COMPARISON OF SNODGRASS VERSUS SNODGRAFT TECHNIQUES FOR DISTAL PENILE HYPOSPADIAS REPAIR - A PROSPECTIVE STUDY

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DOI: https://doi.org/10.5281/zenodo.13626239

INTRODUCTION

Hypospadias is a development abnormality of anterior urethra and penis in which urethral opening is located in the ventral of penis proximal to the tip of glans penis, any where up to perineum.[1]

The penis is more likely to have associated ventral shortening and curvature, called chordee and an abnormal distribution of Foreskin with a hood present dorsally and deficient foreskin ventrally.[2]

This abnormally is present in approximately 1 in 300 live birth male new borns and may be an isolated anomaly or a phenotypical component of a complex state known as intersex.[3]

The goals of treating Hypospadias are: —

1. To create a straight penis by repairing any chordee (orthoplasty)
2. To create a urethra with its meatus at the tip of the penis (urethroplasty)
3. To reform the glans into a more natural clinical configuration (glanuloplasty).[4]
4. To achieve cosmetically acceptable penile skincoverage.
5. To create a normal appearing scrotum.

The resulting penis should be suitable for future sexual intercourse, should enable the patient to void standing, and should present an acceptable cosmetic appearance.

Based on above principles and according to most common classification various methods commonly used now a days are: —

1. Anterior Hypospadias:
a. Tubularized incised urethral plate.
b. Meatal advancement and glanuloplasty.

2. Middle Hypospadias:

a. Tubularized incised urethral plate,

b. Transverse inner prepurcial tube urethroplasty.

c. On lay island flap of transverse prepucial skin,

d. Bracka's two stage repair.

3. Posterior Hypospadias:

a. Transverse inner prepucial tube urethroplasty.

b. Bracka's two stage repair.

A modification of the Thiersch-Duplay Technique[5] wasdescribed by Snodgrass.[6] The Tubularized Incised Plate (TIP) Urethroplasty Combines modifications of the previously described technique of urethral plate incision and tubularization.

The onlay island flap initially described for distal and mid shaft repairs (Elder et a!36 1987) has been increasingly employed for repair of more severe hypospadias as well as for proximal repairs as in middle hypospadias.

The onlay-tube-onlay urethroplasty technique a variation of the onlay principle that comprises a central tubularized and distal and proximal onlay components has been described based on the same strip of penile shaft and preputial skin (harvested in longitudinal orientation) or prepucial skin above (harvested transversely).

AIMS AND OBJECTIVE

1. To evaluate the outcome of snodgrass technique in distalhypospadias repair.

2. To evaluate the outcome of snodgraft technique in distalhypospadias repair.

3. To compare the outcome of snodgrass versus snodgraft techniquein distal hypospadias repair.

REVIEW OF LITERATURE

Hypospadias means atypical placement of the urethral meatus, which is ectopically located on the ventrum of the penis. Hypospadias may convey a range of abnormalities involving abnormal development of the corpora spongiosum. In more severe forms of the disease, the corpora spongiosum is absent resulting a perineal urethral opening (Moosa and AL-hallak, 2020). Proximal to the ectopic meatus there is a segment of hypoplastic urethra that is not surrounded by any spongiosum. The corpus spongiosum division marks the proximal limit of the malformation (Renaux-Petel *et al.,* 2019).

In addition to abnormal meatal location, the classic presenting triad of hypospadias includes ventral curvature (chordee) and abnormal prepuce with excessive redundant skin hood on the dorsal penis (Nurhadi and Saputra, 2018).

Hypospadias is one of the oldest diseases described in the practice of medicine, it was first documented by Galen of Pergamon, the well- known physician of Roman emperors and gladiators in the second centurywho gave the condition its name (Maitra *et al.,* 2019).

Since this initial description of the condition, hypospadias management has been the focus of a myriad of surgeons and till today there have been over 400 described operations for hypospadias repair together with thousands of publications. The anomaly continues to pose a challenge and there is a learning curve for every surgeon (Hadidi, 2017).

Hypospadias is the second most common congenital anomaly ofthe genitourinary system after undescended testes and it is the common estcongenital malformation of the penis (Van der Horst and De Wall, 2017).

The international incidence is 1 per 200 to 300 live male births per year (Shah *et al.,* 2018). Up to 70% of the detected cases are mild, where the urethral opening lies close to its normal location and just below the glans (distal hypospadias) (Cripps *et al.,* 2019).

Unfortunately, hypospadias etiology in the majority of patientsremains unknown. Genetic and environmental factors are the main susceptibilities (Chang *et al.,* 2020). Several other factors such as advanced maternal age, maternal obesity, premature delivery in addition to low-birth-weight babies and twins have all been observed to have a higher risk of occurrence of hypospadias (Chen *et al.,* 2018).

Although hypospadias is not life threatening, it can result in functional abnormalities with urination, intercourse and sperm deposition (Van der Horst, 2017). Therefore, the main goals of management include reconstruction of the urethra with placement of the meatus at the tip ofthe glans to allow proper urinary stream as well as correction of the penile curvature to minimize sexual dysfunction and achievement of acceptable cosmetic results to reduce the psychosocial burden on the affected individual (Chan *et al.,* 2020).

TIP repair was first introduced in 1994 and it has revolutionized the management of hypospadias. It has many advantages such as better cosmesis, meatus at the tip of the penis and straight phallus. It is considered the procedure of choice in management of distal hypospadias by many surgeons (Zain, 2017). Rational of the technique is to perform an incision in the urethral plate to permit tension-free tubularization of the neourethra that later on undergoes healing (Keays and Dave, 2017).

However, the mechanism of healing of the incised plate is still debatable and many authors believe that it heals by epithelial creeping, which theoretically increases the incidence of complications because of healing by primary intention if allowed to contract (Salah *et al.,* 2019).

Kolon and Gonzales published a new technique of one-stage urethroplasty with a dorsal inlay graft using inner preputial skin (GTIP)in 2000 (Abbas, 2018). They predicted the effectiveness of GTIP because the neourethra is not left with a large denuded surface that allows for possible scar formation. With insertion of a free preputial graft, the urethral plate could be preserved in an attempt to improve healing of the neourethra after TIP urethroplasty (Kishk *et al.,* 2018).

HISTORICAL REVIEW

The first account of hypospadias surgery was written by **HELIODORUS AND ANTYLLUS (100 to 200 AD)**. The repair consisted of amputation of the penile shaft distal to existing meatus. **GALEN** described this anomaly some time in second century. **PAULAS**of **AEGINETA (625-690 AD)** suggested penile amputation distal to the existing meatus.

DIEFFENBACH (1836) pierced the glans to the normal urethral meatus, allowing a cannula to remain in position until the channel became lined with epithelium – an unsuccessful procedure.

The first successful repair was reported in **1842 BY METTAUER**, from Virginia. He also suggested correction of chordee by use of subcutaneous incisions in succession until the organ is liberated.

BOUISSON (1861) first suggested a transverse incision at the point of greatest curvature for release of chordee. He also reported the use of scrotal tissue to reconstruct the urethra.

In **1869, THIERSCH**[7] described the use of local tissue flaps to repair epispadias, a technique he later used in hypospadias. He suggested performing perineal urinary diversion to divert urine temporarily away from the urethral reconstruction.

Three famous French surgeons, **DUPLAY (1880), OMBREDANNE (1923) AND NOVE JOSSERAND (1919)** made the first contributions to hypospadias repair.

DUPLAY was the first to recommend opening the skin of the penis to excise completely the tissues causing chordee as a preliminary operation. To repair the urethra he made parallel incisions on the ventral penile skin from urethra to glans. **MODIFYING THEIRSCH's**[8] procedure he made a tube of the outlined skin by partially undermining and sewing it over a catheter. Later, he found that a smaller median strip of skin could be used if the lateral edges of this median strip were undermined, partially elevated and sutured around a catheter. He demonstrated the principle that a strip of buried skin would continue to grow until a canal had been formed by growth of the lateral skin edges.
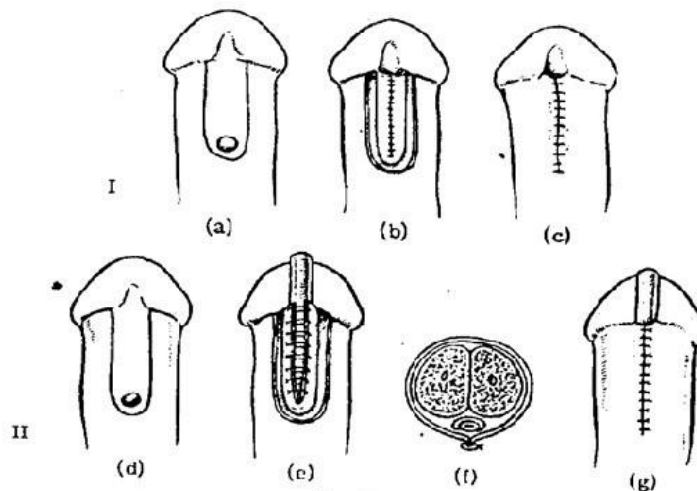

Fig. 1: The two techniques Duplay.

(I) Modification of Thiersch's procedure

(a) Flap of skin outlined

(b) Tube formed

(c) Skin coverage.

(II) Second technique – (d, e, f, g) Epithelial growth of the buried skin allowed a complete tube to form

In **1923, OMBREDANNE** recommended a distally based flap at the urethral meatus, brought forward with a purse-string suture to the tip of the penis (Fig. 2). He also recommended a buttonhole type of preputial hood flap to transfer the prepuce to the ventral penile surface.

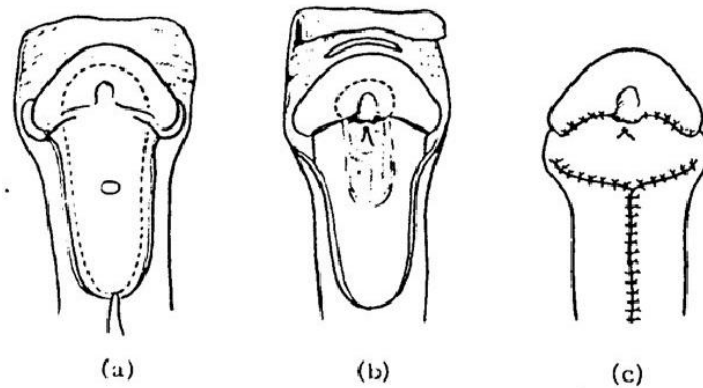This preputial flap was later modified and popularized by Nesbit.

Fig. 2: Technique of Ombredanne.

(a) A purse string suture is sewn around the edges of the flap andinto the glans.

(b) Purse string pulled forming a baggy tube.

(c) Covered with perforated preputial hood.

The use of free split thickness skin grafts to reconstruct the urethra was proposed by **NOVE-JOSSERAND IN 1919** (Fig. 3). Because split-thickness skin grafts contract, many strictures have resulted from this surgery and therefore many other urethral substitutes were tried. Bladder mucosa, vein grafts and the appendix have all been tried at one time or another for urethral reconstructionand have fallen into disrepute.
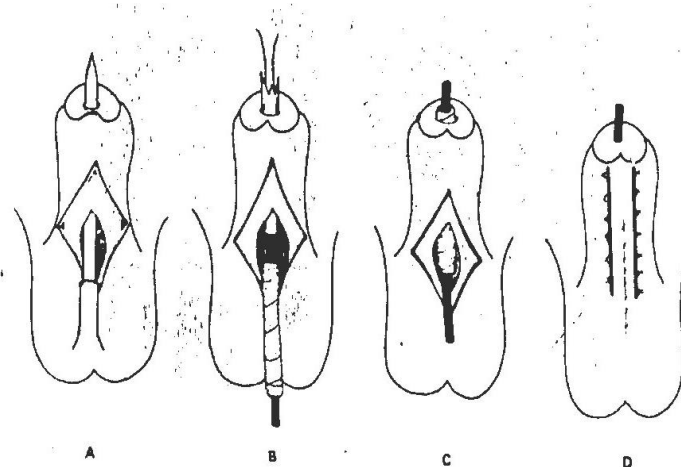

Fig. 3: Nove-Josserand was the first surgeon to report attempts torepair hypospadias with a free split thickness Graft.

Numerous surgical techniques have been described. **BACKUS (1960)** found over 150 techniques of hypospadias surgery. More have been added since then. Till date, over 200 reported original methods have been found (Campbell). Modern techniques usually stem frommodifications of older operations.

These techniques may be classified as multistaged or one-stage procedures and can be divided into those using only penile skin, those using penile and scrotal skin and those using free grafts in the repairs.
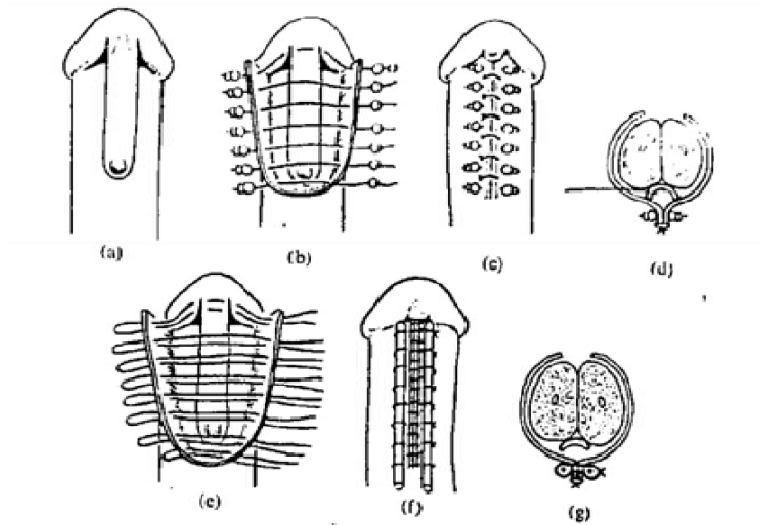
MULTI-STAGE

(i) SIR DENIS BROWN (1949)

Fig. 4: Denis Browne Technique.

(a) After chordee release incision outlining skin from urethra to glans.

(b) Lateral margins elevated and after incision on dorsum of the penis mobilized for closure over skin strip. Wire sutures used as tension sutures.

(c) Sutures secured with glass beads.

(d) Crushed metal sleeve used to allow adequate space for edema.

(e, f, g) Culp modification by mattress sutures tied over rubber bolsters.
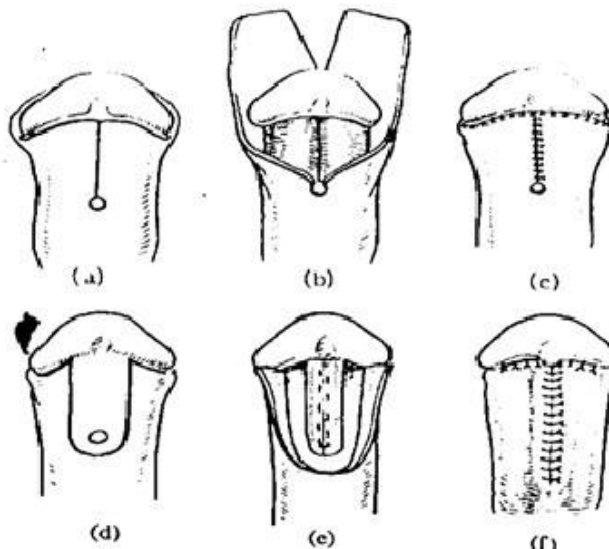
(II) BYARS (1955)

Fig. 5: Byars Technique.

(a) Incision.

(b) Chordee resected Prepuce unfolded and incision given in midline.

(c) Flap brought to ventrum.

(d) Later stage: Central flap incised to form new urethra.

(e) Lateral skin edges undermined after new tube formed.

(f) Multilayer closure.

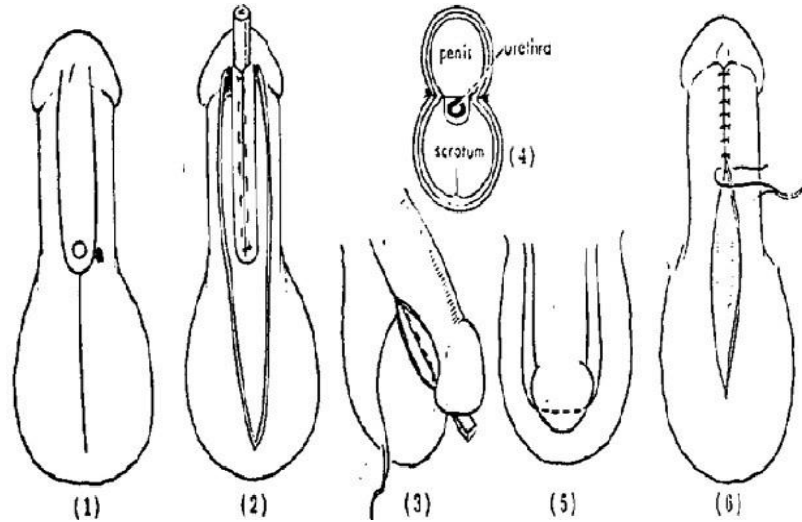## (III) THE CECIL OPERATION AS MODIFIED BY DR. ORMONDCULP

Fig. 6: Cecil-Culp Technique.

(1) After preliminary penile straightening 'U' shaped incision given around meatus to glans and continued proximally to scrotum for a distance equal to penile length.

(2) Tube found with penile skin flap with continuous suture andedges of penile skin and scrotal skin undermined.

(3),(4) Penis sutured to scrotum in two layers: scrotal subcutaneous tissue to tunica albuginea of corpora cavernosa, penile skin to scrotal skin.

(5) 2-3 months later, scrotal skin incised and penis freed

(6) Defectclosed

PATHOLOGICAL ANATOMY

In the usual case of hypospadias, the penis of the newborn is of normal size and is curved ventrally by a dense band of fibrous tissue which extends from the abnormality situated meatus of the urethra distally to the glans. This fibrous tissue may be the result of anomalous development of the structures which would have surrounded the normal urethra - the corpus spongiosum, buck's fascia and dartos fascia **(HORTON AND DEVINE, 1979)**[9] (Fig. 9).

The fibrous tissue extends forward from the end of the normal corpus spongiosum, surrounds the urethra and inserts distally into the under surface of the glans, equal to the width of the ventral defect in the prepuce. Occasionally there may be hypoplasia of the penis.
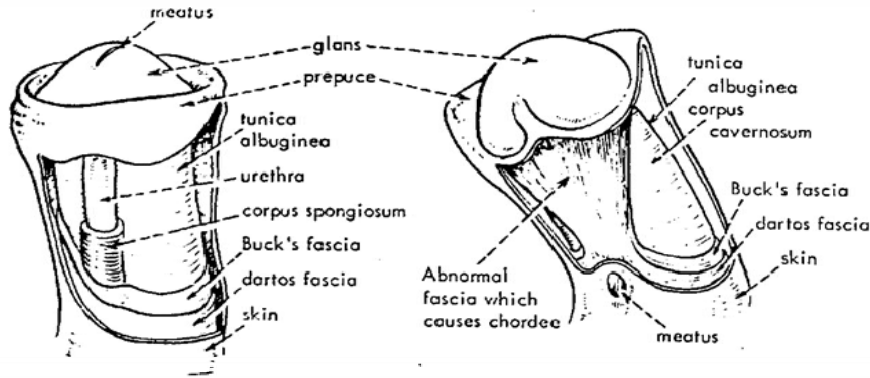
Fig. 10: Anatomy of the normal penis and penis with hypospadias.In hypospadias, the normal structures – urethra, corpus spongiosum, Buck's fascia and dartos fascia are replaced by the fan shaped fibrous band which holds the penis in chordee.

The meatus may be small and dilatation or meatotomy soon after birth may be necessary to allow normal micturation.

In some instances the urethra will end in the midshaft of the penis yet a small mucosal tract may extend form the distal end in a blind pouch. This is the remnant of the lacunum magnum and not incomplete development of the glanular urethra.

Occasionally the penis may be twisted and the raphe which is normally situated in the ventral midline may be extended to one side or other of the shaft. The scrotum may extend superiorly around the base of the penis (anterior scrotum), or in the case of scrotal or perineal hypospadias will be cleft in the midline.

The glans will usually be indented at the fossa navicularis simulating a normal urethral opening at the tip. Rarely a congenital urethral fistula may be present in association with hypospadias. Associated anomalies include undescended testis, renal anomalies, hernia, small genitalia, bladder neck deformities and ambiguous genitalia. The diagnosis of intersex must be ruled out in more severe forms of hypospadias, especially in those with cryptorchidism **(RAJFER AND WALSH, 1976).[10]**

ETIOLOGY

The multifactorial etiology of hypospadias is becoming more defined with ongoing investigation. Implicated factors include testosterone biosynthesis defects, 5-alpha-reductase type 2 mutations, androgen receptor mutations (rare), in vitro fertilization (progesterone administration or endocrine abnormalities associated with infertility) and environmental agents that can disrupt the male sex hormone axis(Silver RI, 1999, 2000).

A maternal vegetarian diet rich in phytoestrogens in pregnancy has been shown to be associated with hypospadias (North K, 2000).

Familial tendencies indicate some polygenic factors. Fathers of 8% of patients have hypospadias. 14% of male siblings are affected (Bauer et al, 1981).[11] The condition is more common in whites than in blacks and in Italians and Jews than in other groups **(WELCH, 1979).** The higher incidence (8.5 times higher) in monozygotic twins **(ROBERTS AND LLOYD, 1973)[12]** may be explained by the demand of two fetuses on the placental production of human chorionic gonadotropin (hCG) in the first trimester.

More specifically, the defects of the hypospadias anomaly may result from (i) abnormal androgen production by the fetal testis (ii) limited androgen sensitivity in the target tissues of the developing external genitalia and/or (iii) premature cessation of androgenic stimulation secondary to premature involution of leydig cells of the fetal testis **(DEVINE AND HORTON, 1977).**[9]

Several endocrinopathic/enzymatic factors have been identified in humans and in animal models of hypospadias. It has been observed that genotypic male infants born with a severe deficiency of 3β- hydroxysteroid dehydrogenase enzyme (a microsomal enzyme essential in biosynthesis of almost every biologically active steroid hormone) have incomplete masculine development and hypospadias **(GOLDMAN AND BONGIOVANNI, 1967).**

Allen and Griffin (1984)[13] evaluated 15 boys with 'advanced degrees' of hypospadias for an endocrinopathy. Six different endocrine-related abnormalities were identified in 11 boys. According to **Allen and Griffin (1984)**, the most striking finding was the poor testosterone response to injections of human chorionic gonadotropin (hCG), observed in seven patients. In most cases, this improved or normalized with time, suggesting that hypospadias is a local manifestation of an endocrinopathy rather than a local dysmorphic problem, and that one major cause may be a delay in maturation of the hypothalamic- pituitary-testicular axis.

The hypothesis of an **'ARREST OF DEVELOPMENT'** as noted by **Mettauer (1942) and Van Hook (1896)** would seem the most plausible explanation for hypospadias. Although this theory does not identify a possible specific cause of the arrested development, it would account for the concomitant occurrence of all 3 typical characteristics of hypospadias – penile curvature, hypospadiac meatus, and deficient foreskin.

Baskin (2000) proposed that future areas of study, such as endocrine disruptors, mesenchymal epithelial interactions and mechanisms of penile growth, may hold the key to explaining the etiology of hypospadias. He showed that disruption of fibroblast growth factor 10 (FGF 10) gene results in hypospadias.

CLASSIFICATION

The most commonly used classification of hypospadias **(Browne, 1936)**[14] is based on the location of the meatus (Glanular, distal penile, proximal penile, penoscrotal junction and perineal). However, the severity of hypospadias cannot always be defined by the original site of the meatus. **Barcat (1973).**[15] proposed a classification based not on the original site but on the new location after correction of the associated curvature (orthoplasty).

Barcat's Classification (1973)

(a) Anterior hypospadias (50%)

(i) Glanular

(ii) Coronal

(iii) Anterior penile – in distal third of the shaft

(b) Middle hypospadias (20%) – meatus in middle third of the shaft.

(c) Posterior hypospadias (30%)

(i) Posterior penile – meatus in posterior third of shaft

(ii) Penoscrotal

(iii) Scrotal

(iv) Perineal

Duckett (1992)[16] classified hypospadias as shown in the figurebelow which is similar to **Barcat's** classification.
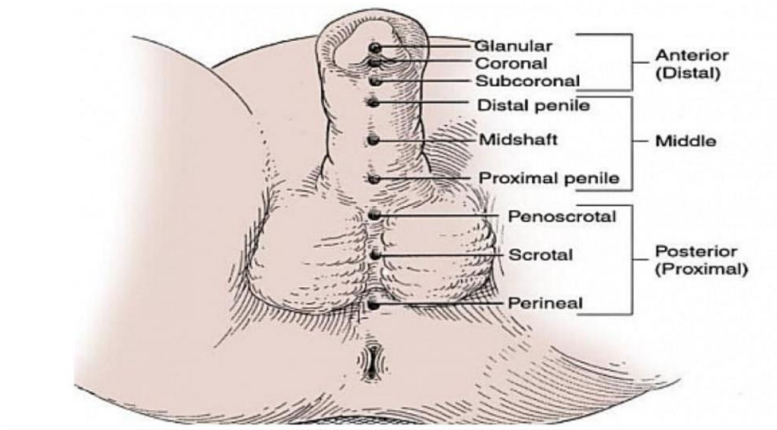

Fig. 11: Anatomically descriptive classification of hypospadias based on level of meatus following orthoplasty Recently Mouriquand et al (1995) have come forth with apractical classification of hypospadias.

(a) Glanular hypospadias: Meatus is distal to corona and there isusually no chordee.

(b) Anterior hypospadias with no chordee: Meatus is at any positionbetween corona and midshaft.

(c) All other hypospadias with chordee.

(d) Hypospadias cripple.

General Principles in Treatment of Hypospadias

As regards the timing of operation, the growth of the child and particularly of the penis should be evaluated at intervals until the organis large enough to undergo the delicate surgery required to correct the condition.

A committee of the section on urology of the **American Academy of Pediatrics (1975)** concluded "psychological consideration suggests that the optimal timing for elective surgery on the genitalia is either the first 6 months of life or sometimes during the fourth year. Technical considerations have greatest bearing on timing, but depending on the individual surgeon the precise time varies".

Schultz and colleagues (1983) pointed out that an ideal time for hypospadias repair might be 6 to 18 months to minimize the emotional effect of the trauma of maternal child separation. The advantages of improved optical magnification have made surgical correction at the earlier age more successful.

Duckett and Baskin (1996)[17] prefer to do the surgery between 3- 9 months and believe that penis size is sufficient by that age.

Criteria of successful hypospadias repair are:

(1) The chordee should be completely relieved so that the penis isunrestricted in erection.

(2) The urethra should be brought to the tip of penis.

(3) A solid stream of urine should flow from the urethra onmicturition with no splattering, splashing or backflow.

(4) The external surface of the penis should be symmetrical and noabnormal tissue tags or fistulas should be present.

(5) Normal sexual functions of the penis should be possible.

Commonly used tissues to form urethral tube in hypospadias repair

1.   Local tissue: Penile skin or glandular tissue

−   MAGPI

−   Mathieu

−   Snodgross

−   Thiersh Duplay

2.   Preputial skin flaps   –   Asopas

                              –   Ducketts

3.   Grafts

•   Skin grafts   –   Full thickness

−   Hairy   -   Scrotum

                        -        Abdomen

−   Non hairy   -   Prepuce

−   Split thickness

•   Grafts from other tissues

−   Buccal mucosa

−   Bladder mucosa

COMMONLY DONE PROCEDURES IN HYPOSPADIAS REPAIR

•   **ANTERIOR TYPE**

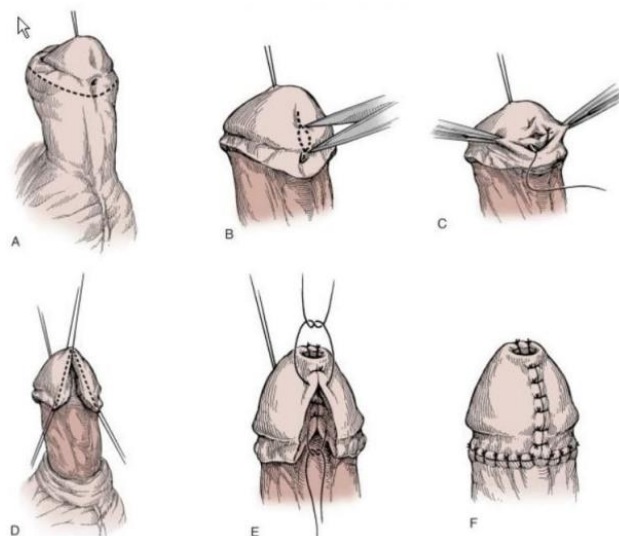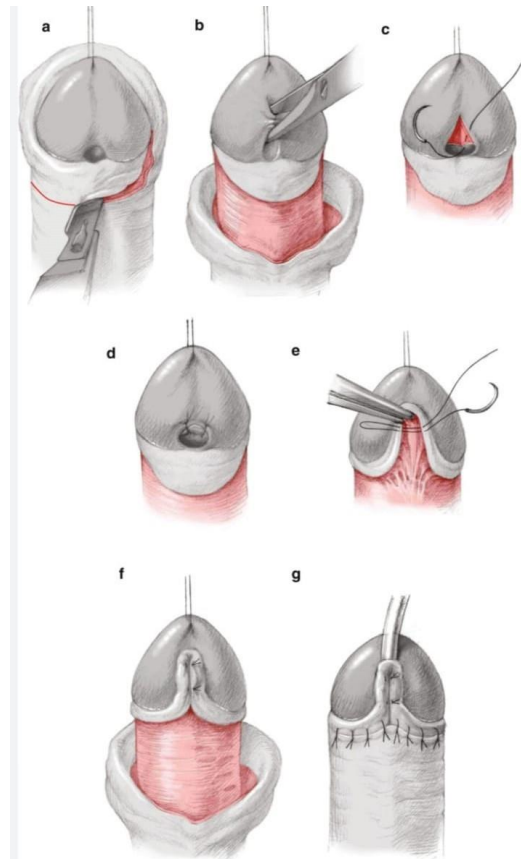1)   **MAGPI (Duckett, 1981b, Duckett and Snyder, 1992)[16]**

Fig. 12: Meatal advancement by glandulo preputial incorporation (MAGPI).

(A) Circumferential subcoronal incision.

(B) Longitudinal incision.

(C) Transverse approximation of transverse Glanular "bridge" inurethral plate.

(D) Ventral edge of meatus pulled distally and medial glans "trimming" incision marked.

(E) Deep suture glans approximation.

(F) Superficial approximation of glans and skin.

It was developed to correct a meatus which defects the stream downward, using a distal bridge and a prominent glans groove. With this technique the bridge is divided and meatus is advanced into the granular groove. Ventral meatal edge is elevated forward and the glans tissue is brought around the ventrum into the midline. Pre-requisite for application of this technique is a mobile urethra failing which urethral mobilization cannot be achieved. It is indicated for coronal or glandularhypospadias without chordee or with only skin chordee.

Duckett (1992)[16] reported 1111 MAGPI's with 1.2% cases requiring secondary procedures.

A review of 100 MAGPI cases reported by **Park et al (1995).**[18] showed an excellent cosmetic and parental satisfaction score with the MAGPI procedure.

2) Arap Modification of MAGPI

Arap et al (1984)[19] have slightly modified the MAGPI procedure to improve the cosmetic appearance. The Arap repair advances two flaps of lateral coronal tissue distally, approximating them in the midline, effectively lengthening the urethra. The glans is then closed over this tissue, normalizing its ventral appearance.

3)   Perimeatal based flap (Mathieu's procedure)

In 1932, Mathieu[20] described this technique of advancing a ventral adjacent skin flap into the Glanular groove with parallel suture line. It is still widely used and offers excellent results (Fig. 13a, b).
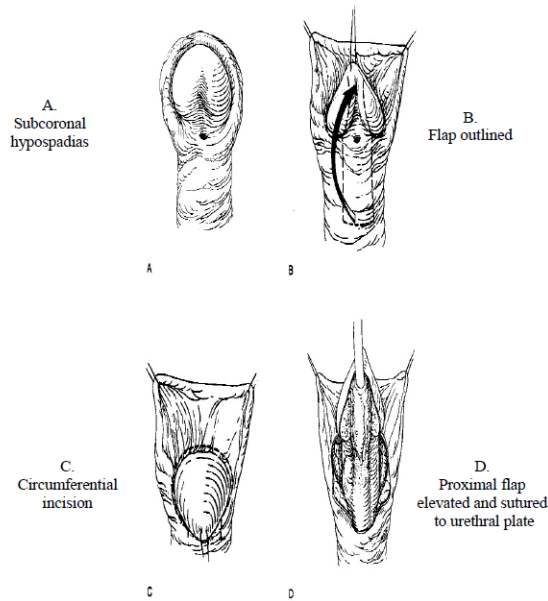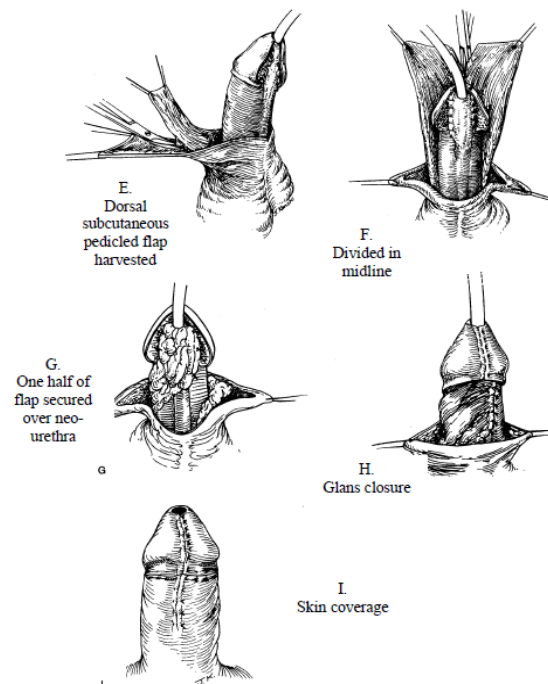

Fig. 13a: Mathieu's Repair.

Fig. 13b: Mathieu's repair.

4)   Tubularized incised plate (Snodgross, 1994)

A modification of the Thiersch-Duplay technique was described by Snodgross[6] The Tubularized incised plate (TIP) urethroplasty combines modifications of the previously described techniques of urethral plate incision and tubularization.

TIP urethroplasty involves

(a) A longitudinal midline incision of the urethral plate from the tip of the penis to, as necessary, the level of the hypospadiac meatus (Fig. 14a (C)). The depth of the urethral plate incision depends primarily on the configuration of the glans and the Glanular groove. The urethral plate is then Tubularized over a No. 7 Fr catheter (Fig. 14b (E)).
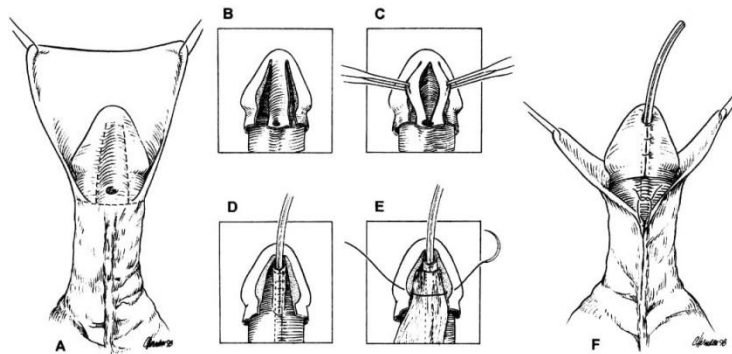

Fig.- : Tubularized incised plate urethroplasty. (A) Horizontal line indicates circumscribing incision to deglove penis. Ventral lines demark junction of urethral plate to glans wings. (B) Urethral plate is separated from glans wings but is too narrow for tubularization. (C) Midline relaxing incision of urethra! plate is made from within the meatus to its distal extent to widen and deepen the plate. (D) Urethral plate is tubularized over 6F stent. (E) Dartos pedicle covers the neourethra. (F) Clans wings, mucosal collar, and ventral shaft are closed.
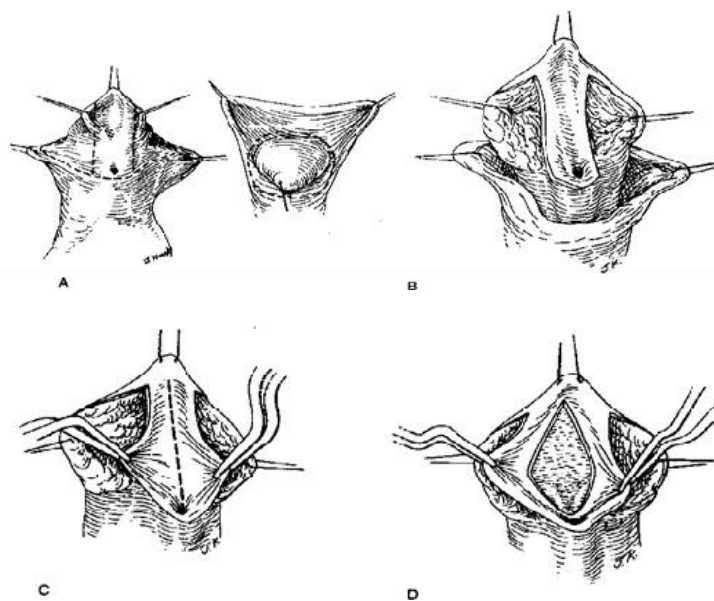
Fig. 14a: Tubularized incised plate (TIP) urethroplasty.

(b) Fashioning of a wide meatus

(c) Second layer coverage of the neourethra with a well-vascularizedsubcutaneous (dartos) tissue flap, harvested from the dorsal preputial and shaft skin (Fig. 14b (F)). For more proximal repairs,a tunica vaginalis flap may be used for this purpose. The glans wings are then approximated without tension (Fig. 14b (G)).

This technique results in a normally appearing penis with a 'slit- like' vertically oriented meatus.
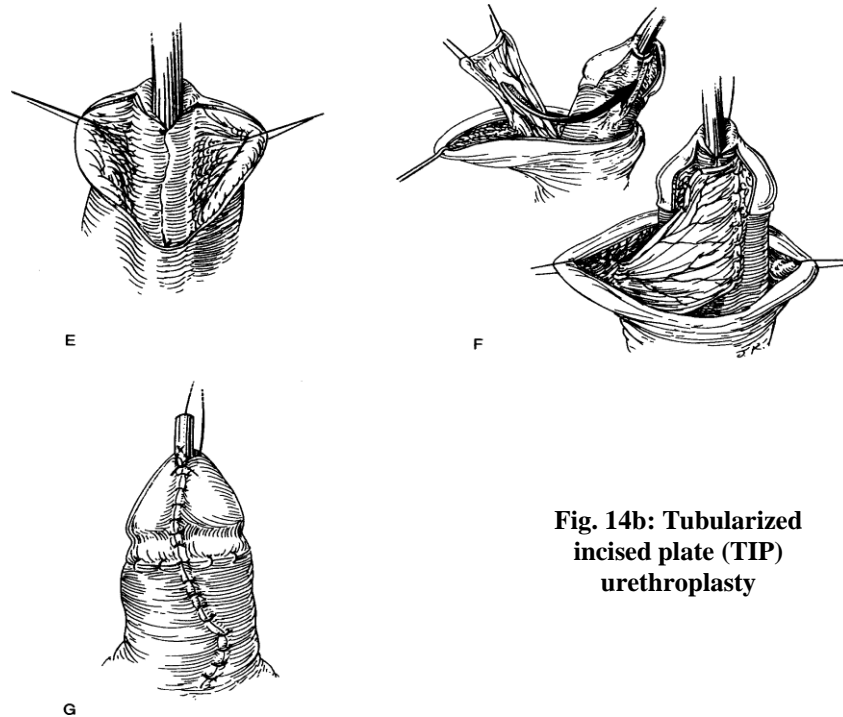
Fig. 14b: Tubularized incised plate (TIP) urethroplasty

- **DISTAL PENILE HYPOSPADIAS**

1) **Island Onlay Flap (Elder and Duckett 1987)[21]**

This technique shows excellent results with 5-6% complication rate even with more proximal meatus. It involves creation of the deficient ventral urethral wall from vascularized transverse preputial onlay flap form inner prepuce. Urethral plate is preserved with U- shaped incision around the meatus, skin and dartos fascia are dissected from the shaft, removing fibrous tissue beside the urethral plate.

Chordee, if still present is corrected by Tunica albuginea plication (**TAP- Baskin and Duckett et al, 1994).[17]**

A.
Proposed incision

B.
Pedicled preputial skin onlay

C.   Full thickness suture approximation   D.
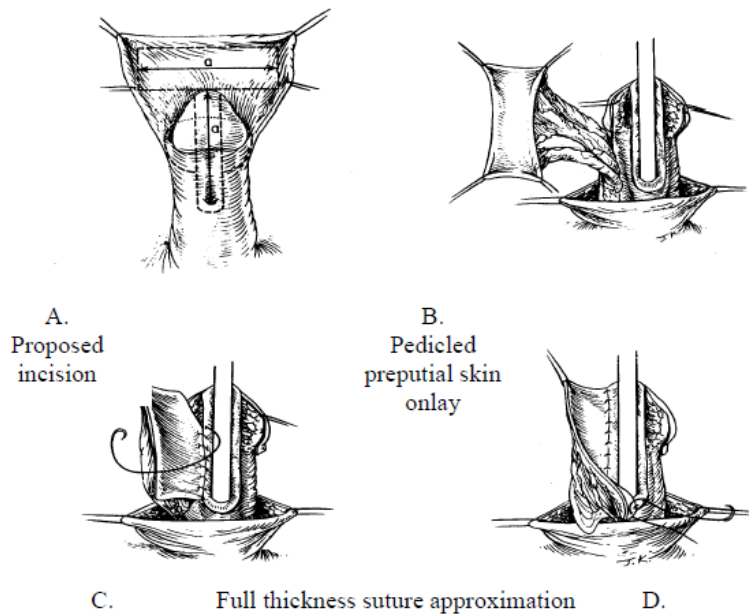
Fig. 15a: Onlay island flap repair.
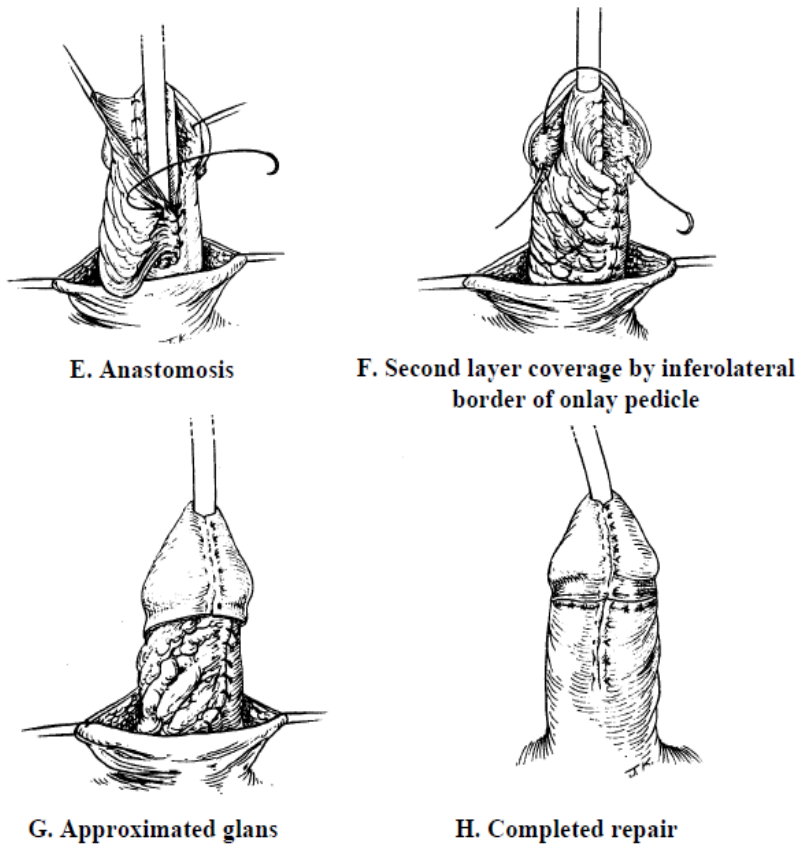
Fig. 15b: Onlay island flap repair.

Fig. 15b: Onlay island flap repair.

2) Mustarde Procedure

This technique popularized by **Mustarde (1965)** involves tubularization of proximal parameatal based flap to construct the neourethra which is then brought through the glans tunnel and sutured to the glans. The main draw backs are distal meatal stenosis and chances of compromise of viability of pedicle flap as it passes through the glans channel.

- **MID SHAFT AND PROXIMAL PENILE HYPOSPADIAS**

1. Adjacent skin flaps

It involves construction of neo urethra by tubularization of skin adjacent to meatus in long axis of penile shaft.

2. Asopa's

In 1971, Asopa and colleagues[22] described use of preputial skin for formation of a Tubularized neo urethra transferred to the ventrum for hypospadias repair as a single unit, with the inner prepuce as the Tubularized neo urethra and the attached outer prepuce for skin cover.

Fig. 16: Modified Asopa's repair (A) Transverse preputial island flap and Degloving of penis (B) Tubularization (C) Lateral incisions (D & E) Rotation of neourethra along with skin around penis, glans channeling and penoscrotal incision (F) Skin coverage.
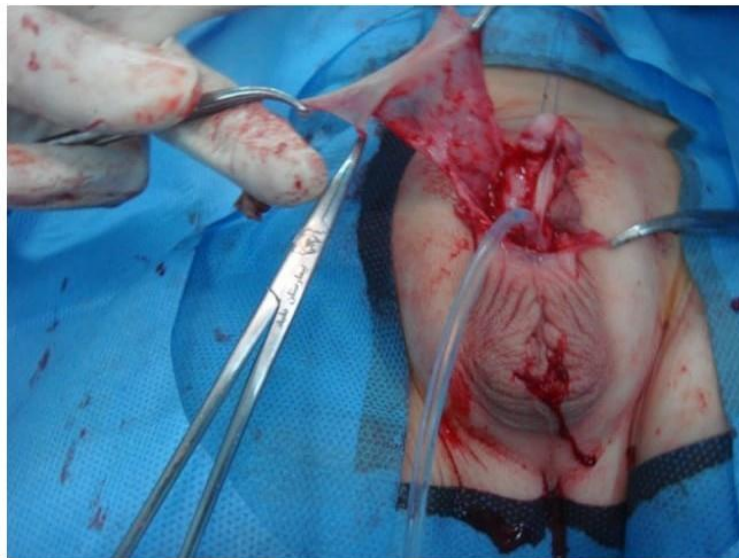
3. Duckett's (transverse preputial island flap – TPIF)

TPIF employs preputial skin for formation of a Tubularized neo urethra transferred to the ventrum for hypospadias repair as separate components of the repair: inner prepuce with its vascular pedicle for the neourethra, separated from and followed by transfer of the longitudinally split outer prepuce as skin cover.
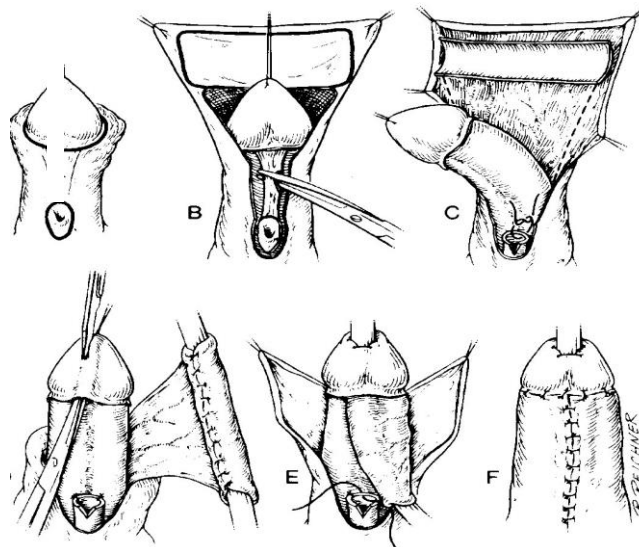
Fig. 17: Duckett's repair (TPIF) (A) Incision, (B) Release of tethering urethral plate (C) Harvested transverse preputial island flap (D) Tubularization around catheter and glans channeling (E) Anastomosis of native urethrato neourethra after fixation of native urethra to corpora cavernosa (F) Skin coverage.
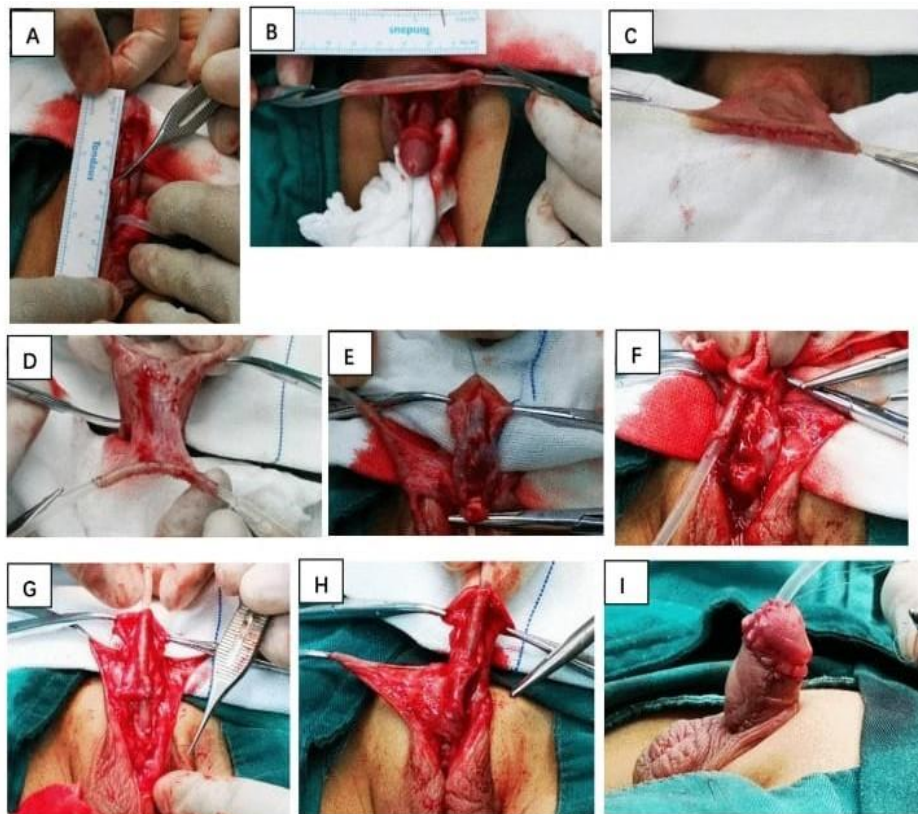
Fig.: Modified Duckett's repair.

GRAFT

Graft is tissue that has been excised and transferred to a graft host bed where a new blood supply develops (neo vascularization). Flap is tissue that is excised and transferred with the blood supply either preserved or surgically re-established at the recipient site.

'Take' is the process whereby graft tissue develops a new blood supply after excision and transfer to a host bed. Take occurs in 2 phases that together requires 96 hours. The initial phase known as imbibition takes 48 hours. During imbibition the graft temperature is less than body temperature and the graft survives by drinking nutrients from the adjacent graft host bed. The second phase, termed inosculation, also requires 48 hours. During inosculation the temperature of the graft risesto the core body temperature and true microcirculation is reestablished in the graft. The process of take is influenced by both the nature of the grafted tissue and the conditions of the graft host bed, thus processesthat interfere with graft host bed vascularity or the vascular characteristics of the graft itself interfere with graft take.

Four grafts commonly used for urethral reconstruction are the

1. Split thickness skin graft
2. Full-thickness skin graft
3. Bladder epithelial graft
4. Buccal mucosal graft

Fig. 18: Graft levels (A) Skin (B) Bladder wall (C) Buccal mucosa.

SPLIT THICKNESS GRAFT (STG)

It carries the epidermis or covering and exposes the superficial dermal (intradermal or intralaminar) plexus (Fig. 18A). The superficial plexus is generally composed of small but numerous vessels, a favourable vascular characteristic, STG also carries few lymphatics and physical characteristics of the transferred tissue and thus has a tendency to be little and less durable.
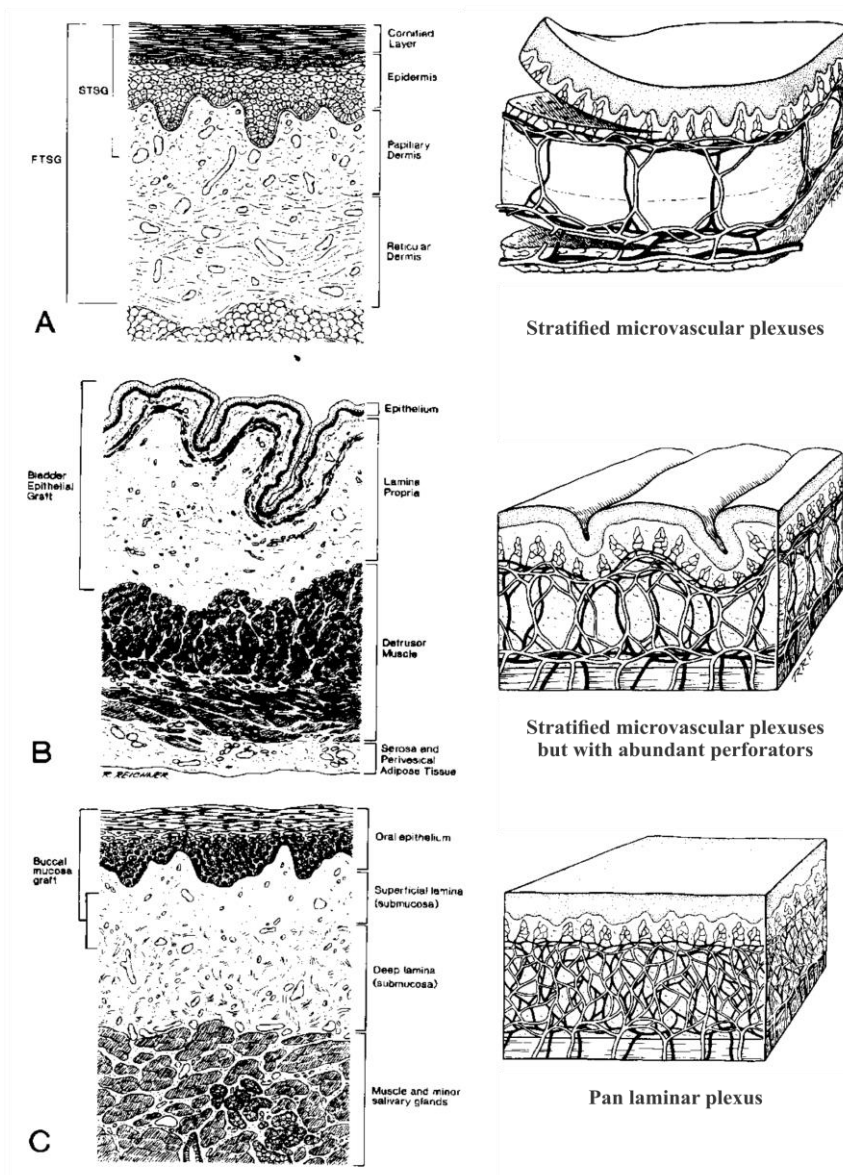
Mesh Graft

A mesh graft is generally STG with systematic slits placed in it after harvest and before application. These slits can expand the graft by various ratios, and in the case of reconstructive surgery, they can allow sub graft collections to escape with better conformation to irregular graft host beds. It has also been proposed that mesh grafts take more readily because the slits increase growth factors. Full thickness grafts can be meshed, but they rarely are, exceptions are found in preputial or penile skin split thickness. Mesh skin graft as first stage, followed by tubularization at second stage, may be a last resort for hypospadias cripple with failed multiple previous attempts **(Schreiter, No ll, 1989).[23]**

FULL THICKNESS

A full thickness graft (FTG) carries the covering, the superficial dermis or lamina, and the deep dermis or deep lamina. The deeper plexus is composed of larger, more sparsely distributed vessels, and therefore its vascular characteristics are more fastidious than that of an STG. FTG also carries most of the lymphatics and physical characteristics of the transferred tissue, is generally more durable at maturity, and does not contract as much as STG. Although these are general characteristics of FTGs, grafts also have distinctive characteristics that are dependent on the donor site. For example, extra genital full thickness skin grafts carry increased mass, which generally makes them more fastidious than genital full thickness skin grafts (i.e. penile and preputial skin grafts). An exception to this is found in the extra genital skin of the posterior auricular graft (Wolfe graft). Posterior auricular skin is thin, overlies the temporalis fascia, and is carried on numerous perforators. The sub dermal plexus of the Wolfe graft therefore seems to mimic the characteristics of the intradermal plexus and its total mass is more like that of STG.

The use of skin for urethroplasty was first described by **Nove- Josserand in 1897 and 1914. In 1941, Humby[24]** used Tubularized skin as a free graft for primary hypospadias repair in 12 patients, and Devine and Horton popularized use of the Tubularized skin graft with their description of a preputial, free graft Tubularized neourethra in 1961. **Bracka (1995a, 1995b)[25]** has continued to be a proponent of the skin graft tube as the second stage of a universally applicable two stage technique for hypospadias repair.

BLADDER EPITHELIAL GRAFT

This has a superficial and a deep plexus, however, the plexuses are connected by many more perforators, and therefore tend to have more favorable vascular characteristics (Fig. 18B).

The use of bladder mucosa was first reported by **Memmelaar in 1947,[26]** and later by others **(Marshall and Spellman, 1955; Hendren and Reda, 1986),** for primary repair of severe hypospadias in cases with a paucity of local tissue. However, protruding mucosa at the neomeatus resulted in a significant reoperation rate for revision at that site. Unlike bladder mucosa, which tends to shrink and requires a greater size of tissue at harvest in relation to the defect to be repaired, **buccal** mucosa may be harvested in a one-to-one ratio **(Burger et al, 1992)[27] Dessanti et al, 1992; Baskin and Duckett, 1994, 1995).[17]** This characteristic of buccal mucosa results from a

lamina propria rich with vascularity. As with all free grafts, a well vascularized graft host bed is a necessity for successful take via the processes of imbibition and inosculation.

Bladder mucosa is harvested by distending the bladder with saline and dissecting the detrusor muscle, anteriorly, off the underlyingmucosa (Fig.19).
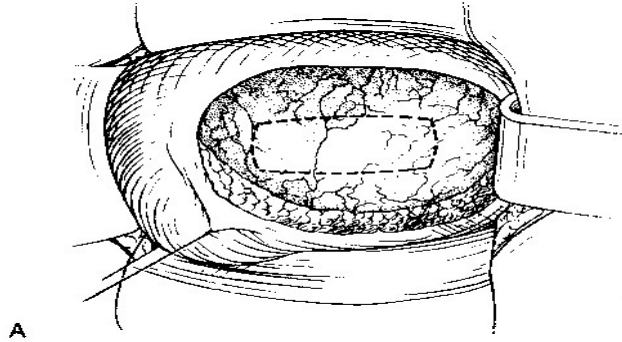

Fig. 19: Proposed site of bladder mucosa harvested in anterior wall of saline filled bladder following dissection of detrusor.

A rectangular donor site is marked to a size 10% greater than the size of the defect to be repaired.

As part of a composite repair, Tubularized skin or buccal mucosa may be added to the distal extent of the Tubularized bladder mucosa graft to decrease the risk of meatal complications.

The length of the bladder mucosa graft harvested should equal that of the defect when used in a composite repair. The two grafts are approximated with two running sutures of 6-0 or 7-0 polyglactin. The composite graft is then Tubularized over a silastic catheter using arunning, locking technique. The proximal anastomosis is performed with two running, locking sutures of fine polyglactin and the neomeatus is matured with simple interrupted fine absorbable suture. A second layer of neourethral coverage is provided by either a dorsal subcutaneous flap or tunica vaginalis. The bladder is drained with a suprapubic catheter, and the repair is stented for 7 to 10 days postoperatively with asilastic catheter. Immobilization of the patient in the early postoperative period is crucial to graft survival.

BUCCAL MUCOSAL GRAFT

A buccal mucosal graft has a 'pan laminal plexus' which is felt to provide optimal vascular characteristics (Fig. 18C). When a sufficient portion of the deep lamina is carried with the graft to preserve the tissues physical characteristics it can be thinned without adversely affecting the grafts vascular characteristics. Additionally, the wet epithelial surface of the buccal mucosal graft is considered to be a favourable characteristic for urethral reconstruction, thus a buccal mucosal graft is preferred in many cases.

The technique for use of buccal mucosa in hypospadias repair begins with induction of general anaesthesia and nasotracheal intubation. A self-retaining retractor is then placed in the oral cavity and with care taken to avoid stensons duct, a graft of appropriate size is marked on the mucosa of the check and/or lip.
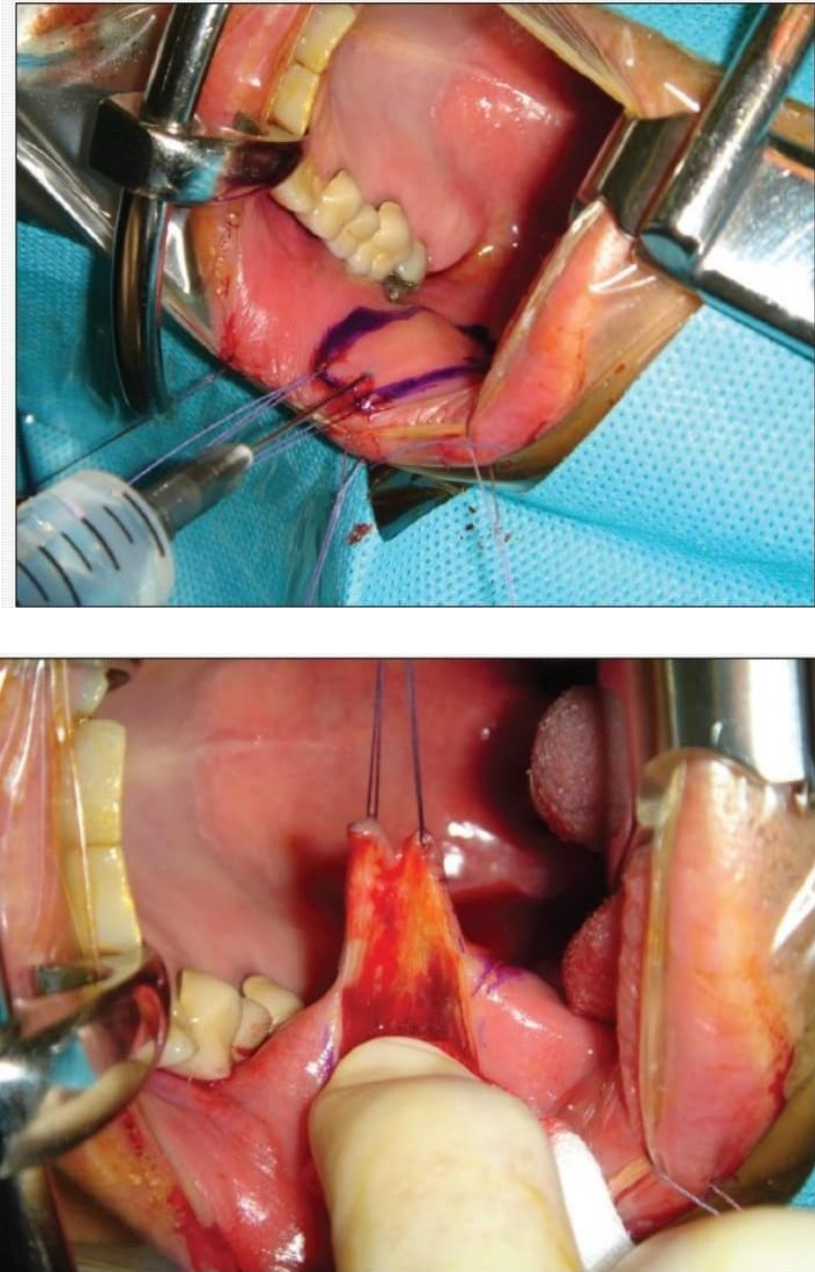
Fig. 20: Buccal mucosa harvest site.

Epinephrine (diluted 1:200,000 in 0.5% lidocaine) is injected submucousally, fine stay sutures are place in the corners of the graft, and the graft is harvested with sharp dissection superficial to the buccinators muscle. Buccal mucosal edges at the harvest site are approximated with 5-0 chromic catgut suture in a running simple fashion.

The graft is defatted on a sterile cardboard scaffold and then **Tubularized** in a manner similar to that for bladder mucosa. Proximal and meatal anastomosis and second layer neourethral and skin coverage and closure are performed similarly as well. The repair is stented for 7 to 10 days postoperatively. Improved results are noted when buccal mucosa is used in an onlay fashion compared with a tubularized technique (**Ahmed and Gough, 1997;**[28] **Duckett et al, 1995).**[29]

Colonic Mucosal Grafts and Appendicular Mucosal Graft

The colonic mucosal grafts and appendicular mucosal grafts have mainly been used in experimental studies. They may have a role to play in future in treatment of hypospadias and urethral strictures (**Lebret T et al, 1994; Yue-Min Xu et al, 2003).**[30]

Grafts in Urethral Reconstruction

Grafts have been most successfully employed in the area of bulbous urethra in which the urethra is invested by the ischial cavernosus muscles. The graft can be applied to the ventrum of the urethra, but a ventral urethrotomy appears to be advantageous only when employing spongioplasty.

SPONGIOPLASTY

Spongioplasty requires that the corpus spongiosum adjacent to the stricture be relatively normal and free of fibrosis. The use of a lateral urethrostomy (Fig. 21B) or dorsal graft onlay (Fig. 21C) was preferred by **Jordan GH (2002).**
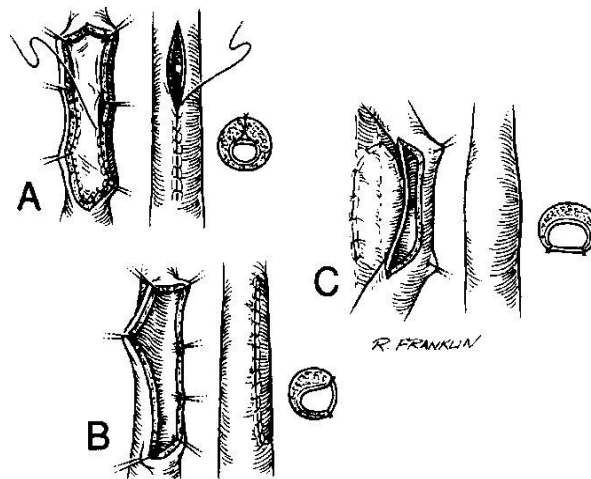
Fig. 21: Various techniques of onlay (A) Graft onlay with spongioplasty (B) Lateral onlay (C) Dorsal onlay.

Placing the urethrostomy laterally allows exposure of the urethra while cutting through the corpus spongiosum where it is relatively thin, thus limiting bleeding and maximizing exposure. In addition, the graft can be sutured to the underlying muscle bed to improve graft bed immobilization and approximation.

Alternatively, the **Monseur** urethral reconstruction technique, which is used in only a few centers, creates the urethrostomy through the dorsal wall of the stricture, and the edges of the stricture are sutured open to the underlying triangular ligament or corpora cavernosa.

1. In a modification of this technique described by **Barbagli**, the urethrostomy is performed through the stricture on the dorsal wall, and a graft is applied and fixed in the area of the urethrostomy to the triangular ligament or corpora cavernosa.

2. The edges of the stricture are then sutured to the edges of the graft and adjacent structures. The results of this modification are promising, with early follow up data yielding good results.

In addition, the dorsal graft onlay technique can be used with stricture excision and strip anastomosis (i.e. augmented anastomotic procedure).

Kolon TF, Gonzales ET (2000)[31] described a technique of single stage urethroplasty using an inner preputial based dorsal inlay graft.

After degloving the penis and correcting chordee, incisions were made bilaterally along the urethral plate form the native urethral meatus to the glans tip. The urethral plate in incised longitudinally. A graft harvested from the inner prepuce was defatted and sutured onto the incised urethral plate. The neourethra was rolled into a tube in **Thiersh-Duplay** fashion. They used this technique in 32 patients. The original meatus was coronal to penoscrotal and chordee release was performed concomitantly. At 21 months of follow up no patient had a stricture, fistula or diverticulum at the inlay graft site. The technique fulfilled all traditional hypospadias repair criteria and was believed to the authors to be a rapid, easy and successful technique for hypospadias repair.

COMPLICATIONS

Early

1. *Bleeding and Hematoma*

Bleeding has been noted as the most common complication of hypospadias repair **(Campbell 8th Ed.).** The use of tourniquet or cutaneous infiltration with 1:100,000 epinephrine has been recommended in past to minimize intraoperative bleed. Judicious use of precise point tip cautery can also help to control bleeding. **Gunter et al (1990)** stated that caudal block causes less intraoperative bleeding.

2. *Oedema*

Pressure of oedema can lead to meatal stenosis. This can be controlled by compression dressing **(Duckett and Baskin, 1996)**[17] and serratio peptidase.

3. *Infection*

It is an uncommon complication when suspected, culture, incision and drainage and debridement when indicated are incorporated with appropriate empirical and definitive antibiotic therapy. Severe infection may lead to breakdown of the entire repair.

4. *Meatal stenosis*

This is most commonly caused by technical issues at the time of repair, such as fashioning of the urethral meatus with too narrow a lumen or performance of glanuloplasty too tightly. Predisposing factors are crusting, oedema or synechia which may be avoided by properly calibrated urethral stent or application of ophthalmic ointment tube nozzle into the meatus (Duckett and Baskin, 1996).[17] Urethral (meatal) dilatation or meatotomy may be sufficient for the mildest forms of meatal stenosis.

5. *Devitalized skin flaps (repair breakdown)*

Most common site for this is ventral aspect of penis where dorsal skin has been transposed and is sequelae of ischaemic flap. Breakdown may also result from urethroplasty and/or glanuloplasty under tension, excessive use of electocautery, unidentified vascular pedicle injury during repair, or hematoma formation (Elbakry et al, 1998).[32]

Late Complications

1.   *Urethrocutaneous Fistula*

Fistula may result from, or be associated with distal stricture or meatal stenosis. Other risk factors include failure to invert all epithelial edges at urethroplasty, devitalization of tissue, and failure to add appropriate second layer urethroplasty coverage. Second layer coverage of the neourethra has been shown to significantly reduce the fistula rate as reported by several authors **(Smith, 1973; Belman, 1988; Retik et al, 1988; Churchill et al, 1996).**[33,34]

Repair of urethrocutaneous fistula is optimized by the same principle (**Davis, 1940; Cecil, 1946; Goldstein and Hensle, 1981; Retik et al, 1988).**[33] At times larger or multiple fistulas may require incision of the intact skin bridges and delayed repeat hypospadias repair.

2.   *Urethral Diverticula*

It may be associated with distal stricture or meatal stenosis. **Zaontz and colleagues (1989)**[35] described repair of this entity with circumferential skin incision, penile shaft skin degloving, diverticular excision and urethral closure, followed by **"pants over vest"** subcutaneous tissue coverage of the repair with excellent results.

3.   *Balanitis Xerotica Obliterans (BXO)*

It is a chronic inflammatory process of unknown cause. BXO can arise spontaneously or occur after minor trauma or penile surgery like circumcism or hypospadias repair. **Kumar and Harris (1999)** reported eight patients with histologically proven BXO. Seven of these patients presented with difficult micturation and meatal stenosis or neourethral stricture, at varying periods from 1-8 years after primary hypospadias repair. They recommended use of bladder or buccal mucosal free graft for repair of such cases, in order to improve on an alarming 50% complication rate with the use of skin grafts for urethroplasty.

4.   *Recurrent Penile Curvature*

Late-onset, recurrent curvature has been described by several authors as a complication of orthoplasty performed alone or in conjunction with hypospadias repair. It has been thought to be caused equally by extensive fibrosis of the reconstructed urethra, corporeal disproportion, or both **(Vandersteen and Husmann, 1998).**[36]

5.   *Urethral Stricture*

Its occurrence is multifactorial. The type of repair and the method in which neourethra is constructed as well as anastomotic and tissue factors, such as revascularization, all contribute to formation of the stricture **(Belman, 1988).**[34]

The proximal anastomotic site of a tubularized repair such as TPIF appears to be particularly at risk. This type of stricture may be successfully treated with endoscopic cold knife urethrotomy **(Schierz et al, 1988).**

A more extensive stricture may warrant patch with free graft or preferably pedicled flap urethroplasty, either of these two techniques achieves greater success when used as an onlay rather than a tubularized segment. In a thorough review of anterior urethral stricture repair techniques, **Wessells and McAninch (1998)**[37] reported near identical overall success rates of approximately 85% for both free graft and pedicled skin flap methods.

In **1989, Schreiter** described a two-stage mesh-graft urethroplasty using split thickness skin, for application in the absence of available pedicled flap tissue or an appropriate graft bed **(Schreiter and Noll, 1989;**[23] **Wessels**

and McAninch, 1998).[37] The mesh-graft technique would be useful in those instances when all other options have failed.

FUTURE CONCEPTS

Atala and colleagues (1999)[38] have explored the use of a human cadaveric, bladder sub mucosal, collagen based inert matrix as a potential substitute for use in hypospadias repair. In their preliminary report, four patients with one or more failed previous repairs underwent urethroplasty with the collagen based inert matrix material in an onlay fashion. Length of tissue used ranged from 5 to 15 cm, and all repairs were covered with a tunica vaginalis flap. One patient developed a urethrocutaneous fistula, which was repaired by standard techniques. Postoperative urethrography and endoscopy showed a normal appearing urethra in all patients.

MATERIAL AND METHODS

Place and Duration

This is a prospective randomised study to be conducted from Nov. 2020 to June 2022 in all patients of distal hypospadias who are admitted and operated in the pediatric surgery unit & Uro-surgery unit in the department of General Surgery, *S.* N. Medical College, Agra.

Patients

Inclusion Criteria

Patients with glanular, coronal, sub coronal and mid penile without chordee hypospadias to be included.

Exclusion Criteria

Patients with posterior (proximal) hypospadias and those with severe chordee are to be excluded.

Starting with the standard history and physical examination, investigation, assessing anesthetic fitness, we correct the defect with the help of standard surgical procedures and evaluate the result of each of the procedure performed.

These patients are divided into 2 groups according to type of technique used:

Group A (sample Size-20): In these patients, hypospadias repair is done with tubularised incised plate urethroplasty with inner free prepucial inlay graft.

Group B (sample Size-20): In these patients, hypospadias repair is done with tubularised incised plate urethroplasty without prepucial graft.

In all patients, urethroplasty was done on a catheter which will be kept for 7-10 days after surgery.

All patients have been followed at sixth post-operative day and at every 3 month for 2 years.

Time for Surgery

The ideal time of surgery is 6-18 months at age and onwards but preperably before age of school going.

Anaesthesia

Spinal, caudal or general anaesthesia according to age and general condition of patient.

Suture material & magnification

Fine plastic, microvascular or ophthalmic instruments including sharp and blunt scissors are necessary.

Optic magnification is helpful; although low magnification was suffice. Suture 5/0 or 6/0 chronic catgut or vicryl are used for urethroplasty.

Hemostasis

To obtain blood less field; a tourniquet (release every 30-45 min) or epinephrine 1:800:000 in 0.50% lidocaine is used.

Precise bipolar diathermy is also be used to ensure haemostasis. Post operative dressing and catheterization:

A circular mild compressing dressing is applied post operativelyfor 2-5 days loose fitted silastic or portex catheter (6 fr to 10 fr) according to size of urethra left for 7-10 days after surgery.

Criteria on which result shall be assessed are:

1. Age at Surgery
2. Site and shape of meatus
3. Size of catheter used for urethroplasty
4. Urinary stream during voiding.
5. Size of neourethra as calibrated by appropriate size well lubricated; infant feeding tube.
6. Infection
7. Fistula formation
8. Bleeding
9. Cosmetic appearance
10. Stricture formation

The data is collected and statistics is applied accordingly to assessthe outcome.

CASE SHEET
Name
Age/Sex
Date of Admission
Date of Discharge
Phone no.
Registration no.
Address
Socio-Economic Status
Consent

PERSONAL HISTORY

*   Present history
*   Past medical history
*   Family history

- Undescended testis

- Inguinal hernia

- UTI

- Hematuria

- Incontinence

- In-vitro fertilization

EXAMINATION

- Meatal location

- Glans configuration

- Dorsal preputial hood

- Ventral curvature (Chordee)

- Penile angulation

- Urinary stream

OBSERVATIONS

The present study is carried out in 40 patients of distal penile hypospadias without chordee admitted at S.N. Medical College, Agra**.** They are selected on random basis and divided into 2 groups. They are studied from Nov. 2020 to June 2022.

Group A comprised of 20 patients in whom free preputial graft urethroplasty (SNODGRAFT) is done and formed the test group.

Group B was the control group comprising of 20 patients in whom Tubularized Incised Plate Uretroplasy (SNODGRASS) isperformed.

Table 1: Age at time of presentation.

Age group (years)	Group A		Group B		Total	
	No.	%	No.	%	No.	%
<4	6	30	5	25	11	27.5
4–6	11	55	8	40	19	47.5
>6	3	15	7	35	10	25
Mean ± SD	4.7±1.71		5.2±2.36		4.95±2.10	
p-value	0.34					

Most of the patients are between 4-6 years in age. The mean age 4.7±1.71 in Group-A and 5.2±2.36 in Group-B. The difference between the groups is non-significant (p = 0.34).
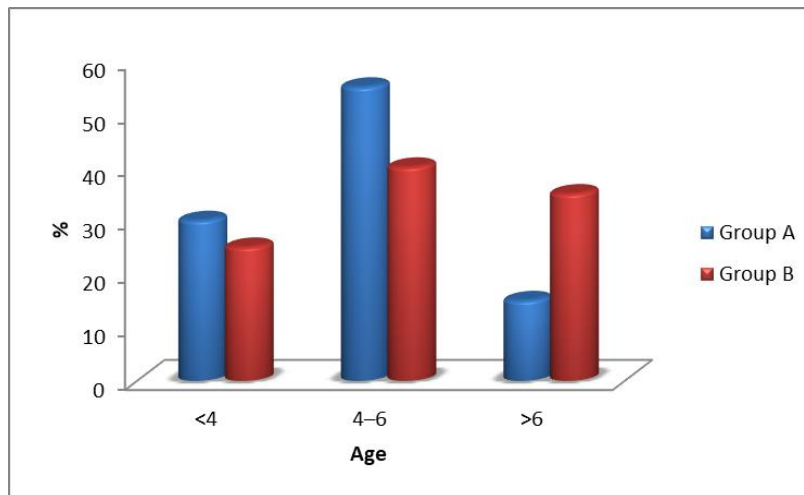
Fig.-1: Age at time of presentation.

Table 2: Rural-Urban Distribution.

	Group A		Group B		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**
Rural	16	80	15	75	31	77.5
Urban	4	20	5	25	9	22.5
Mean±SD	10±8.49		10±7.07		20±15.56	
p-value	0.7					

Most of the patients belonged to rural background. Applying Chi square test, $\chi^2 = 0.12$ (p=non significant). Hence both groups havecomparable distribution into rural and urban regions.
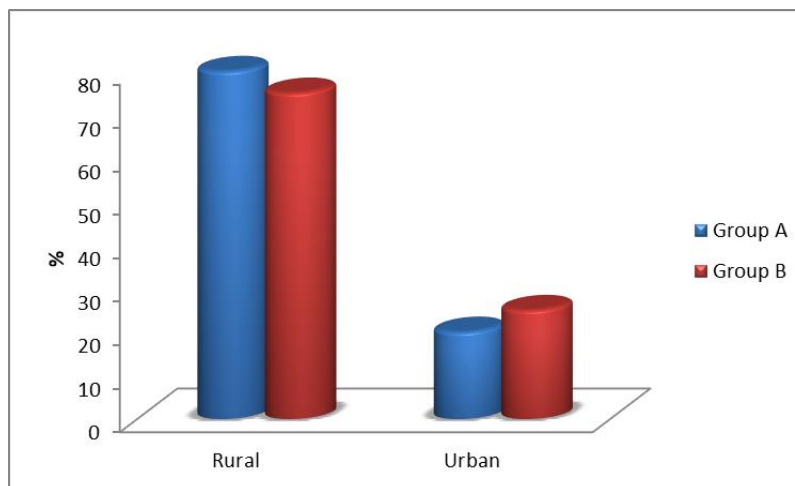
Fig.-2: Rural-Urban Distribution.

Table 3: Classification.

Type	Group A		Group B		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**
Glanular	4	20	6	30	10	25
Subcoronal	10	50	8	40	18	45
Coronal	6	30	6	30	12	30

In group A, 10 out of 20 (50%) patients have sub coronal while in group B, 8 out of 20 (40%) patients have subcoronal distal penile hypospadias.

Thus, both groups are comparable with almost similardistribution into distal penile hypospadias.
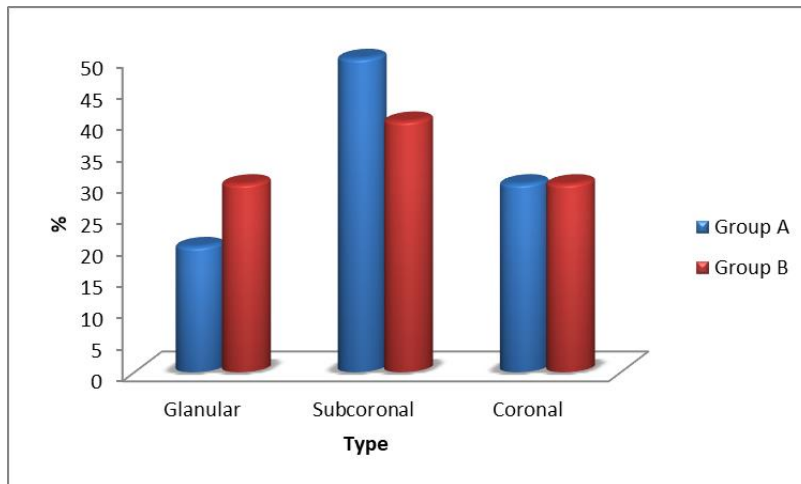
Fig.-3: Classification.

Table 4: Presenting Symptoms.

	Group A		Group B	
	No.	**%**	**No.**	**%**
Thin stream	4	20	3	15
Cosmetic	20	100	20	1000
Other symptoms	0	0	0	0
mean±sd	2±2.83		1.5±2.12	
p-value	1			

All patients have complains of abnormal location of urethralopening on undersurface of penis. 4 patients out of 40 have a thin stream of urine.
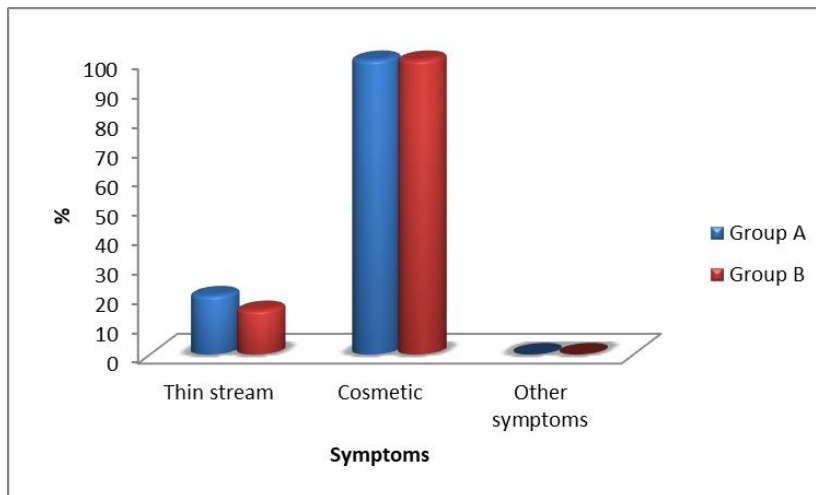
Fig.-4: Presenting Symptoms.

Table 5: Associated Meatal Stenosis.

	No. of cases	**Percentage**
Group A	3	15
Group B	4	20
Total	7	17.5

Meatal stenosis is commonly associated in distal penilehypospadias in both the groups.
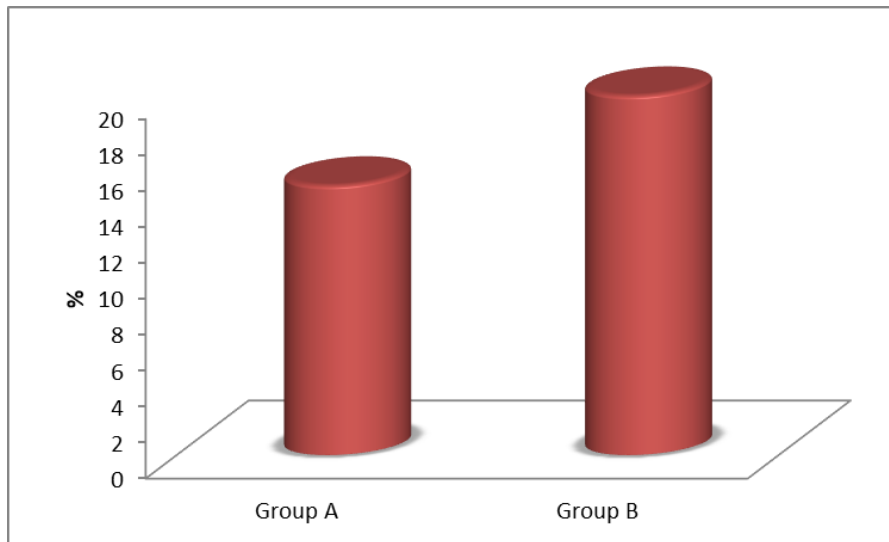
Fig.-5: Associated Meatal Stenosis.

Table 6: Penile length and age at presentationin hypospadiac patient.

Age	4 cm (3.5-4.5)	5 cm (4.5-5.5)	6 cm (5.5-6.5)
1–2	-	-	-
2–4	5	7	-
4–6	3	16	1
6–8	-	2	1
8–10	-	2	1
10–12	-	-	2
mean±sd	3.75±0.97	4.93±0.47	8.6±2.33
pvalue	0.38	4.04	2.6

The mean penile length in group A is 3.75±0.97 cm and in group B is 4.93±0.47 cm. On comparing both groups, (t=0.15) hence the difference between the two groups is not significant. Taking all 40 cases together, the mean penile length is 3.75±0.97 cm (range 3.5-4.5) at 4.93±0.47 years (range 4.5-5.5 years) and 8.6±2.33 cm (range 5.5-6.5 years).
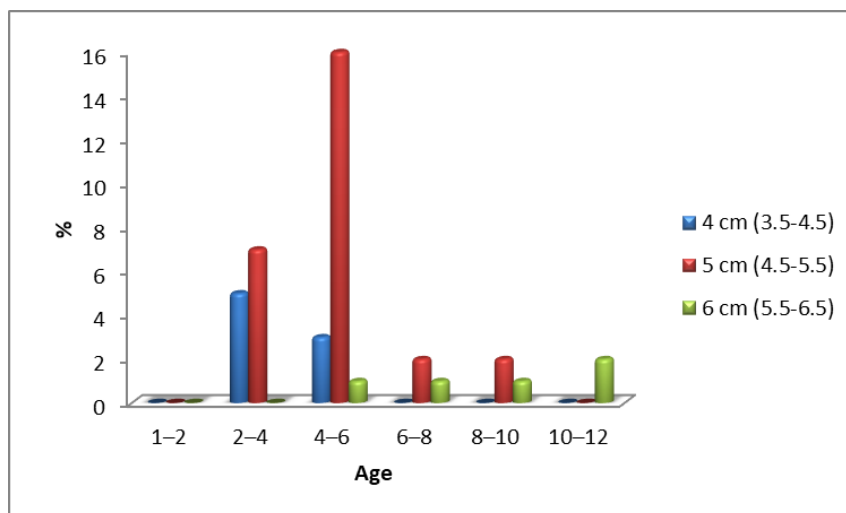
Fig.-6: Penile length and age at presentationin hypospadiac patient.

Table 7: Associated Disease.

	Group A	Group B	Total
Undescended testis	1	1	2
Inguinal hernia	0	1	1
Others	-	-	-
mean±sd	0.5±0.71	1±0	
p-value	0.39		

The most commonly associated disease is undescended testis.
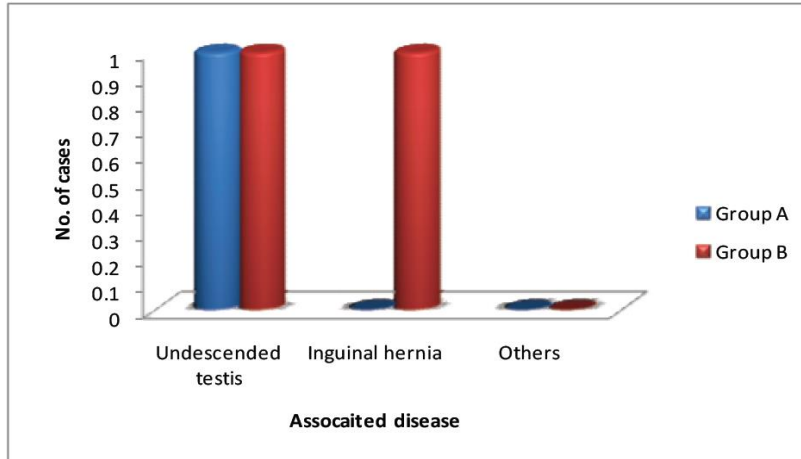
Table 8: Measurement of preputial graft.

Preputial graft	No. of cases	mean±sd
Length (mm)		
15-20	11	21.36±5.42
20-25	4	
25-30	2	
30-35	3	
Breadth (mm)		
7	1	9.05±1.02
8	5	
9	8	
10	4	
11	2	

The length ranged from 15 to 35 mm (mean 21.36±5.42 mm) and breadth ranged from 7 to 11 mm (mean 9.05±1.02 mm).
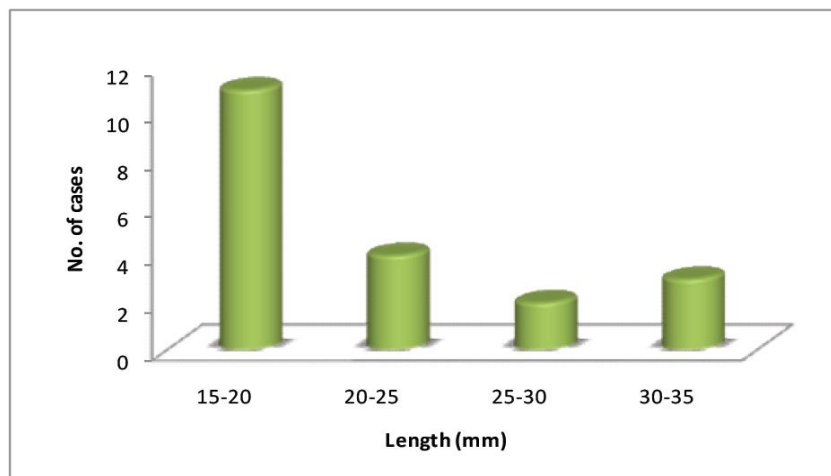
Fig.-8(a): Measurement of Preputial Graft.
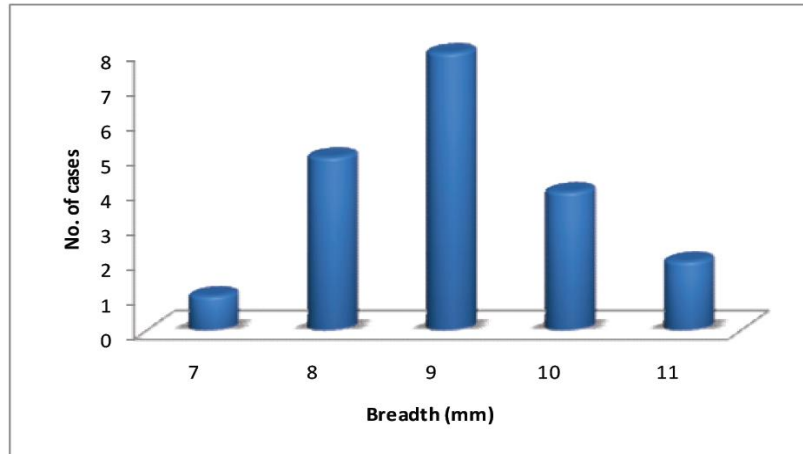
Fig.-8(b): Measurement of preputial graft.

Table 9: Timing of catheter removal.

Days	Group A	Group B
0-6	1	1
6–8	1	3
8–10	18	16
mean±sd	8.6±1.36	8.4±1.43
p-value	2.06	

Most of the catheters are removed on the tenth postoperative day. They are removed earlier in cases of pericatheter leak. The mean duration of urethral catheter drainage in group A is 8.6±1.36 days and in group B is 8.4±1.43 days. On comparison, p=2.06 (non significant).
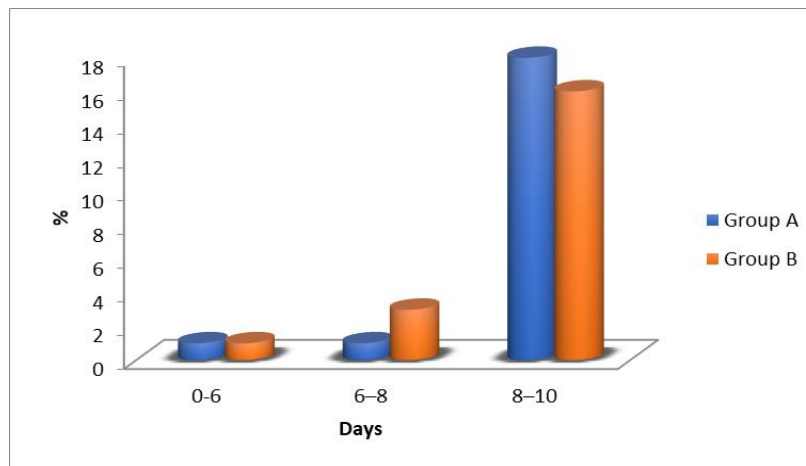
Fig.-9: Timing of catheter removal.

Table 10: Incidence of early complications.

Complication	Group A		Group B	
	No.	%	No.	%
Pericatheter leak	2	10	2	10
Postoperative oedema	2	10	2	10
Fistula	2	10	3	15
Diverticulum	0	0	1	5
Infection / wound healing by secondary Intention	1	5	1	5
Total	7	35	9	45
mean±sd	2.4±2.3		4±2.41	
p-value		0.7		

The most common complications are postoperative oedema and fistula formation. On comparing the number of fistula formation ingroup A and B statistically, p = 0.7 (not significant).
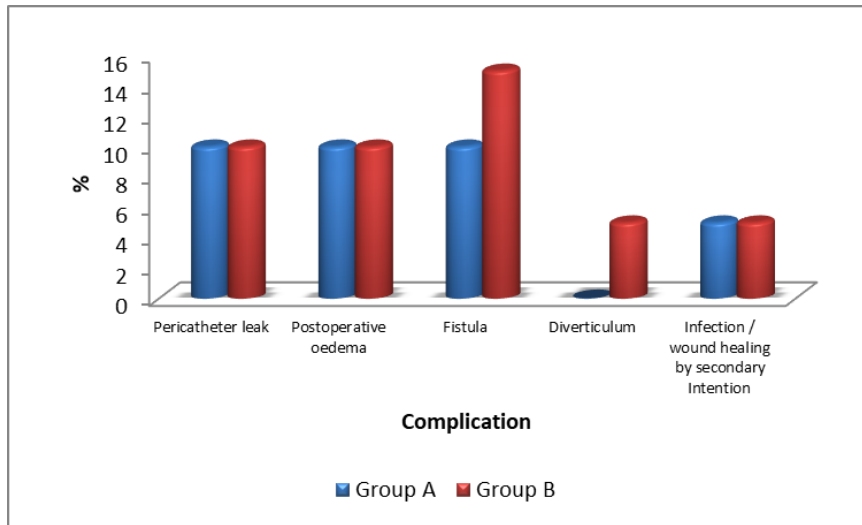
Fig.-10: Incidence of early complications.

Table 11: Cosmetic result.

	Group A		Group B	
	No.	**%**	**No.**	%
Bad	0	0	2	10
Fair	2	10	4	20
Good	4	20	9	45
Excellent	14	70	5	25
mean±sd	5±5.48		5±2.74	
p-value	0.1			

The cosmetic results are much better in group A with 14 out 20 (70%) having excellent cosmetic results while in group B, 5 out of 20 cases (25%) have excellent cosmetic result, which is significant at p<0.1.

In group A, 18 patients have good or excellent results while ingroup B, 14 patients have good or excellent results.
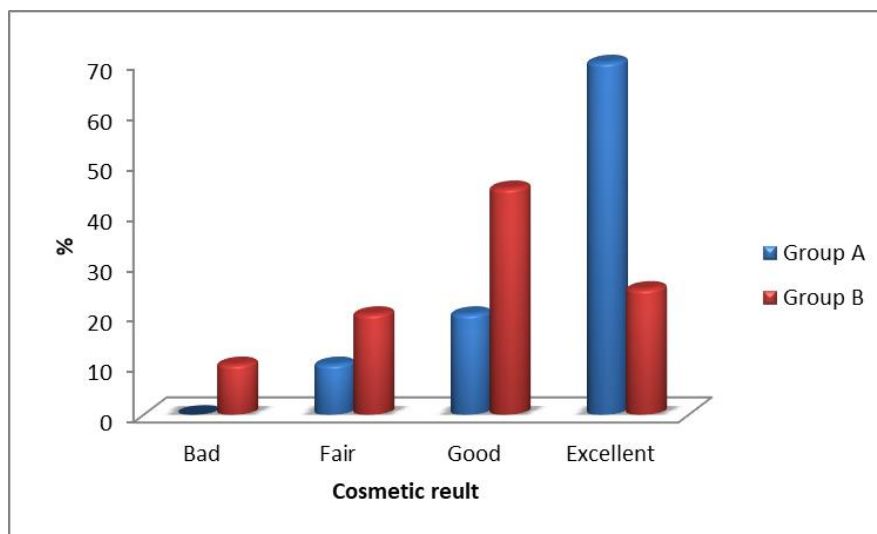
Fig.-11: Cosmetic Result.

Table 12: Requirement of post operative calibration.

No. of times	Group A	Group B
1	5	2
2	8	4
3	5	4
4	2	5
5	0	5
mean±sd	4±3.40	4±1.48
p-value	0.06	

On comparing requirement of 4 or 5 times dilatation, only 2 patients in group A (10%) required dilatations 4 times while 11 patients in group B (55%) required 4 or 5 times dilatation. On statistical analysis, z = 3.33 which is significant at p<0.001.
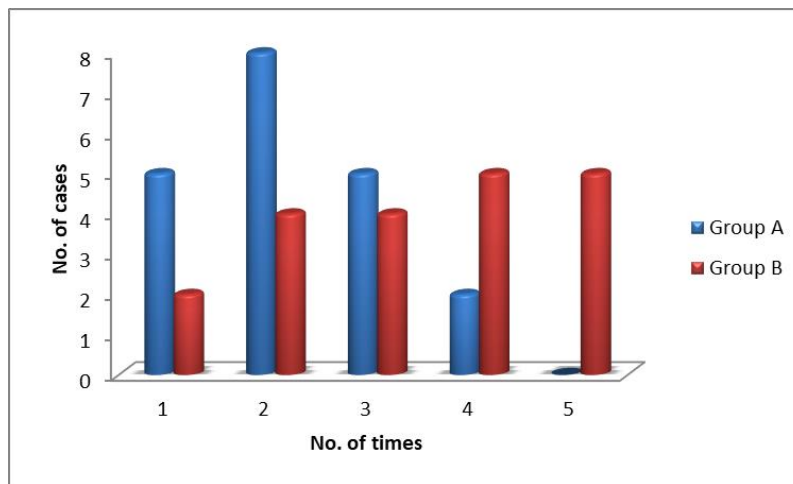
Fig.-12: Requirement of post operative calibration.

Table 13: Dilator size reached after calibration.

Hagar dilator size	Group A	Group B
3	8	9
4	12	11
mean±sd	3.6±0.49	3.55±0.50
p-value	0.75	

Both the groups have similar diameters of urethra after calibration. Thus there is no shrinkage of the free preputial graft.
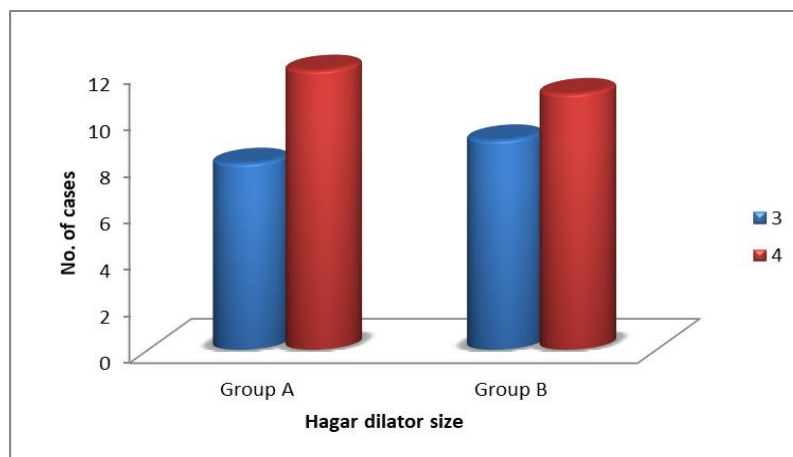
Fig.-13: Dilator size reached after calibration.

Table 14: Treatment of Fistula.

Outcome of fistula	Group A	Group B
Spontaneous	1	0
Operative	1	2
Waiting for operation	0	1
Total	2	3
mean±sd	1±0.82	2±2.94
p-value	0.28	

Out of the 2 fistulae in group A, one closed spontaneously and 1 required operative treatment while 3 patients required operative treatment in group B (z=1.56, significant).
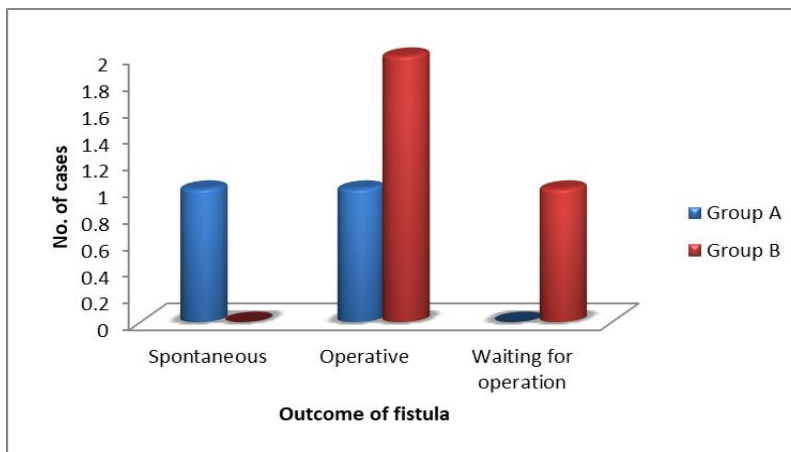
Fig.-14: Treatment of Fistula.

Table 15: Second Operation Required.

Complication	Group A	Group B
Fistula	1	2
Diverticulum	0	1
Total	1	3
mean±sd	1±0	2±1.41
p-value	0.001	

Second operation is required for treatment of complications like fistula formation and diverticulum in 3 out of 20 patients (15%) in group B and 1 out of 20 patients (5%) in group A. Statistically the difference is significant (z=1.869).
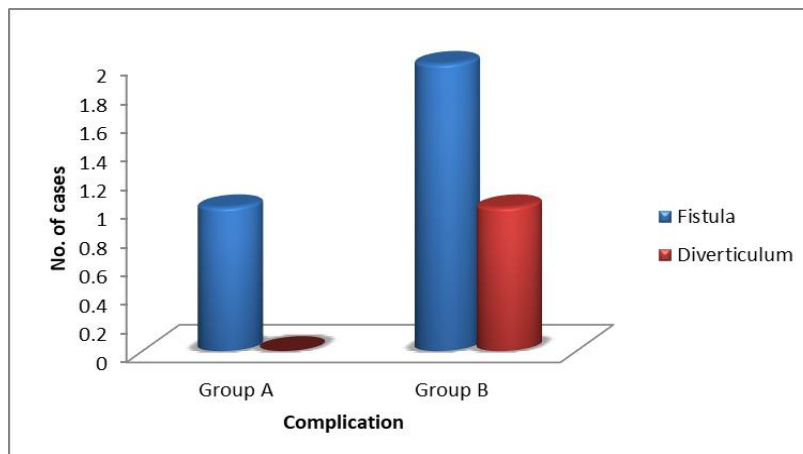
Fig.-15: Second Operation Required.

Table 16: Delayed Complications.

Complication	Group A	Group B
Meatal stenosis	1	2
Proximal stricture	0	2
mean±sd	0.05±0.22	0.25±0.22
p-value	0.27	

The delayed complications like meatal stenosis and proximal stricture are detected during postoperative urethral calibrations and are treated by repeated dilatation.
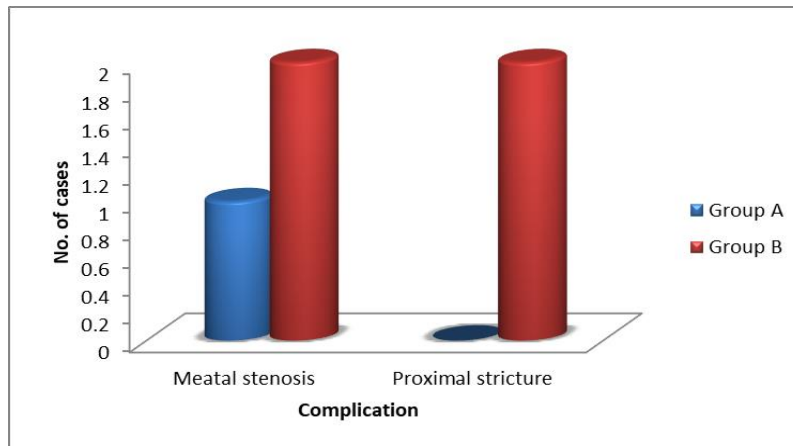
Fig.-16: Delayed Complications.

Table 17: Overall Complications.

Complication	Group A (%)		Group B (%)	
	No	%	No	%
Fistula	2	10	3	15
Diverticulum	0		1	5
Infection	0		0	
Meatal stenosis	1	5	2	10
Proximal stricture	0		2	10
Total	3	15	8	40
Mean±Sd	0.4±0.63		1.2±1.55	
p value	0.5			

4 patients in group B had 2 complications together. On analyzing the difference between the overall complications between the 2 groups statistically, z = 3.68 which is statistically significant (p<0.001).
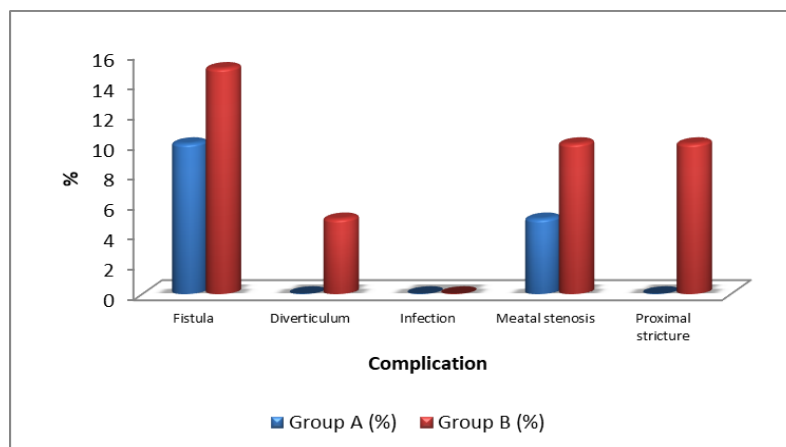
Figure 17: Overall Complications.

Table 18: Patient wise overall complication.

	Group A	Group B
No. of patients with complications	3	8

On analysis, z = -2.00 which is significant at p < 0.01.

Follow up

Our follow up period ranged from 2 months to 30 months (mean 8.7 months). The mean follow up in group A is 8.5 months and in groupB is 8.8 months.

DISCUSSION

Innovative concepts and techniques continue to emerge in the field of Hypospadiology and with time may herald improvements to even the most basic of principles necessary for successful hypospadias repair.

Every new technique needs to be practiced and mastered over time. A comparison with the existing methods helps to prove thesuperiority of one technique over another.

In this study, a new method of forming the deficient urethral tube distal penile hypospadias without chordee chordee with a full thicknessfree inner preputial inlay graft (SNODGRAFT) has been studied and compared with the TIP (SNODGRASS).

All the operations have been done by the same surgeon to avoid any difference due to technical skill.

The study is carried out on fourty patients of distal penile hypospadias. They are divided into 2 groups on random basis depending upon the type of operation performed to form the deficient urethral tube (20 patients in each).

The results of the two groups are then compared in terms of complications and cosmetic outcome and analyzed statistically.

AGE DISTRIBUTION

The distribution of the subjects according to their ages is shownin Table 1 and Fig. 23. The range of the ages is from 2-12 years with a mean of 5.81 ± 2.35 years. Most of the boys are between 4-6 years in agein both the groups (51.51%). The two groups are not different statistically in age distribution (t=1.15).

Ghali A.M.A (1999)[39] analyzed the difference between the complication rates when the patients underwent repair when aged <2 years with those >2 years and did not find any significant difference statistically.

We did not have any patient less than 2 years as most of the patients are from rural areas and did not feel the need to come earlier. However we feel that the patients of hypospadias should be operated upon well before they join school to avoid the psychological effects of a congenital defect.

RURAL / URBAN DISTRIBUTION

Majority of the patients are from rural background. This is due to the reason that S.N. Medical College, Agra is a referral centre covering a large population most of whom belong to nearby villages where pediatric surgical or urological facilities are not available. Both groupshave comparable distribution into rural and urban regions (χ^2=0.12

which is not significant)

CLASSIFICATION

Out of the 40 patients selected for the study, 18 (45%) have distal penile subcoronal hypospadias, and 12 (30%) have distal penile coronal hypospadias. However, this is not a true indicator of frequency of distal penile hypospadias as patients of distal penile hypospadias in whom no tissue is used to form the urethral tube (e.g. MAGPI) are not included in the study. Similarly, patients of mid penile hypospadias with moderate or severe chordee are excluded from the study.

As seen in Table 3, both the groups have similar distribution distal penile hypospadias and hence are comparable.

Sweet et al (1974) reported 87% anterior, 10% middle and 3% posterior type of hypospadias in their series.

Standoli (1982) reported 45% anterior, 49% middle and 6% posterior type of hypospadias. **Duckett (1992)**[16] showed that 50% of patients had anterior, 20% had middle and 30% had posterior type of hypospadias.

PRESENTING SYMPTOMS

All the 40 patients seeked medical advice for cosmetic reasons thus highlighting the fact that a procedure with better cosmetic result is essential for patient satisfaction. 4 patients in group A (20%) and 3 patients in group B (15%) have complains of thin stream of urine.

ASSOCIATED MEATAL STENOSIS

Meatal stenosis is associated in 7 out of the 40 patients in both groups (17.5%). No previous data is available on association of meatal stenosis in hypospadias patients.

Duckett and Baskin (1996)[17] stated that the more distal the meatus, the more often it is associated with meatal stenosis. In our series also, majority of the patients with meatal stenosis have distal penile hypospadias (6/8).

In the presence of preexisting meatal stenosis, quite a number of cases require meatotomy along with urethroplasty. In our method, both these procedures can be done simultaneously in the same sitting as meatotomy can be incorporated in the urethroplasty. Whereas in other procedures like Mathieu's meatotomy has to be done prior to the urethroplasty in different sittings.

PENILE LENGTH

Fig. 25 shows the normal penile length distribution according to age in 50 normal subjects in North India. According to Table 6, the average penile length is around 4 cm at 2 years of age and then raises up to 5 cm up to 10 years of age. After that the length may increase at a faster rate depending upon the spurt of puberty as the range of penile length was 5-8 cm in the 10-12 years age group. This is similar to the findings of Feldman DW and Smith DW (1975) (Table 24).

Table 18: Stretched penile length in normal males.

Age	Mean ± SD (cm)	Mean -2.5 SD (cm)
Newborn, 30 wk	2.5 ± 0.4	1.5
Newborn, 34 wk	3.0 ± 0.4	2.0
Newborn, term	3.5 ± 0.4	2.4
0-5 mo	3.9 ± 0.8	1.9
6-12 mo	4.3 ± 0.8	2.3
1-2 yr	4.7 ± 0.8	2.6
2-3 yr	5.1 ± 0.9	2.9
3-4 yr	5.5 ± 0.9	3.3
4-5 yr	5.7 ± 0.9	3.5
5-6 yr	6.0 ± 0.9	3.8
6-7 yr	6.1 ± 0.9	3.9
7-8 yr	6.2 ± 1.0	3.7
8-9 yr	6.3 ± 1.0	3.8
9-10 yr	6.3 ± 1.0	3.8
10-11 yr	6.4 ± 1.1	3.7
Adult	13.3 ± 1.6	9.3

As seen in Table 6, the length remained around 5 cm till 10 years of age. From 2 years to 12 years the range of the length in the 40 hypospadiac patients in our study is between 4.1 cm to 6.2 cm with a mean of 4.92 cm. Between 4-6 years which comprised of the maximum number of patients the range is between 4.2 cm to 5.4 cm with a mean of 4.90 cm.

Thus the penile length in patients with distal penile hypospadias without chordee or with minimal chordee is similar to that in normal subjects. In our study, there is no patient with associated micropenis.

ASSOCIATED DISEASES

Undescended testis is associated in 2 cases and inguinal hernia in one case out of 40 cases. Undescended testis is the most commonly associated congenital anomaly with hypospadias.

Khuri et al (1981) reported an incidence of 9.3%.

Ross et al (1959) and Felton (1959) reported an incidence of 15% and 6% respectively.

Cerasaro and coworkers (1986) have reported an incidence of 18%.

Belman (1992) reported an incidence of 10% in his series.

In our study the incidence of associated undescended testis is low as posterior type of hypospadias in which this anomaly is commonly associated has not been included in the study.

MEASUREMENT OF PREPUTIAL GRAFT

The sizes of the inner preputial graft ranged from 16 to 35 mm in length (mean 21.75±5.54 mm) and 7 to 11 mm in breadth (mean 9.05±1.02 mm). Most of the grafts are between 15-20 mm in length and 9 mm in width. The length of the graft is 1-2 mm more than the distance between the urethral opening and the glans tip. The width of the graft depended upon the diameter of the urethral opening, whether 6 Fr or 8Fr tube is used to catheterize the urethra and the available width of the urethral plate.

Kaplan GW (1988)[40] used onlay grafts in 4 patients measuring 6to $8 \times 5 \times 20$ mm.

TIMING OF CATHETER REMOVAL

The catheter is removed on the day of pericatheter leak if it occurred. Otherwise it is kept in situ till 10th postoperative day in all thecases. Buson H et al (1994) had reported the catheter could be safely removed between 2-5 days postoperatively for distal hypospadias but we have kept it till 10th postoperative day to keep uniformity for comparison. The mean duration of urethral catheter drainage in group A is 8.6±1.36 days and in group B is 8.4±1.43 days. On comparison, t=0.13 (non-significant). Both groups taken together, the mean day is 8.5±1.40.

COMPLICATIONS

The incidence of early complications is shown in Table 10. Pericatheter leak is almost similar in both the groups (2 cases in group A and 2 cases in group B). Postoperative oedema is observed during the time of first dressing (5th postoperative day) is similar in both groups 2 cases in each. Fistula formation is observed in 2 cases in group A (10%) and 3 cases in group B (15%). Out of these, one fistula in group A healed spontaneously so 1 out of 20 cases (5%) required operative closure in group A and 3 out of 20 cases (15%) required operative closure in group B.

One case in group B has diverticulum formation and 1 case in group B has infection and healed by secondary intention.

Weiner JS et al found that no diverticulum developed after inlayrepair whereas 12% of the tubularized repairs in their series of 132 patients developed diverticulum. The overall complication rates were 36% for tubularized and 31% for inlay repairs and fistula sites were 17% and 14% respectively.

Vella et al (1991)[41] studied the comparison of free skin graft, free bladder mucosal graft and transverse pedicle preputial graft for single stage repair of distal hypospadias. They found preputial grafts to be better than the other grafts. They found that free skin grafts resulted inmaximum stricture formation. The result of bladder mucosa was in between the two but was the only solution in very posteriorly situated meatus and in those children who had already undergone multipleoperations.

Catanon M et al (2000) compared the results of tubularized island flap urethroplasty and the inlay technique in posterior hypospadias. They also found fistula formation to be the most frequent complication without any significant difference between the 2 groups (21.4% for Duckett technique and 18.4% for inlay repair, p>0.5).

However, they found that the anastomotic stricture was much more common in the tubularized flap group (7.14% vs 2.63%; p<0.05). Moreover, a mega urethra was found only in the Duckett technique group (4.7%).[17]

Kaplan GW (1988)[40] used preputial free graft for neourethral construction in 21 patients (17 as tubed graft and 4 as onlay graft) and reported complications of one temporary fistula and one permanent fistula with stricture. He had done the procedure for proximal hypospadias and had compared the results with other procedures and found his method statistically better than the combined results of other reports ($\chi^2 = 5.38$, p<0.05).

Ghali et al (1999)[39] performed the following procedures in 418 subjects and had the following complication:

Table 19: Comparaison of complications (Ghali et al, 1999).

Complications	Mustarde (n=12)	Mathieu (n=216)	inlay (n=42)	Snodgrass (n=148)	Overall (n=418)
Meatal stenosis	1/12	1/216	-	17/148	18/418
Meatal retraction	-	3/216	1/42	-	4/418
Fistula	3/12	19/216	1/42	22/148	45/418
Stricture	-	-	-	12/148	14/418
Tubal abnormality	-	-	-	10/148	10/418
Residual chordee	-	7/216	1/42	3/148	9/418
Flap necrosis	2/12	3/216	-	4/148	9/418
Overall	6	33/216	3/142	48/148	90/418

They also had minimum complications with inlay urethroplasty.

All tubal abnormalities and almost all strictures occurred after **TIP repair**. The rate of urethrocutaneous fistula was significantly higherin Mathieu (9%) than in inlay (2%).

Ghali et al (1999)[39] found that the complication rate was significantly (p<0.05) higher in patients with a proximal urethral meatus, with severe chordee or in repairs involving transaction of theurethral plate.

Powell CR et al (2000)[42] compared the results of flaps versus grafts in proximal hypospadias surgery and concluded that tubed graft repair has a higher stricture rate than inlay graft repair; otherwise the complication rate of flaps and grafts for repair is not significantly different. They reported an overall complication rate of 27% with 2% fistula, 3% stricture and 3% meatal stenosis. Our results are better thantheirs perhaps as we did the study in distal and mid penile hypospadiasand their study was in proximal hypospadias.

Table 20: Results of Powell CR et al (2000).

	Type of urethroplasty			
	Tubed flap (%)	Tubed graft (%)	Onlay flap (%)	Inlay graft (%)
Overall complication	9 (33%)	21 (34%)	6 (30%)	10 (29%)
Fistula	7 (26%)	21 (18%)	3 (15%)	7 (21%)
Stricture	1 (4%)	8 913%)	1 (5%)	0
Meatal stenosis	1 (4%)	1 (2%)	1 (5%)	2 (6%)
Diverticulum	0	1 (2%0	1 (5%)	1 (3%)

Powell et al used inlay free graft in 34 patients and had a fistularate of 21% (7 out of 34), meatal stenosis was observed in 2 patients and 1 patient developed diverticulum. They also did not have a single case of stricture formation as in our study (Group A).

REASONS FOR LESS FISTULA FORMATION IN FREE PREPUTIALGRAFT INLAY URETHROPLASTY

1. *Preservation of the urethral plate*

Preservation of the urethral plate is associated with fewer complications. This was also reported by **J.G. Hollowel et al (1990)** whofound that onlay island flap with preservation of urethral plate had a complication rate of 8% compared with Mathieu's (10%), preputialisland tube (15%) and double faced island flap (18%).

Elbakry (1999)[32] also emphasized that every effort should be made to preserve the urethral plate during orthoplasty minimizing the need to use tubularized preputial island flaps and expanding the application of inlay procedures.

Historically, preservation of the urethral plate was thought to contribute to ventral penile curvature that often complicates hypospadias surgery. However, **Snodgross et al (2000)[43]** studied the histology of the urethral plate in 17 boys and found all specimens consisting of well vascularized connective tissue comprised of healthy appearing, smooth muscle and collagen. There were no histological findings of fibrous scar or dysplastic tissues. These histological findings support reasonable efforts to preserve the urethral plate even in cases of mild to moderate penile curvature.

2. *Second Layer Closure*

Fistula rate was less in free preputial graft inlay urethroplasty due to the second layer closure by dartos. **Hayashi Y et al (2001)** also emphasized that urethrocutaneous fistula can be prevented by 2-layer closure of the neourethra and application of the Wrapping technique of the proximal anastomosed portion with corpus spongiosum tissue.

Ross JH and Kay R (1997)[44] used a modified Snodgrass technique in treatment of distal or midshaft hypospadias in 18 boys.

They used a local de-epithelialized skin flap to cover the urethroplasty instead of a transverse island flap of subcutaneous tissue. They reported excellent cosmetic and functional results in the 16 boys who came for follow up with no case of fistula or meatal stenosis. They concluded that by this technique optimal blood supply to the ultimate skin coverage is preserved and penile torsion is avoided.

Stock JA; Cortez J; Scherz HC and Kaplan GW (1994)[40] studied a total of 77 patients with distal hypospadias who underwent a single stage hypospadias repair using a preputial free graft for neourethral construction and a preputial pedicle flap for ventral skin coverage. Of all the patients, 84% achieved excellent functional and cosmetic results with one procedure.

Table 21: Complication rates of inlay graft in various studies.

	No. of patients	Complications				
		Overall	Fistula	Stricture	Meatal stenosis	Diverticulum
Present study (2023)	20	3	2	0	1	-
Powellet al (2000)	34	27	21	3	6	3
Vyas et al (1987)	4	39.4	-	-	-	-
Rober et al (1990)	37	38	46	5.4	-	-

COSMETIC RESULT

Hinderer UT (2000) also emphasized the importance of a normal aesthetic appearance, resembling a circumcised penis, and with the meatus at the tip of the glans.

An abnormal aesthetic appearance affects the patient's body image and has a negative influence on his self-esteem. Psychological stress is brought on form genital comparison with schoolmates.

The cosmetic result was evaluated depending upon

1. Wound healing by secondary intention or infection
2. Meatus at tip
3. Glans shape maintained
4. Supple penile skin

They are divided into bad, fair, good and excellent as seen in Table 11. The cosmetic results are much better in group A with 14 out 20 (70%) having excellent cosmetic results while in group B, 5 out of 20 cases (25%) have excellent cosmetic result On comparison, z=2.453 which is significant at p<0.05.

In group A, 18 patients have good or excellent results (90%) whilein group B, 14 patients have good or excellent results (70%).

Ghali AMA (1999)[39] had described an excellent result as a cosmetically and anatomically normal-looking penis able to direct a forceful urinary stream. A minor defect that would require no further management was considered a satisfactory outcome. A complication was an anatomical or a functional defect that required surgical intervention. The management was considered to have failed when there was a complication that required complete reconstruction.

Table 22: Comparison of outcome (Ghali AMA, 1999 and present study).

Outcome	INLAY		SNODGRASS		Group A (Present study)	Group B (Present study
	Double	Single	Double	Single		
Excellent	83%	88%	46%	58%	14/20 (70%)	5/20 (25%)
Cosmetic defect	11%	4%	24%	8%	0/20 (0%)	2/20 (10%)
Complication	6%	8%	30%	34%	3/20 (15%)	8/20 (40.00%)

If the same criteria were applied to our study group and control group, similar results were obtained compared to single onlay flap in group A. The results in group B were similar to Dukett's double urethroplasty.

DELAYED COMPLICATIONS

Mild meatal stenosis is seen in one patient in group A and no patient have proximal stricture. In group B, 2 patients have proximal stricture formation and 2 patients have meatal stenosis.

Ghali AMA[39] treated strictures by dilatation (3/15), optical urethrotomy (6/15) resection anastomosis (2/15), patch urethroplasty (2/15) and complete reconstruction (2/15). In our series, only dilatation sufficed to treat the strictures.

POSTOPERATIVE CALIBRATION

This is done to assess the presence of meatal stenosis and proximal stricture formation. Most of the cases (5) (Table 12) required up to only 3 dilatations to reach a diameter of Hagar no 3/4 in group A.In group B only 4 patients required up to 3 dilatations. Thus there ismore incidence of proximal stricture formation in group B. On comparing the requirement of 4 or 5 times dilatation, only 2 patients in group A (10%) required dilatations 4 times while 11 patients in group B (55%) required 4 or 5 times dilatation.

TREATMENT OF FISTULA

Out of the 2 fistulae in group A, one closed spontaneously and 1 required operative treatment while 3 patients required operative treatment in group B (z=1.56, significant). All fistulas requiring operative treatment are corrected by local excision and layered closureof the fistulous tract.

Wiener JS et al (1997) concluded that tubularized repairs tended to have larger fistulas that required more complex repairs then onlay flaps.

SECOND OPERATION REQUIRED

A second operation is required in 3 patients in group B (15%) andonly 1 patients in group A (10%). Out of the 3 patients, 2 cases are of fistula repair and 1 of diverticulectomy. The 1 case reoperated in group A is of fistula.

OVERALL COMPLICATIONS

The number of overall complications is 3 in group A (out of 20, 15%) and 18 in group B (out of 20, 40%). 4 patients in group B have 2 complications together. On analysing the difference between the overall complications between the 2 groups statistically, z = 3.68 which is significant (p<0.05).

Chin TW et al (2001)[45] performed hypospadias repair in 15 subjects with a double onlay preputial flap and reported an overall complication rate of 13%.

PATIENT WISE OVERALL COMPLICATION

4 patients in group A developed complications while 13 patients in group B have complications. On analysis, z = 1.970 which is significant at p<0.05.

FOLLOW UP

Our follow up period ranged from 2 months to 30 months (mean 8.7 months). The mean follow up in group A is 8.5 months and in group B is 8.8 months. Further follow up is essential to include the incidence of delayed complications.

Powell et al (2000)[42] had cases of delayed presentation ofcomplications with one patients presenting at 22.9 months postoperatively with proximal stricture and fistula and emphasized the need for larger number of patients and longer follow up.

Lay L et al (1995) had a decrease in fistula rate from 25% to 11% in 10 years following vascularized tube graft indicating the existence of a learning curve.

We feel that the following are the advantages of free graft preputial inlay repair

1. Inlay repair has the advantage of easier dissection since the wholeurethra need not be mobilized. Powell et al (2000) also held this opinion. Graft harvesting is often easier than dissecting out the vascular pedicle of a flap.
2. Placing a thin graft on the urethra produces less tissue bulk, there is no torsion of the repair. This aids in skin closure, glandularreapproximation and improved cosmesis.
3. Second layer coverage prevents the formation of fistula
4. Urethral plate preservation may help to prevent the formation offistula.
5. The meatus is at tip in the final result
6. The glans shape is maintained.
7. The penile skin is supple.
8. The histology of inner preputial graft is similar to that of urethra next only to bladder mucosal graft. However, bladder mucosal graft is more time consuming and tedious and the results are not as satisfactory as free preputial graft.

All these factors conform to the desired end result of hypospadiasrepair.

Hypospadiologists must be cognisant with the general principles of repair and should be well versed in several techniques for all levels of hypospadias. The surgeon must have meticulous surgical technique and patient care for perfection in this ever flourishing field.

CONCLUSION

Forty patients of hypospadias are studied after dividing them into two groups. Group A patients are repaired by free preputial inlay graft urethroplasty (SNODGRAFT). In group B, tubularized incised plate uterthroplasty (SNODGRASS) are used to form the control group. The results are compared in terms of complication rate and cosmesis.

1. Most of the patients are between 4-6 years in age. The mean of the ages is 5.81 ± 2.35 years.

2. The presenting complains are thin stream in 17.5% and cosmetic deformity in 100% taking all the 40 cases together.

3. Majority of the patients are from rural background (77.5%).

4. 6 cases of distal penile hypospadias (3 in group A and 4 in group B) have associated meatal stenosis.

5. The mean penile length in 50 normal subject is 4.96 ± 0.48 cm (range 3-8 cm) at 6.12 ± 3.42 years (range 1-12 years).

6. The mean penile length in the cases of distal hypospadias, without chordee or with minimal chordee is 4.92 ± 0.51 cm (range 4-6.2 cm) at 5.81 ± 2.35 years (range 2-12 years).

7. There is a positive correlation between penile length and age both in 50 normal subjects ($r=0.529$) and 40 hypospadiac subjects ($r=0.239$).

8. The most common associated disease is undescended testis.

9. The mean length of the preputial graft is 21.75 ± 5.54 mm and breadth is 9.05 ± 1.02 mm.

10. The mean duration of urethral catheter drainage is 8.6 ± 1.36 days in group A and 8.4 ± 1.43 days in group B. On comparison, $t=0.11$ (non significant).

11. The most common complications noted are post operative oedema (2 cases in group A and 2 cases in group B) and fistula formation (2 cases in group A and 3 cases in group B). Diverticulum is seen in 1 case in group B and infection and healing by secondary intention is seen in 1 case in group B.

12. The cosmetic results are much better in group A with 70% cases having excellent results while in group B 25% cases have excellent cosmetic result. On comparing the difference between the two, $z = 2.45$ which is significant ($p<0.05$).

13. Mild meatal stenosis is seen in 1 patient in group A and 2 patients in group B. Two patients in group B (10%) have proximal stricture formation.

14. 10 patients in group B (50%) required postoperative urethral dilatation 4 times or more while only 2 patients in group A (10%) required 4-5 times dilatation. On statistical analysis, $z = 3.33$ is significant ($p<0.05$).

15. Out of the 2 fistulae in group A, one closed spontaneously and 1 required operative treatment. All the 3 fistulae in group B required operative treatment.

16. Second operation is required in 1 out of 20 patients (5%) in group A and 3 out of 20 patients (15%) in group B.

17. The overall complications seen in group A, 3 out of 20 (15%), are fistula in 10% and meatal stenosis in 5%. In group B the overall complications (40%) are fistulae in 15%, diverticulum in 5%, meatal stenosis in 10% and

proximal stricture formation in 10%.

18. Patient wise complications developed in 15% cases in group A and 40% cases in group B.

Tubularized incised plate utrethroplasty is associated with high of incidence of stricture formation. We have tried to modify the technique by using it as inner preputial inlay graft method thus avoiding the formation of stricture. This method of repair seems to be promising with better cosmetic and functional result. Inspite of having encouraging results we feel this is a learning phase and time will prove its superiority over other methods after long term follow up in more number of cases.

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