Defining The Learning Curve of Flexible Ureterorenoscopy and Laser Lithotripsy

Cem Kezer[1], Faruk Ozgor[2]*

Purpose: To investigate the impact of learning curve (LC) on flexible ureterorenoscopy (f-URS).

Materials and Methods: Patients who underwent kidney stone surgery in a urology clinic from a tertiary health care institution with f-URS were enrolled in the study. Patient characteristics, the properties of kidney and kidney stones were recorded. Also, f-URS-related parameters, hospitalization time, the success of the procedure, and complications were noted. Patients were categorized equally into 4 groups, the first 20 f-URS cases in Group 1, and the last 20 f-URS cases in Group 4. Groups were compared according to patient preoperative parameters, intraoperative outcomes, success rate and complication rate.

Results: Time from the induction of anaesthesia to insertion of flexible ureterorenoscope was 18.6 min in group 1 and 17.2 min in group 2; then it significantly decreased to 15.0 min for cases 40 through 60 and 12.4 min for cases 60 through 80 ($p = 0.001$). Operation time in group 3 and group 4 was significantly shorter than in group 1 and group 2 ($p = 0.001$). Also, fluoroscopy time was significantly longer in group 1 (82.9 seconds) and reached a plateau in group 3 (50.3 seconds) and group 4 (41.7 seconds) ($p = 0.001$). Additionally, after the 20th case, we achieved a significantly higher success rate in comparison to the first 20 cases (65% in group 1, 85% in group 2, 85% in group 3, and 90% in group 4, $p = 0.001$).

Conclusion: Flexible ureterorenoscopy is a surgery that requires high technique and experience. The present study found that success of f-URS reached satisfactory levels after 20th cases. In addition, 40 cases may be enough for surgical proficiency regarding decreases in preparation time, operation time, and fluoroscopy time.

Keywords: flexible ureterorenoscopy; learning curve; lithotripsy; success

INTRODUCTION

Flexible ureterorenoscopy (f-URS) is an endoscopic surgery which is used in diagnosis and treatment of pathologies of the upper urinary system. Although f-URS can be used for cancers and obstructions of the upper urinary tract, the main indication for f-URS is kidney stones[(1)]. According to European Urology Association Urolithiasis guidelines, f-URS is the preferred surgical method for kidney stones smaller than 20 mm, achieving higher stone free status compared to Shock Wave Lithotripsy and associated with lower complication rates compared to percutaneous nephrolithotomy (PNL)[(2)]. Stone size, possible stone composition, anatomy of the kidney, clinician and patient preference are important factors in the choice of treatment[(3)]. Percutaneous nephrolithotomy is the gold standard treatment for kidney stones larger than 2 cm[(4)]. For stones between 1-2 cm, all modalities may be appropriate, but the success of SWL seems to be low for kidney lower pole stones[(3)].

The learning curve (LC) is defined as the period and/or number of operations an average surgeon requires in order to perform an operation with acceptable success and complication rates according to the literature[(4)]. Previous studies investigated the LC of different surgical procedures and studies stated that different surgical procedures have unique learning curves. Sahan and colleagues investigated the LC for supine mini PNL, and emphasized that surgeons achieved satisfactory success rate and complication rate after 45 mini PNL cases[(6)]. In another study about LC in robotic-assisted laparoscopic retroperitoneal lymph node dissection, Sophia et al. found significant decreases in complications and operation time after 44 cases[(7)].

Although previous reports analysed the LC of different stone surgery methods, no study has evaluated the LC for f-URS. This study is the first prospective research to investigate to LC for f-URS.

MATERIALS AND METHODS

The present study was planned according to the principles of the Helsinki Declaration from July 2017 to July 2020. Patients who underwent kidney stone surgery with f-URS were enrolled in the study. Eighty patients were included in the study. All f-URS operations were done by one surgeon, who had experience of 250 ureterorenoscopy and 100 PNL cases. Also, the surgeon observed 100 f-URS cases and participated in a 12-hour f-URS course including a simulation programme and dry laboratory. Patients with kidney stone $\leq$ 20 mm were accepted as candidates for f-URS. Patients with renal abnormalities, and with history of coagulopathy

[1]Department of Urology, Erdem Hospital, Istanbul, Turkey.
[2]Department of Urology, Haseki Training and Research Hospital, Istanbul, Turkey.
*Correspondence: Haseki Training and Research Hospital, Millet Street, Istanbul, Turkey.
Tel: +90 536 728 63 12. Fax: +90 212 585 44 00. E-mail: md.farukozgor@gmail.com
Received August 2022 & Accepted November 2022

Table 1. Demographic and postoperative data of all patients.

	N = 80
Age (years)*	44.6 ± 14.6
Sex	
Male	52 (65%)
Female	28
BMI (kg/m²)*	28.0 ± 5.2
ASA score	
ASA 1	58 (72.5%)
ASA 2-3	22
History of previous stone surgery	19 (23.7%)
Stone opacity (non-opaque)	6 (7.5%)
Stone localization	
Upper	31 (38.7%)
Pelvis	28 (35.0%)
Lower	11 (13.8%)
Multiple	10 (12.5%)
Stone size (mm)*	12.5 ± 3.8
Presence of hydronephrosis	38 (47.5%)
Operation side	
Right	46 (57.5%)
Left	34
Success	65 (81.2%)
Complications	6 (7.5%)
Minor (Clavien-Dindo grade 1-2)	5 (6.3%)
Major (Clavien-Dindo grade 3-5)	1

*mean ± standard deviation
BMI: Body mass index, ASA: American society of anesthesiologists

were excluded from the study. Also, bilateral f-URS cases, patients < 18 years of age, patients with history of ureteral stenosis, and patients with positive urine culture operated under antibiotic regimen were excluded. Patient characteristics and operative parameters were noted. F-URS-related parameters, hospitalization time, complications, and success were recorded. Patients were categorized into four groups, as the first 20 f-URS cases in Group 1, and the last 20 f-URS cases in Group 4. Groups were compared in regards of patient preoperative data, operative parameters, success rate, and complication rate.

Surgical technique

Under general anesthesia, a safety guide wire was inserted into renal pelvis. After, ureterorenoscopy was performed for direct visualisation of the ureter and passive dilatation of the ureter to facilitate insertion of the ureteral access sheath (11-13 Fr diameter). Fibre optic f-URS (Storz FLEX-X2, Tuttlingen, Germany) was used and stone fragmentation was done with 200 or 273 µm laser fibre. Stone retrieval was performed with nitinol baskets. At the end of the operation, 4.8 F JJ stent was inserted under fluoroscopy guidance.

The presence of any residual stone was evaluated by kidney-ureter-bladder (KUB) graphy on the first day after the operation. Final stone free status was assessed with non-contrast abdominal computed tomography in the third postoperative month. Success was accepted as the absence of any stone.

Statistical analysis

Study sample size analysis was computed using the G*Power (Erdfelder, Faul, & Buchner, 1996) program. The study of Jang et al. was used as a pilot study to calculate the sample size[8]. To obtain a significance of $\alpha = 0.05$, and 90% power ($1-\beta = 0.9$), the required sample size per group was at least 16. Statistical analysis was done by using Statistical Package for the Social Sciences version 20 (SPSS IBM Corp., Armonk, NY, USA). The distribution of continuous variables was determined by Shapiro–Wilk test. One-way ANOVA test was used for the comparison of continuous variables. Levene's test was performed to evaluate the homogeneity of variance. Tukey test and Games-Howell test were used for post hoc analysis to compute pairwise comparisons. For categorical variables, Chi Square test was used for binary, outcomes with large expected cell counts and Fisher s exact test for small cell counts. The data were analysed at 95% confidence level and P value of less than 0.05 was accepted as statistically significant.

RESULTS

Total 80 participants were divided into four groups and 14 patients were excluded (eight patients had JJ stent, one patient had nephrostomy tube, two patients underwent bilateral f-URS operation, one patient had pelvic kidney, one patient was operated under antibiotic regimen and one patient was under 18 years of age). The mean age of participants was 44.6 ± 14.6 years, and 52 (65%) patients were male. The most common stone lo-

Table 2. Comparison of preoperative demographic data between groups

	Group 1 (n=20)	Group 2 (n=20)	Group 3 (n=20)	Group 4 (n=20)	*P* value
Age (years)*	47.6 ± 13.8	46.7 ± 15.6	41.3 ± 13.6	42.6 ± 15.6	0.359
Sex					0.988
Male	12 (60%)	13 (65%)	14 (70%)	13 (65%)	
Female	8 (40%)	7 (35%)	6 (30%)	7 (35%)	
BMI (kg/m²)*	28.3 ± 5.0	27.7 ± 5.5	27.1 ± 5.4	29.0 ± 5.3	0.692
ASA score					0.920
ASA 1	15 (75%)	13 (65%)	15 (75%)	15 (75%)	
ASA 2-3	5 (25%)	7 (35%)	5 (25%)	5 (25%)	
History of previous stone surgery	4 (20%)	7 (35%)	3 (15%)	5 (25%)	0.565
Stone opacity (non-opaque)	2 (10%)	1 (5%)	3 (15%)	0 (0%)	0.499
Stone localization					0.365
Upper	10 (50%)	6 (30%)	9 (45%)	6 (30%)	
Pelvis	5 (25%)	9 (45%)	5 (25%)	9 (45%)	
Lower	3 (15%)	2 (10%)	4 (20%)	**2** (10%)	
Multiple	2 (10%)	3 (15%)	2 (10%)	3 (15%)	
Stone size (mm)*	12.8±4.4	11.8 ± 3.9	12.7 ± 3.6	12.6 ± 3.7	0.683
Presence of hydronephrosis	12 (60%)	8 (40%)	10 (50%)	8 (40%)	0.576
Operation side					0.872
Right	13 (65%)	10 (50%)	11 (55%)	12 (60%)	
Left	7 (35%)	10 (50%)	9 (45%)	8 (40%)	

*mean ± standard deviation
BMI: Body mass index, ASA: American society of anesthesiologists

Table 3. Comparison of operation data and postoperative results between groups

	Group 1 (n=20)	Group 2 (n=20)	Group 3 (n=20)	Group 4 (n=20)	*P* value	F
Preparation time (min)*	18.6 ± 4.8[a]	17.2 ± 4.7[a]	15.0 ± 4.9[b]	12.4 ± 2.2[b]	0.001	20.4
Operation Time (min)*	44.1 ± 5.8[a]	39.7 ± 5.8[a]	33.0 ± 5.0[b]	30.0 ± 4.4[b]	0.001	29.4
Fluoroscopy time (sec)*	82.9 ± 15.0[a]	62.1 ± 16.5[b]	50.3 ± 14.4[c]	41.7 ± 16.4[c]	0.001	26.07
Hospitalization time (hour)*	23.9 ± 7.1	24.7 ± 7.1	22.3 ± 7.9	23.3 ± 8.0	0.581	0.36
Stone free rate	13 (65%)[a]	17 (85%)[b]	17 (85%)[b]	18 (90%)[b]	0.037	
Complications	3 (15%)	1 (5%)	1 (5%)	1 (5%)	0.712	
Minor (Clavien-Dindo grade 1-2)	2 (10%)	1 (5%)	1 (5%)	1 (5%)		
Major (Clavien-Dindo grade 3-5)	1 (5%)	0 (0%)	0 (0%)			

*mean ± standard deviation

Lower-case letters are used to define the group that makes the difference. The same letters (such as a-a) define that there is no difference, different letters (such as a-b) define that there is a difference.

cation was upper calyx (31 patients, 38.7%), and ten patients had multiple renal stones. The mean stone size was 12.5 mm. Overall success was 81.2% and complications occurred in six (7.5%) patients (**Table 1**).

Age, sex, BMI, and ASA score were comparable between all groups. Also, operation side, stone size, stone location and stone opacity were not statically significant. Comparison of pre-surgical parameters is summarized in **Table 2**.

Time from the induction of anaesthesia to insertion of flexible ureterorenoscope was 18.6 min in group 1 and 17.2 min in group 2; then it decreased to 15.0 min for cases 40 through 60 and 12.4 min for cases 60 through 80 ($p = 0.001$). Similarly, operation time progressively decreased (44.1 min, 38.7 min, 33.0 min, and 30.0, respectively) and operation time in group 3 and group 4 was significantly shorter ($p = 0.001$). Also, fluoroscopy time was significantly longer in group 1 (82.9 ± 15.0 seconds) and reached a plateau in group 3 (50.3 ± 14.4 seconds) and group 4 (41.7 ± 16.4 seconds) ($p = 0.001$). Additionally, after the 20th case, we achieved a significantly better success rate (65% in group 1, 85% in group 2, 85% in group 3, and 90% in group 4, $p = 0.001$). Hospitalization time and complication rate were similar between the groups ($p = 0.581$ and $p = 0.712$) (**Table 3**).

DISCUSSION

The learning curve is an entity to define the number of operations that a surgeon should do before reaching proficiency level. Previous reports attempted to determine the LC for different procedures in urology practice[9,10], but no study evaluated the LC for f-URS yet. This study focused to determine LC of f-URS for the first time. Our results showed that the success of f-URS reached a plateau after 20 cases. In addition, preparation time, operation time, and fluoroscopy duration were significantly decreased following 40 cases.

The mean goal of kidney stone surgeries is to obtain stone free status without complications. Stone-free rate following f-URS was reported to have a wide range, between 50% and 100% [11]. Although no study focused on the impact of LC on f-URS success, Ziaee and colleagues investigated the number of cases required to complete the LC following PNL, and obtained sufficient stone free rates after 105 PNL operations[7]. Sahan et al. achieved a plateau for supine mini percutaneous nephrolithotomy stone free rates after the 45th case[6]. In the present study, we achieved a satisfactory success rate after 20 f-URS cases. We believe that obtaining access to the stone is a more complicated process in percutaneous nephrolitotomy than gaining access to the kidney with flexible ureterorenoscope, which makes to LC of f-URS shorter.

Longer operation time is associated with anaesthetic complications, increased cost, morbidity, and even mortality. When beginning to perform a new surgical technique, unfamiliarity with surgical instruments, possible incompatibilities between the surgical team, and inability to make some decisions subcortically could make the operation time longer. Tanrıverdi and colleagues found 144 minutes of mean operation time after the first 15 PNL cases, and their operation time decreased to 90 minutes between the 45th and 60th cases[12]. Moreover, Sahan et al. faced significant decreases in supine mini PNL operation time from the 1st -15th patients to the 46th to 60th patients; however, the authors did not observe any reduction in operation time after 60 cases[6]. We achieved significant reductions in preparation time and f-URS operation time after 30 cases.

Fluoroscopically-guided diagnostic and therapeutic processes began to be performed more commonly all over the world in recent decades. The harmful impact of fluoroscopy on cancer development, eyes, and skin is well-known[13]. Many studies which analyzed fluoroscopy-assisted surgeries in urology ignored this situation. Tanrıverdi et al. stated that fluoroscopy time decreased from 17.5 minutes in the first 15 cases, to 8.9 minutes by the 60th case[9]. Also, Sahan et al. found associations between increased experience in supine mini PNL and reduction in fluoroscopy time[6]. In the present study, we significantly reduced fluoroscopy time from the first 20 cases to 40th – 60th cases, and fluoroscopy time reached a plateau after the 60th case.

The present study, the first prospective research to evaluate LC in f-URS, has some limitations. The low number of patients could be accepted as a limitation. Also, our study focused on one-month outcomes after f-URS, and the impact of LC on long-term outcomes of f-URS is lacking, which may be the subject of another study. Additionally, we did not analyse the effect of LC on cost-effectiveness of f-URS, which may be clarified in further studies. Lastly, the impact of LC on patient quality of life was not evaluated in this prospective study.

CONCLUSIONS

The present study is the first to determine the learning curve of f-URS, and we found that the success of f-URS reached satisfactory levels after 20th cases. In addition, 40 cases may be enough for surgical proficiency regarding decreases in preparation time, operation time, and fluoroscopy time.

REFERENCES

1. Sargent MA. What is the normal prevalence of vesicoureteral reflux? Pediatr radiol. 2000;30:587-93.
2. Peters CA, Skoog SJ, Arant BS, et al. Summary of the AUA guideline on management of primary vesicoureteral reflux in children. J Urol 2010;184:1134-44
3. Subcommittee on Urinary Tract Infection, Steering Committee on Quality Improvement and Management. Urinary tract infection: clinical practice guideline for the diagnosis and management of the initial UTI in febrile infants and children 2 to 24 months. Pediatrics. 2011;128:595-610.
4. Tokhmafshan F, Brophy PD, Gbadegesin RA, Gupta IR. Vesicoureteral reflux and the extracellular matrix connection. Pediatr nephrol. 2017;32 565–76.
5. Baek M, Kim KD. Current surgical management of vesicoureteral reflux. Korean J Urol. 2013;54:732-37.
6. Radmayr C, Bogaert G, Dogan HS, et al. Guidelines on paediatric urology. European Association of Urology. 2020:67-9.
7. Elder JS, Peters CA, Arant BS, et al. Pediatric Vesicoureteral Reflux Guidelines Panel summary report on the management of primary vesicoureteral reflux in children. J Urol. 1997;157:1846–51.
8. Sung J, Skoog S. Surgical management of vesicoureteral reflux in children. Pediatr Nephrol. 2012;27:551-61.
9. Bayne AP, Shoss JM, Starke NR, Cisek LJ. Single-center experience with pediatric laparoscopic extravesical reimplantation: safe and effective in simple and complex anatomy. J Laparoendosc Adv Surg Tech 2012;22:102-6.
10. Kurtz MP, Leow JJ, Varda BK, et al. The decline of the open ureteral reimplant in the United States: national data from 2003 to 2013. Urology. 2017; 100:193-7.
11. Casale P, Patel RP, Kolon TF. Nerve sparing robotic extravesical ureteral reimplantation. J Urol 2008;179:1987.
12. Clavien PA, Barkun J, De Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250:1987-90.
13. Lopez M, Varlet F. Laparoscopic extravesical transperitoneal approach following the Lich-Gregoir technique in the treatment of vesicoureteral reflux in children. J Pediatr Urol. 2010;45:806-10.
14. Roshani H, Dabhoiwala NF, Verbeek FJ, Kurth KH, Lamers WH. Anatomy of ureterovesical junction and distal ureter studied by endoluminal ultrasonography in vitro. J Urol. 1999;161:1614-19.
15. Tanagho EA, Pugh RC. The anatomy of the ureterovesical junction. Br J Urol. 1963;35:151-65.
16. Paquin AJ. Ureterovesical anastomosis: the description and evaluation of a technique. J Urol. 1959;82:573-83.
17. Riedmiller H, Gerharz EW. Antireflux surgery: Lich-Gregoir extravesical ureteric tunnelling. BJUI. 2008;101:1467-82.
18. Kirsch AJ, Arlen AM. Evolving surgical management of pediatric vesicoureteral reflux: is open ureteral reimplantation still the ‘Gold Standard’?. International braz J Urol. 2020;46:314-21.
19. Tam PK. Laparoscopic surgery in children. Arch Dis Child. 2000;82(3):240-3.
20. Bustangi N, Kallas Chemaly A, Scalabre A, et al. Extravesical Ureteral Reimplantation Following Lich-Gregoir Technique for the Correction of Vesico-Ureteral Reflux Retrospective Comparative Study Open vs. Laparoscopy. Front Pediatr. 2018;6:388.
21. Farina A, Esposito C, Escolino M, Lopez M, Settimi A, Varlet F. Laparoscopic extravesical ureteral reimplantation (LEVUR): a systematic review. Transl Pediatr. 2016;5:291-4.
22. Riquelme M, Lopez M, Landa S, et al. Laparoscopic extravesical ureteral reimplantation (LEVUR): a multicenter experience with 95 cases. Eur J Pediatr Surg. 2013;23:143-7.
23. Pérez-Etchepare E, Varlet F, López M. Laparoscopic extravesical ureteral reimplantation following Lich-Gregoire technique. Medium-term prospective study. Cir Pediatr. 2014;2:74-7.