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# Long-term outcomes of the Kropp and Salle urethral lengthening bladder neck reconstruction procedures

K.M. Szymanski, R.C. Rink, B. Whittam, J.D. Ring, R. Misseri, M. Kaefer, M.P. Cain

Division of Pediatric Urology, Riley Hospital for Children, Indiana University School of Medicine, Indianapolis, IN, USA

Correspondence to: R.C. Rink, Robert A. Garrett Professor of Pediatric Urologic Research, Department of Pediatric Urology, Riley Hospital for Children, Indiana University School of Medicine, 705 Riley Hospital Dr., ROC #4230, Indianapolis, IN 46202, USA, Tel.: +1 317 948 8554; fax: +1 317 948 7481

rrink@iupui.edu (R.C. Rink)

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## Summary

### Introduction
The Kropp and Salle procedures have shown good short-term outcomes for managing neuropathic urinary incontinence. However, few studies have assessed their long-term results.

### Objective
This study aimed to evaluate the long-term outcomes of Kropp and Salle procedures, including: dryness, secondary interventions for incontinence or complications, upper urinary tract changes, and use of urethral catheterizations.

### Study design
Consecutive patients undergoing Kropp and Salle procedures at the present institution (1983–2012) were retrospectively reviewed. Patients with <1-year follow-up or prior bladder neck (BN) continence procedures were excluded. Data were collected on postoperative dryness per urethra at 4-hourly and 3-hourly intervals, secondary interventions, lab tests, and imaging. Non-parametric tests were used for statistical analysis.

### Results
Thirty-eight patients had Kropp (K: 30 boys) and 12 had Salle procedures (S: 8 boys). Patients underwent surgery at similar median ages (K: 7.4 vs S: 8.7 years old, $P = 0.51$) and had similar median follow-up (6.9 vs 10.3 years, $P = 0.10$). Most patients had myelomeningocele, a prior/concomitant bladder augmentation (K: 73.7%, S: 58.3%) and catheterizable channel (K: 81.6%, S: 50.0%). Differences in all outcomes between Kropp and Salle procedures were statistically non-significant. The majority of patients did not have additional BN procedures for dryness (K: 84.2%, S: 66.7%). Of this group, K: 81.3% and S: 75.0% were dry for ≥4 h, K: 93.8% and S: 87.5% were dry for ≥3 h between catheterizations (Table). Of the minority of patients who underwent additional BN procedures for dryness (K: 15.8%, S: 33.3%), most achieved dryness for ≥4 h (K: 66.7%, S: 100%) and ≥3 h (100% for both). Among patients without an initial catheterizable channel, 57.1% had one subsequently created after a Kropp procedure, and 33.3% after a Salle. Among patients without bladder augmentation, approximately half underwent delayed augmentation (K: 50.0%, S: 40.0%). Ultimately, most patients required a secondary intervention under anesthesia for incontinence or complications (K: 79.0%, S: 66.7%). Few patients developed worsening hydronephrosis, vesicoureteral reflux or renal function (K: 2.6%, S: 0.0%). At the end of follow-up, few patients catheterized per urethra (K: 10.5%, S: 33.3%).

### Discussion
This was a retrospective study without urodynamic data. Originating from a tertiary center, the results may not apply to other clinical settings.

### Conclusions
At the present institution the Kropp and Salle procedures attained similar dryness in 75–81% at 4-hourly intervals and 88–94% at 3-hourly intervals without additional BN procedures. Few patients required subsequent BN procedures to achieve dryness. However, the overall need for secondary procedures during long-term follow-up was high for both procedures.

**Summary table** Dryness after urethral lengthening procedures.

| Dryness | Kropp | | Salle | | *P*-value |
|---|---|---|---|---|---|
| Secondary bladder neck continence surgery | No ($n = 32$) | Yes ($n = 6$) | No ($n = 8$) | Yes ($n = 4$) | |
| 4 h or longer | 81.3% | 66.7% | 75.0% | 100.0% | 0.65 |
| 3 h or longer | 93.8% | 100.0% | 87.5% | 100.0% | 0.50 |
| Overnight | 90.6% | 100.0% | 87.5% | 50.0% | 0.99 |

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## Introduction

Management of neuropathic urinary incontinence continues to be a challenge in children. Conservative management with anticholinergics and CIC achieves success in 34—81% [1—4]. Several surgical techniques have been developed to address low urethral impedance to achieve sufficient bladder outlet resistance, including: bladder neck (BN) bulking injections, BN slings, artificial urinary sphincters, BN narrowing and reconstructions, and urethral lengthening procedures [5].

The Kropp [6] and Salle urethral lengthening procedures [7] were described in 1986 and 1994, respectively, to manage neuropathic urinary incontinence while allowing catheterizations per urethra in an era before routine use of catheterizable urinary channels. Both procedures narrowed and lengthened the urethra while creating a flap-valve mechanism, and both demonstrated encouraging short-term outcomes [8—19]. However, current literature examining long-term outcomes of these procedures is sparse [13], while a direct comparison of these techniques is completely absent.

This study aimed to evaluate the long-term outcomes of Kropp and Salle procedures at the present institution, including: dryness, secondary interventions for incontinence and complications, upper urinary tract outcomes, and using the urethra to catheterize. Based on the unpublished, short-term results, dryness was anticipated to be significantly higher after Kropp than Salle procedure.

## Methods

An IRB-approved, retrospective, single center review of consecutive patients who underwent Kropp or Salle procedures (1983—2012) was performed. Patients with a prior BN procedure or <1-year follow-up were excluded. Data were collected on demographics, initial surgery, postoperative dry periods per urethra, and subsequent procedures performed under general anesthesia. Dryness was defined as dry per urethra for ≥4 h between catheterizations. As secondary outcomes, dryness per urethra using a 3-hourly interval and overnight was also assessed. Since the primary goal of a urethral lengthening procedure is urinary dryness, two groups of patients were analyzed: those who did not and those who did undergo additional BN procedures after failure in achieving dryness. In an effort to comprehensively assess subsequent interventions, BN procedures were analyzed for dryness separately from other procedures. A primary vesicourethral fistula was defined as persistent incontinence after surgery, without postoperative dryness, which was confirmed endoscopically. Those with secondary fistulas had documented postoperative dryness followed by continuous incontinence. Febrile UTI had a positive urine culture with fever ≥38 °C.

Choosing between Kropp and Salle procedures was largely based on surgeon preference. Salle procedures (three surgeons) were performed earlier in the series than Kropp procedures (five surgeons) (median surgery in 1996 vs 2005, $P = 0.001$); two surgeons performed both procedures.

Fisher's exact test and Mann—Whitney U tests were used for statistical analysis, with a critical $P = 0.05$. Analysis was performed using Stata v10.1 (Stata-Corp, College Station, TX).

## Results

Of the 59 patients who underwent a urethral lengthening procedure, 50 met inclusion criteria. Four patients were excluded who were followed by urologists at other institutions after a Kropp procedure, and subsequently had <6 months follow-up at the present institution. Five other patients were excluded due to prior BN surgery (K: 1 BN sling followed by an artificial urinary sphincter, 1 BN Deflux injection; S: 2 BN sling, 1 Young-Dees-Ledbetter BN reconstruction and Deflux injection).

### Demographics

Overall, 38 patients had a Kropp (K: 30 boys) and 12 had a Salle procedure (S: 8 boys) performed by one of six surgeons (Table 1). Differences in baseline characteristics between Kropp and Salle procedure groups did not reach statistical significance ($P \geq 0.09$). Most patients had myelomeningocele (K: 89.5%, S: 91.7%) and a ventriculoperitoneal shunt (K: 81.6%, S: 58.3%). Patients underwent surgery at similar median ages (7.4 vs 8.7 years old, respectively, $P = 0.51$), with similar follow-up (6.9 vs 10.3 years, respectively, $P = 0.10$). Baseline age-adjusted creatinine was normal for all patients.

### Prior and concomitant procedures

Five patients (13.2%) underwent ureteral reimplantation during the Kropp, and five (41.7%) during the Salle procedure. Accounting for patients who underwent ureteral reimplantation beforehand, 10 (26.3%) and six (50.0%) patients had ureters reimplanted before or during the Kropp and Salle procedures, respectively ($P = 0.16$).

Most patients underwent bladder augmentation at the start of follow-up (K: 73.7% vs S: 58.3%, $P = 0.47$). One bladder was augmented with sigmoid and the remainder with ileum. Similarly, at least half of patients had a continent catheterizable urinary channel at the start of the study (K: 81.6%, S: 50.0%, $P = 0.06$).

### Secondary bladder neck procedures for dryness

During follow-up, the majority of patients did not undergo additional BN procedures for dryness (K: 84.2%, S: 66.7%, $P = 0.26$). Of this group, at least 3/4 were dry for ≥4 h (K: 81.3%, S: 75.0%) and 9/10 were dry for ≥3 h (K: 93.4%, S: 87.5%). Similarly, 9/10 were dry overnight (K: 90.6%, S: 87.5%) (Fig. 1). There were no statistically significant between-group differences for dryness measured at any interval ($P \geq 0.50$).

The minority of patients underwent additional BN procedures for dryness, having not achieved satisfactory dryness immediately after surgery (K: 6, 15.8%, S: 4, 33.3%, $P = 0.26$). These patients underwent one additional BN continence procedure each, except for one patient who had two Deflux injections (Table 2). At least 2/3 achieved