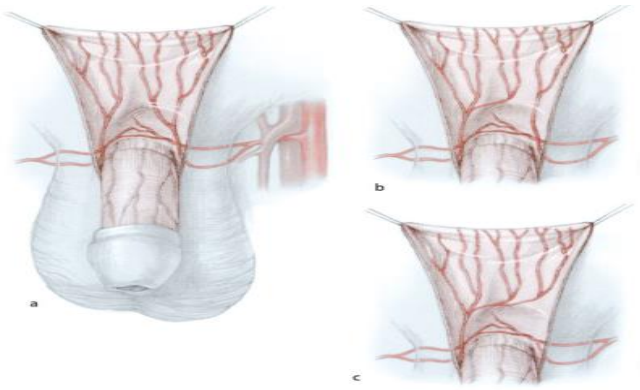

Fig 3: End arteries to the prepuce: anormal blood supply, equal distribution from both sides; b, c dominant right-sided distribution. (Quoted From: Zacharias Zachariou. Blood Supply of the Penile Skin; Hypospadias Surgery an Illustrated Guide, Ahmed T. Hadidi· Amir F. Azmy (Eds.), 2004; 73-77).

The arterial supply of the prepuce origins from the dorsal aspect of the penis, and the minute arteries supplying the outer prepuce layer fold by 180˚ to terminate at the corona. The reason is that the prepuce must form a one-layer skin sheet during erection and the terminal vessels become straightened when erection and preputial retraction begin. When erection terminates the prepuce vessels loop back upon themselves, terminating at the corona and not at the preputial ring (**24*).***
So, an incision along the coronal sulcus would not damage the arterial supply of the prepuce in any way as the vessels terminate at this site. The inner layer of the prepuce can be dissected without jeopardizing the vascular pedicle (***23).***

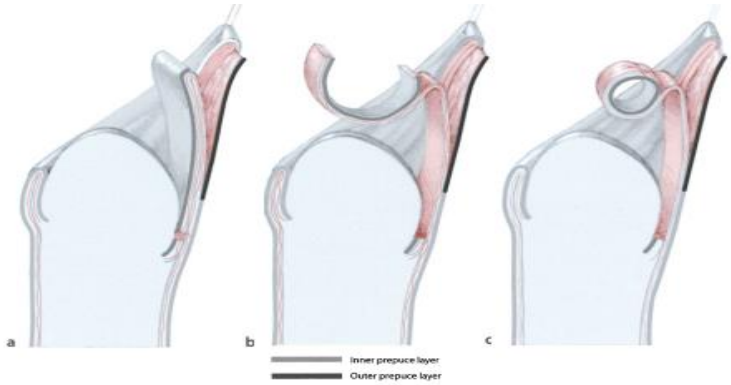

Fig4: Incisions for pedicle flaps with intact vascular blood supply: a incision at the coronal sulcus where the vessels terminate; b dissection of the inner and outer layer of the prepuce with intact vascular supply; c neo urethra from the inner prepuce layer and well-vascularised outer prepuce layer to cover the defect. (Quoted From: *Zacharias Zachariou.* Blood Supply of the Penile Skin; Hypospadias Surgery *an Illustrated Guide,* Ahmed T. Hadidi· Amir F. Azmy (Eds.), 2004; 73-77).

Variations of the superficial penile arteries are possible with dominance of one side pair. Marty et al distinguished 3 main patterns of vascularization of the penile shaft skin. Both inferior external pudendal arteries supply the skin of the penile shaft, but one is dominant Based on the transillumination technique, 4 types of preputial vascularization in normal boys were defined: - One artery predominant (41.67%), 2 arteries predominant (25%), H-type (12.5%) and netlike (no predominant artery) (20.83%). (***25).***

Venous drainage of the prepuce is less well organized. Multiple small veins in the prepuce without a particular orientation join the superficial dorsal veins and drain into the saphenous vein. Superficial venous drainage occurs through several veins that course in the dartos fascia along the dorsolateral, lateral, and/or ventrolateral aspect of

the penis. These vessels unite at the base of the penis to form a superficial dorsal vein. Drainage of the latter is usually into the left saphenous vein, but communication with the deep dorsal vein of the penis may sometimes occur. (***25).***

Preoperative Evaluation of Hypospadias:

The initial diagnosis of hypospadias is made after birth during physical exam, when boys are found to have a ventral skin deficiency with a dorsal hood of foreskin and an abnormally located meatus with varying degrees of ventral penile curvature (**13**).

The preoperative physical examination should assess severity, which will guide surgical planning. The assessment includes the degree of penile curvature, the location of the urethral meatus, the quality of the urethral plate, and the quality of penile skin for reconstruction (**26**).

The main aspect in its diagnosis is the abnormal position of the ventral urethral meatus, and to many, this position is related to complexity of the case and the type of repair chosen; but in fact, there are other associated morphological aberrations that should be taken into consideration when considering repair. Common meatal positions are distal penile 70%, mid-penile 10%, and proximal types 20 % **(27).**

Fig5: severity of Hypospadias (left to Right);subcronal, midshaft, penoscrotal and Perineal (Quoted from Keays MA, Dave S. Current hypospadias management: Diagnosis, surgical management, and long-term patient-centred outcomes. *Can Urol Assoc J*. 2017;11(1-2Suppl1): S48-S53).

The **GMS** score (glans meatus and penile shaft [curvature]) incorporates physical examination findings in the operating room, assessing the quality of the glans and urethral plate, the location of the urethral meatus, and the degree of penile curvature, to objectively assign scores to stratify severity. Indeed, higher GMS scores correlate with an increased risk of developing a complication (**26, 28**).

Glans (G) Score:
1. Glans good size; healthy urethral plate, deeply grooved
2. Glans adequate size; adequate urethral plate, grooved
3. Glans small in size; urethral plate narrow, some fibrosis or flat
4. Glans very small; urethral plate indistinct, very narrow or flat
Meatus (M) Score:
1. Glanular
2. Coronal sulcus
3. Mid or distal shaft
4. Proximal shaft, penoscrotal
Shaft (S) Score:
1. No chordee
2. Mild (<30°) chordee
3. Moderate (30–60°) chordee
4. Severe (>60°) chordee

Fig6: The glans meatus and penile shaft (GMS) score is assessed at the time of the procedure. (Quoted

From Merriman LS: The GMS hypospadias score. *J Pediatr Urol* 9:707–712, 2013).
The Scientific Committee of the Hypospadias International Society (HIS) including the author, Mark Zaontz, Luis Braga, Antonio Macedo, Ibrahim Ulman, Grahame Smith, and Chris Long have shared their experience to develop the **Hypospadias International Score** as a base to be used and to modify it whenever needed.

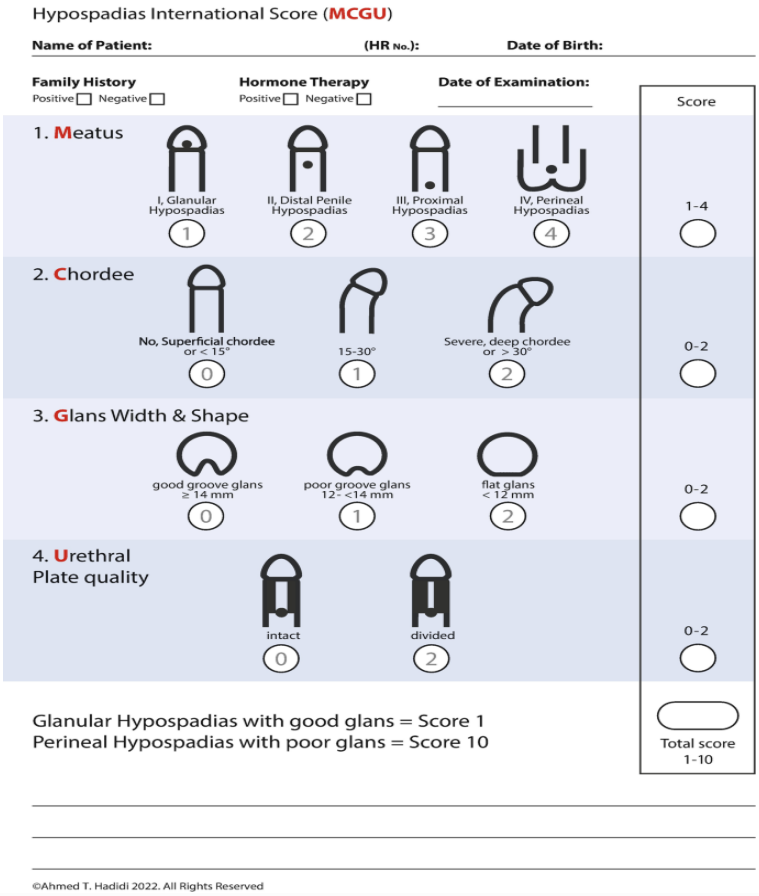

Figure 7: The MCGU Score that gives an idea of the difficulty of the hypospadias and the possibility of complications.

The most common anomalies associated with hypospadias are inguinal hernia and/or hydrocele ranging from 9% to 16%, but no increased incidence is noted with severity of hypospadias (**10**).
Proximal hypospadias occurs in 10% to 25% of patients and has several unique management challenges to the surgeon (**39, 30**). Especially due to Associated abnormalities that encompass a large spectrum, including ventral curvature (VC) up to 50 degrees or more, ventral skin deficiency, a flattened glans, penile torsion and penoscrotal transposition (**31**).
Physical examination may note dysplastic ventral tissue in boys with hypospadias. Anatomic studies have shown worsened curvature and shorter penile length in boys with proximal hypospadias. Ultrasonic elastography studies have found less elastic tissue and androgen resistance in boys with proximal hypospadias, suggesting more dysplastic tissue, which not only causes penile curvature but can also complicate surgical reconstruction (**32-34**).
Those with a nonpalpable testis (es), either unilateral or bilateral, had a threefold increased risk for having an underlying DSD diagnosis identified (approximately 50% vs. 15%). There was a significantly increased risk of DSD with

proximal hypospadias compared with distal hypospadias (64% vs. 7%) (**11**). In these cases, referral to an endocrinologist for a full genetic and hormonal evaluation is warranted (**3**).
In proximal and complex hypospadias, further diagnostic evaluation is advised, such as ultrasonography of the urinary tract and internal genital organs to detect other nephrourological malformations (**30**). A Müllerian remnant (utricular cyst or dilated utriculus) is seen in 11–14% of all hypospadias and up to 50% of perineal hypospadias (**35**).

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