A New Modification of the Koyanagi Technique for the One-stage Repair of Severe Hypospadias

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OBJECTIVE
To describe a new modification of the Koyanagi technique for the one-stage repair of severe hypospadias and its short-term outcomes.

PATIENTS AND METHODS
Our modified Koyanagi technique was performed in 24 patients with severe hypospadias between February 2012 and January 2015. The age of the patients ranged from 1.9 to 11.9 years (mean = 3.5 years). The flap design was similar to the Koyanagi technique, but our modified technique highlighted the following points: after the chordee was completely corrected, the urethral plate was recreated using foreskin, and then a U-shaped incision was made on the original and recreated urethral plate (as in the Duplay technique); a pedicled flap of the tunica vaginalis or scrotal dartos was used for additional coverage of the neourethra.

RESULTS
The operation time lasted from 120 to 150 minutes (mean = 140 minutes). There were 5 patients (20.8%) who developed complications: 4 patients (16.7%) developed a fistula and 1 patient (4.2%) developed dehiscence of the urethra. There were no reported urethral strictures, meatal stenosis, or urethral diverticula. The complications in the 5 patients were successfully addressed with secondary repair, and all patients achieved satisfactory cosmetic and urethral functional results.

CONCLUSION
The modified Koyanagi technique simplified the operation and better preserved the blood supply to the flap. The additional coverage of the neourethra using a pedicled flap of the tunica vaginalis or scrotal dartos significantly decreased the rate of fistula formation. This technique is highly suitable for the one-stage repair of severe hypospadias with penoscrotal transposition.
than 2.5 cm straight, we applied extra hormonotherapy 3-6 months before surgery. We used a cream that was made of testosterone propionate (25 mg) and vaseline (10 g), applying locally and externally, 2 times a day, and lasting for 1 month. A total of 6 cases were managed with topical hormonotherapy in our study.

Technique

After general and caudal anesthesia, an 8-10 Fr silicone double lumen balloon catheter was placed, the size of which depended on the development of the penis and the urethra. A circumferential incision was made 5-8 mm proximal to the coronary sulcus, and then the foreskin and penile skin were degloved to the base of the penis between Buck’s fascia and the dartos fascia. The urethral plate and the fibrous bands were dissociated to the base of the penile to correct the chordee (Fig. 1A). Usually, we achieved satisfactory effect beyond the penoscrotal junction. An artificial erection test was performed after the debonding work was completed. Ventral penile lengthening or dorsal plication was carried out if the chordee was still present. A middle incision was made at the ventral side of the glans, carefully dissecting the glans as a pair of wings. A 1.5-2 cm full-thickness incision was made at the midline of the dorsal prepuce of the penis (Fig. 1B). The prepuce was transferred to the ventral side (Fig. 1C), and the distal aspects of the prepuce and the top of the glanular wings were sutured (Fig. 1D). The incisional edges of the foreskin were continuously sutured with 6-0 monocryl to reconstruct the urethral plate, and the foreskin was fixed to the penile albuginea by 3-5 stitches. A 1.5-1.8 cm width U-shaped incision was outlined by a marking pen surrounding the original meatus and extending to the distal aspect of the penis (Fig. 1E). The skin was then incised along with these markings. The fascia lateral to the U-shaped flap was dissociated about 1-1.5 cm carefully. The outer edges of the flap were sutured together in two layers via a continuous knock suture with 6-0 monocryl (Fig. 1F). The neourethral meatus was sutured and the penile glans was reconstructed. A 1.5 cm-width pedicled flap of the tunica vaginalis was dissected carefully, and the lateral edges of it were sewed to the ventral fascia of the penile by interrupted sutures. That way insured an additional coverage for the neourethra, which may reduce the postoperative complication rate (Fig. 1G,H). The scrotal dartos could be another choice for the additional coverage if it was abundant enough. Penoscrotal transposition would be corrected partly after the scrotoplasty. Residual foreskin was used for the phalloplasty (Fig. 1I), and a piece of rubber was placed in the scrotum for drainage, which was removed within 24-48 hours. After the procedure, a pressure dressing was used to cover the wound for at least a week. The catheter was kept in place for 12-14 days.

Figure 1. (A) Degloving and chordee correction. (B) A full-thickness incision was made at the midline of the dorsal prepuce. (C) The prepuce was transferred to the ventral side. (D) The distal aspects of the prepuce and the top of the glanular wings were sewed together. (E) The urethral plate was reconstructed. The dash line was the marker of the U-shaped incision. (F) The vascularized pedicle was dissociated, and the outer edges of the flap were sutured to reconstruct the neourethra. (G, H) The neourethra was covered with a pedicled flap of the tunica vaginalis. (I) Phalloplasty and scrotoplasty.

RESULTS

All 24 patients underwent the modified Koyanagi technique for the one-stage repair and the penoscrotal transposition was corrected partly. The operation time ranged from 120 to 150 minutes (mean = 140 minutes). The follow-up period ranged from 6 to 34 months (mean = 11 months). The length of the neourethra ranged from 3 to 7 cm (mean = 4.5 cm). Ultimately, 5 patients developed complications, which consisted of fistula (n = 4) and dehiscence of the urethra (n = 1), but no patient experienced meatal stenosis, urethral stricture, urethral diverticulum, bleeding, rotation, or recurrent curvature. As with the prior 7 cases, we did not use the tunica vaginalis or scrotal dartos for additional coverage, and there were 3 fistulas belong to this group. We started from the 8th case to use the additional coverage (12 with tunica vaginalis and 5 with scrotal dartos), and another fistula belong to this group. All 5 patients with complications had their procedures performed earlier in the study. These complications were treated with minor secondary operations 1 year after the hypospadias repair. We evaluated the urethral function by observing micturition and measuring uroflow rate. In our study,
we got urinary flow rate data of 18 cases in total, with average flow rate of 5.9-11.2 mL/second and maximum flow rate of 6.7-13.2 mL/second. All patients ultimately achieved excellent functional and cosmetic results (Supplementary Fig. S1). A total of 3 patients underwent ventral penile lengthening, which was accomplished by albuginea incising and tunica vaginalis patch repairing. There was no complication that happened in the 3 cases.

**COMMENT**

Severe hypospadias is a challenge for pediatric urologists, and there is still great disagreement on the ideal surgical approach, especially with regard to staged or one-stage operations. Some reports in the literature have shown that staged repair results in better cosmetic outcomes and urethral function, but other surgeons have emphasized that the outcomes of one-stage repair have been acceptable and that postoperative complications could be addressed with minor operations. A systematic 20-year review suggested that staged repair led to fewer complications, although 70% of patients who underwent one-stage repair did not require secondary operations.

In the early 1980s, Koyanagi et al described the creation of a parameatal foreskin flap for the one-stage repair of proximal hypospadias. However, the technique was not used widely due to its high complication rate of 47% in the largest series of cases as reported by Koyanagi et al. Even so, the advantages of the technique are numerous: there are no anastomoses between the neourethra and the original meatus, effectively reducing the rate of urethral stricture; the procedure always ensures that there is a sufficient flap for the neourethra; the penoscrotal transposition can be corrected simultaneously. Although Nonomura et al argued that the flap had sufficient microcirculation for the urethroplasty; the high complication rate was mainly attributed to the poor blood supply. Table 1 shows the complications in using the original Koyanagi technique as reported in the literature.

Snow and Cartwright reported a modification of the Koyanagi technique that significantly improved the blood supply, although there was still a 50% complication rate (2/4 cases). Hayashi et al described a similar modification that preserved the entirety of the vascularized pedicle of the preputial skin, with the flap ventrally advanced through a buttonhole, achieving an acceptable complication rate of 30% (6/20 cases), including a 15% rate (3/20 cases) of meatal stenosis. Hayashi et al made a further modification to the technique to reduce the rate of meatal stenosis, and reported no cases with this complication and with a total complication rate of 8.3% (1/12 cases). Emir et al demonstrated another modification of the Koyanagi technique that protected the blood supply, similar to other modifications, and they emphasized that a circumferential anastomosis between the glans and the neourethral meatus should be large enough (20 Fr) to reduce the risk of meatal stenosis, which resulted in an initial success rate of 80% (16/20 cases). Sugita et al also published a series of 151 cases of severe hypospadias that underwent urethroplasty with their modified Koyanagi technique, resulting in excellent outcomes with a total complication rate of only 15.9% (16/151 cases). Nevertheless, in the modification described by Sugita et al, penoscrotal transposition was not simultaneously corrected during the hypospadias repair. Table 2 shows the complications in using modified Koyanagi techniques as reported in the literature.

At our institution, we have employed the Hayashi-modified Koyanagi technique for severe hypospadias since 2001, and have obtained an acceptable complication rate of 16.5% (16/97), as presented in Table 2. Despite over 10 years of experience with this technique, we still felt that it was difficult to dissect the vascularized pedicle, and the operation always lasted more than 3 hours. Based on these shortcomings, we made a new modification of the technique in 2012.

As described above, our modification emphasized the following points:

1. After the chordee was completely corrected, the urethral plate was reconstructed using foreskin, and a U-shaped incision was subsequently made on the original and recreated urethral plate (as performed in the Duplay

**Figure 2.** Intraoperative photos: (A) Degloving and chordee correction. (B) Incision of the dorsal prepuce. (C) The prepuce was transferred ventrally and sewed to the glanular wings. (D) The urethral plate was reconstructed. The U-shaped incision was outlined by a marking pen. (E) The pedicle was dissociated carefully. (F) The neourethra was reconstructed. (G, H) The pedicled flap of the tunica vaginalis was dissected and covered on the neourethra. (I) Phalloplasty and scrotoplasty. A piece of rubber was placed for drainage.
technique). This shortened the width of the vascularized pedicle and made dissection easier, which can be proven by the shortened operation time. The modification also better protected the blood supply to the flap to some extent, because the pedicle of the flap was less dissociated.

(2) The additional coverage of the tunica vaginalis or scrotal dartos on the neourethral ventral side significantly decreased the risk of urethrocutaneous fistula, while also making phalloplasty safer and easier because of the additional coverage. This technique has previously been applied in hypospadias surgery with excellent results.24,25

In our study, the primary outcomes were satisfactory, with a 20.8% complication rate that was a little higher than the rate reported in the case series of the Hayashi-modified Koyanagi technique. We attribute this slightly higher complication rate to the learning curve of adopting this modified technique, with all complications occurring in the first 15 cases. Of the 4 cases with fistulas, 3 of them belong to the 7 cases without additional coverage of tunica vaginalis or scrotal dartos, and we thought these 3 fistulas were mainly attributed to the weakness of the local tissue and its poor anti-inflammatory ability. Another fistula that happened to a case with additional coverage of tunica vaginalis was due to local infection, which appeared with some purulent secretion on the sixth day postoperatively. The only one urethral dehiscence was caused by ischemia of the flap.

To reduce the complication rate, a microdissection electrocautery needle was used for hemostasis, and a piece of rubber for drainage was necessary. Furthermore, we kept the catheter for 12-14 days postoperatively, which was also expected to improve outcomes.

CONCLUSION
Our modified Koyanagi technique simplified the operation obviously, and effectively preserved the blood supply to the flap and residual foreskin. Moreover, the use of the tunica vaginalis or scrotal dartos significantly decreased the rate of fistula. Despite the learning curve, all cases achieved excellent functional and cosmetic results. Our modified Koyanagi technique is highly suitable for the one-stage repair of severe hypospadias, especially in cases with severe chordee and penoscrotal transposition.

References

Table 1. Complications using the original Koyanagi technique as reported in the literature

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Table 2. Complications using modified Koyanagi techniques as reported in the literature

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* Performed with the Hayashi-modified Koyanagi technique.


APPENDIX

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.urology.2016.03.032.