Distal urethral plate adhesions: New anatomical perspective in hypospadias

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Summary

Introduction
We found midline epithelial adhesions in the glandar urethral plate in patients with hypospadias. After dissolution, a blind epithelialized channel becomes visualized inside of the plate pointing to immature embryonic luminization. In addition it reveals that the epithelialized surface of the distal urethral plate is larger than previously considered.

Objective
To determine the incidence and extent of these new anatomical details of urethral plate in hypospadias patients.

Methods
We prospectively assessed the detailed anatomy of the urethral plate in 72 consecutive patients with hypospadias. We recorded the presence of adhesions in the middle of the glandar urethral groove that can be easily dissoluted (dissolution line – D-line). We recorded the plate width before and after D-line dissolution, the presence of the hidden blind channel at continuation of D-line (channel type-A) and of the visible blind channel between D-line and urethral hypospadiac meatus (type-B) (Figure). In 62 patients, where the urethral plate tubularization was considered (Duplay, TIP), septs between channels were opened in the midline and a final width of the plate was measured by rolling the plate around a tube.

Results
Midline adhesions (D-line) were found in all 72 patients. Mean length of D-line was 5.13 ± 0.17 mm. Mean plate width before dissolution was 5.9 ± 0.15 mm, and after dissolution 7.8 ± 0.16 mm. A blind channel of type A was detected in 22 patients (31%), type B in 24 (33%), type A and B in 16 (22%), and none in 10 patients (14%). Mean final plate width after D-line dissolution and opening of sept between channels in 62 patients with urethral plate tubularization was 8.7 ± 0.15 mm.

Discussion
The main contribution of our study is a new perspective of distal urethral plate anatomy that enables enlargement of the epithelialized surface of the distal urethral plate by dissolution of the pre-existing epithelialized groove and opening of epithelialized channels within the plate. To the best of our knowledge, this anatomical anomaly has not been described previously.

Conclusions
The distal urethral plate of all hypospadias patients is partially "folded" in the midline by epithelial adhesions of different depth and extent that may be easily dissoluted. In half of the patients (53%) the "folded" part of the plate continues proximally as a blind channel inside the urethral plate (type A channel). Opening of these structures together with the well-known urethral plate pits (type B channel) helps augment the width and the overall epithelialized surface of the distal urethral plate.

Figure Position of epithelialized groove and channels in distal urethral plate: (U) urethra; (B) channel type-B; (A) hidden channel type-A; (D) groove under D-line.
Introduction

We found that the distal urethral plate is not a flat epithelial strip of tissue, as historically reported in studies [1], but rather an epithelial groove hidden by synechiae (cellular adhesions) in the middle of glandar plate, that may be dissolved. This line of dissolution (D-line) depicted in Fig. 1, may continue proximally and more deeply as a blind luminized channel inside the plate. We found these hidden, not open parts of the plate to be completely epithelized (Fig. 2). Adhesion dissolution in combination with opening of blind channels augment the width of the epithelized urethral plate. This technical modification opens up a new perspective of urethral plate anatomy. To the best of our knowledge, this has not been described previously. We carried out a prospective pilot study to determine the incidence and extent of these anatomical details in hypospadias patients.

Material and methods

We prospectively studied detailed urethral plate anatomy in all consecutive patients with primary hypospadias repair operated on between August 2012 and March 2014. We excluded patients with redo urethroplasty and DSD patients. At the beginning of surgery the patients were assessed for the presence of midline adhesions of the distal urethral plate (D-line), the urethral plate width before and after dissolution of the D-line, length of midline adhesions, and for the presence of dorsal blind channels in the urethral plate. We distinguished two types of channels: Type A - a channel at continuation of D-line that became visible after adhesion dissolution only (Fig. 3); and Type B - a channel opening into the bridge between open D-line and hypospadiac urethral meatus (Fig. 4). In patients with a urethral plate suitable for tubularization and Duplay or TIP repair, we opened all detected channels. All the epithelized walls between D-line, A and (or) B channels and urethral meatus were incised in the midline, creating one large almost completely epithelized urethral plate. Its width was measured by rolling the plate around a catheter. In 10 patients with proximal hypospadias in whom tubularization was not possible because of a narrow and dysplastic plate, we did not open the channels and, instead, directly performed a flap reconstruction (Onlay, Onlay Inlay) or a double stage (Byars) urethroplasty.

To prove epithelization of the hidden groove under the D-line, we carried out histopathological examinations of the distal urethral plate in two boys with severe penoscrotal hypospadias, in whom the short urethral plate was completely excised and a double stage urethroplasty performed. Additionally, we examined the penis of an aborted child of 20 weeks of gestation with hypospadias and Wolf–Hirschhorn syndrome 45XY,del(4)(p13)t(4,21)(p13,q11) (Fig. 2).
Figure 3  Distal urethral plate with channel type-A only: (A) D-line before dissolution, channel type-A is not visible; (B) opening of adhesions makes channel type-A visible. Arrow indicates entry into the channel; (C) enlarged plate after D-line dissolution and channel type-A opening (incision).

Figure 4  Distal urethral plate with channel type-B only: (A) D-line before dissolution, channel type-B is visible; (B) after adhesions dissolution, arrows indicate entry into the channel, (C) enlarged plate after D-line dissolution and channel type-B opening (incision).
Results

A total of 72 patients was assessed during the study period. Patient age ranged from 18 to 140 months, with a mean of 38.7 months. Sixty-two patients (86%) had distal and 10 (14%) proximal hypospadias. No patient was treated with preoperative hormone therapy. The mean length of distal urethral plate synchiae (D-line) was 5.13 ± 0.17 mm. Mean plate width before dissolution was 5.9 ± 0.15 mm, after dissolution 7.8 ± 0.16 mm. A solitary blind channel of type-A was detected in 22 patients (31%), solitary type-B in 24 (33%), both type-A and B in 16 (22%), and none in 10 (14%) patients. In 62 patients, where the urethral plate tubulization was considered (Duplay, TIP repair), sept between channels were opened in the midline and the final width of the plate was measured by rolling the plate around a tube. Mean final plate width after D-line dissolution and opening of sept between channels in these 62 patients with urethral plate tubulization was 8.7 ± 0.15 mm. Histopathological studies of an aborted hypospadic child and two children with severe penoscrotal hypospadias have shown that adhering D-line is in fact a hidden groove under the distal urethral plate completely lined with epithelium (Fig. 2).

Discussion

The concept of modern hypospadias repair is based on urethral plate preservation, if the urethral plate is wide and of good quality. The term urethral plate is transferred from embryology and is commonly applied to the strip of tissue that extends distal from the hypomorphic meatus to near the tip of the glands. Historically it has been thought to contribute to the ventral penile curvature [2]. Anatomical studies demonstrated that the urethral plate consisted of epithelium overlying well vascularized and nerve supplied connective tissue and made urethral plate the most valuable tissue in hypospadias surgeons’ hands [3,4].

After having accidentally noticed the new anatomical details, we started assessing detailed penile anatomy in patients with hypospadias. We noticed a short line of adhesions along the long axis of glandar urethral plate that could be dissolved easily, uncovering an epithelialized groove in the distal plate. This maneuver made the plate significantly wider. We reviewed existing anatomical studies of hypospadias and did not find any notion about this anatomical detail. Interestingly, studying histopathologic images published in the Baskin anatomical study from 1998 [5], that concentrated on the anatomy of the penile dorsal neurovascular bundle on fetuses with hypospadias, we found an epithelial groove in the middle of distal urethral plate, that was not commented in the study. We tried to confirm this detail in our material. Histopathological examinations of distal urethral plate of a hypospadias aborted child proved that the distal urethral plate contains a fully epithelialized groove. Its walls adhere together, creating a visible line on the plate surface that we called the dissolution line (D-line) (Fig. 2). A similar finding was found on histological examination of the excised urethral plate in two of our children with penoscrotal hypospadias.

We aimed to clarify prospectively the incidence of D-line in patients with hypospadias, and the impact of its dissolution on width of the distal urethral plate. The primary outcome of our study was a finding of the glandar D-line in all patients of our group. The length of the D-line was quite similar (5.13 ± 0.17 mm); however, the extent (depth) of adhesions differed. The adhesions were uniformly present in all cases even in patients with proximal hypospadias. In some patients with a deep balanic groove, the adhesions were shallow and almost dissolved, in others they were more pronounced. In our experience, D-line adhesions become less visible with age, probably because of spontaneous separation of the adhering epithelized surfaces, just as in the case of spontaneous separation of adhering foreskin from the glans in young boys. Dissolution of the D-line made the most distal part of the plate wider by a mean of 1.9 mm (from 5.9 to 7.8 mm).

The secondary outcome was histological confirmation of the epithelial groove. The uniform presence of a D-line even in patients with penoscrotal hypospadias, in whom we had to excise and replace the plate, and a rare opportunity to examine an aborted fetus with hypospadias in Wolf–Hirschhorn syndrome, allowed for histopathological studies of prenatal and postnatal urethral plates. In all three cases we found an epithelialized groove in the glandar urethral plate. Our findings are consistent with Hadidi’s recent embryological studies showing that the glanular urethra passes through four developmental stages: a solid epithelial plate, a blind central canal, a deep glanular groove, and, finally, the floor formation from the preputial lamella [6]. The two consequent mechanisms: an initial “opening zipper” that facilitates distal canalization of the solid urethral plate to form the urethral groove, and a “closing zipper” facilitating fusion of the two epithelial surfaces of the urethral groove, appear to be universal steps in human male urethral formation [7]. We hypothesize that a disruption of a “closing zipper” results in an arrest in groove stage. Septs between D-line groove and channels type A and (or) B may represent a disruption of an “opening zipper”.

The tertiary outcome was discovery of an additional blind epithelialized channel inside of the plate, entering the lower pole of the D-line, that was visualized only after D-line dissolution. It was detected in a subgroup of 38 (53%) patients. To distinguish the channels of the urethral plate, we classified them as a type-A (a blind channel at continuation of D-line) and type-B (a channel emptying into the bridge between D-line and urethral meatus). The position of the channels is shown in the Summary Figure and Figs. 3, 4. Dissolution of D-line together with opening of blind channels enlarged the plate width, and contributed to augmentation of its epithelialized surface. This manoeuvre helps the surgeon to open the urethral plate exactly in the middle.

This new perspective of distal urethral plate anatomy, allowing enlargement of its epithelialized surface, is important in light of ongoing discussion concerning persistence of the positive effect of the relaxing midline incision, as described by Orkiszewski [8] and Snodgrass [9–11].

We consider our study a pilot anatomical study with a limited number of patients. The clinical outcome, that is the impact on long-term status of the neourethra and
urinary flow after hypospadias repair, is yet to be elucidated by further follow-up. We believe it would be practical to include these anatomical details in a future hypospadias classification.

Conclusions

The distal urethral plate of hypospadias patients hides a midline epithelial groove underneath epithelial adhesions of different depth and extent, that may be easily dissolved. In half of patients (53%) this continues as a blind channel in the midline inside of the urethral plate (type A-channel). Opening of these structures together with the well-known urethral plate pits (type B-channel) helps augment the width and the overall epithelized surface of the distal urethral plate. This changes anatomical conditions at the very beginning of surgery; however its clinical impact on performance of surgery and postoperative outcome is yet to be elucidated by further follow-up study.

Conflict of interest

None.

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References