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Single-Use Ureteroscopes Are Associated with Decreased Risk of Urinary Tract Infection After Ureteroscopy for Urolithiasis Compared to Reusable Ureteroscopes

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Abstract

Objective: Urinary tract infection (UTI) is a common complication after ureteroscopy. Despite sterilization, there is evidence that reusable ureteroscopes can still harbor bacteria. Whether this property is associated with increased risk of UTI is unknown. The objective of this study was to compare rates of postoperative UTI after ureteroscopy for urolithiasis performed with single-use ureteroscopes *vs* reusable ureteroscopes.

Materials and Methods: This was a single-center, retrospective cohort study of all patients who underwent ureteroscopy for urolithiasis between June 2012 and March 2021. Outcomes were compared between those who underwent stone removal with single-use and reusable ureteroscopes. The primary endpoint was postoperative UTI. The secondary endpoints were intra-operative and postoperative outcomes, and health service utilization after surgery.

Results: Of 991 patients identified, 500 (50.4%) underwent ureteroscopy with a single-use ureteroscope. Rates of postoperative UTI were lower in those undergoing ureteroscopic stone removal with a single-use ureteroscope compared to a reusable ureteroscope (6.5% *vs* 11.9%, $p = 0.018$). In multivariable analysis, use of a single-use ureteroscope was associated with lower odds of postoperative UTI compared to a reusable ureteroscope when adjusting for risk (odds ratio 0.37, $p = 0.015$). Use of a single-use ureteroscope was associated with a higher stone clearance rate compared to a reusable ureteroscope (90.0% *vs* 83.9%, $p = 0.005$). There was no difference in operative time, overall complication rate, readmission, or emergency department visits between two groups.

Conclusion: Single-use ureteroscopes are associated with a twofold decreased risk of UTI and increased stone clearance rate after ureteroscopy for urolithiasis compared to reusable ureteroscopes.

Keywords: ureteroscopy, single-use ureteroscope, urinary tract infection, health care use, stone clearance

Introduction

Flexible ureteroscopes are essential tools for the surgical management of urolithiasis.[1,2] Limitations of reusable ureteroscopes include cost related to scope acquisition and maintenance, limited durability, and need for sterilization and reprocessing.[3] In response to these limitations, single-use ureteroscopes were developed, which have been shown to be comparable to reusable ureteroscopes in intraoperative maneuverability, visual image quality, surgeon satisfaction, and stone-related clinical outcomes.[3–10]

Infectious complications are a common complication after ureteroscopy with occurrence rates of 3% to 18%.[1,10–12] Despite sterilization, there is evidence that reusable ureteroscopes can still harbor bacteria.[13,14] Ofstead et al showed that cleaning and sterilizing with hydrogen peroxide gas was not enough to eliminate contaminants in the ureteroscopes completely.[13] Although Legemate et al found that cumulative

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ureteroscope use was not associated with increasing probability of microbial contamination, reusable ureteroscope cultures were positive in 12.1% of devices, with uro-pathogens detected in 2.3%, indicating that there is persistent bacterial presence even after high-level disinfection.[14] However, it is unknown whether choice of single-use or reusable ureteroscope has an impact on infectious complications after ureteroscopic stone surgery. The objective of this study was to compare rates of postoperative urinary tract infection (UTI) after ureteroscopy for urolithiasis performed with a single-use ureteroscope *vs* a reusable ureteroscope.

Materials and Methods

Study design

This was a single-center, cohort study of patients who underwent ureteroscopy with a single-use ureteroscope (LithoVue™; Boston Scientific, Marlborough, MA) compared to a reusable ureteroscope (URF-P6; Olympus, Tokyo, Japan) at the University of California, San Francisco (UCSF) between March 2012 and June 2021. Between 2012 and 2015, data were retrospectively extracted from the medical records at UCSF. From 2015 and beyond, all data were prospectively captured in the Registry of Stones of the Kidney and Ureter (ReSKU).[15] Single-use ureteroscopes were introduced at our center in 2015. This study received institutional review board approval (CHR 14-14533).

Study population

Inclusion criteria were all consecutive patients >18 years old, who underwent retrograde flexible ureteroscopy for stone removal. Exclusion criteria were concurrent endoureterotomy, endopyelotomy, or infundibulotomy at the time of ureteroscopy. All surgeries were performed by two urologists (M.L.S. and T.C.). The decision for the type of ureteroscope used during the surgery was at the surgeon's discretion. Dusting and basket

Table 1. Baseline Characteristics and Operative Outcomes

	Reusable, n = *491*	*Single use,* n = *500*	p
Age	52.87 (15.49)	51.94 (16.24)	0.359
Male, *n* (%)	220 (44.8)	257 (51.4)	0.042
BMI	30.01 (9.29)	28.89 (7.67)	0.044
ASA score, *n* (%)			
1	47 (9.6)	51 (10.2)	0.907
2	309 (63.1)	320 (64.1)	
3	130 (26.5)	125 (25.1)	
4	4 (0.8)	3 (0.6)	
DM, *n* (%)	71 (14.5)	62 (12.4)	0.353
HL, *n* (%)	45 (9.2)	64 (12.8)	0.069
HTN, *n* (%)	151 (30.8)	144 (28.8)	0.532
Steroid uses, *n* (%)	30 (6.1)	22 (4.4)	0.256
Previous urinary reconstruction, *n* (%)	25 (5.1)	16 (3.2)	0.152
Prior UTIs, *n* (%)	63 (12.8)	60 (12.0)	0.701
Prior stone intervention, *n* (%)			
None	408 (83.1)	413 (82.6)	0.930
SWL	26 (5.3)	27 (5.4)	
URS	47 (9.6)	52 (10.4)	
PCNL	10 (2.0)	8 (1.6)	
Preoperative urine culture, *n* (%)			
Negative	326 (66.4)	321 (64.2)	0.300
Positive	68 (13.8)	87 (17.4)	
No data	97 (19.8)	92 (18.4)	
Preoperative tube, *n* (%)			
None	296 (60.3)	323 (64.6)	0.249
Stent	145 (29.5)	126 (25.2)	
Nephrostomy tube	29 (5.9)	23 (4.6)	
Both	21 (4.3)	28 (5.6)	
Stone burden, *n* (%)			
<1 cm	263 (53.6)	236 (47.2)	0.092
1–2 cm	147 (29.9)	180 (36.0)	
>2 cm	81 (16.5)	84 (16.8)	
Procedure for both kidney and ureteral stone, *n* (%)	61 (12.4)	58 (11.6)	0.697
Access sheath use, *n* (%)	153 (31.2)	209 (41.8)	0.001
Procedure for bilateral stones, *n* (%)	321 (65.4)	302 (60.4)	0.115
Operative time			
Minutes	57.00 [9.0, 260.0]	58.00 [9.0, 492.0]	0.694
Stone clearance, *n* (%)	412 (83.9)	450 (90.0)	0.005

ASA = American Society of Anesthesiology; BMI = body mass index; DM; diabetes mellitus; HL = hyperlipidemia; HTN = hypertension; PCNL = percutaneous nephrolithotomy; SWL = shock wave lithotripsy; URS = ureteroscopy; UTIs = urinary tract infections.

extraction techniques with a combination of gravity drainage and manual pumping were used. Surgical technique, including use of manual pumping, access sheaths, dusting/fragmenting, and stent plan, did not change over the study period.

Perioperative managements

Preoperative urinalysis was performed for all patients. If positive, a reflex urine culture was performed and treated appropriately. Perioperative antibiotics were given in keeping with American Urological Association best-practice statements consisting of empiric trimethoprim-sulfamethoxazole, first-generation cephalosporin, or targeted antibiotics based on culture/sensitivity if available. Routine postoperative antibiotics were not given.

Outcomes

The primary outcome was occurrence of postoperative UTI after ureteroscopic stone removal. Secondary outcomes were operative time, subjective stone clearance, perioperative complications, length of stay, and unanticipated provider visits after surgery. We defined patients with UTIs as those with pyuria and bacteriuria, and/or positive urine culture. Total stone burden was defined as the largest aggregate linear dimension from axial and coronal views and classified as <1, 1 to 2, and >2 cm. Subjective stone clearance was defined as either no remaining fragment or all fragments appearing small enough to pass as assessed by the treating surgeon at the end of the case. Postoperative complications were defined using the Clavien-Dindo classification system. Unanticipated provider visits included telephone calls (including all forms of patient communication, such as messages sent using the electronic medical record), emergency department (ED) visits, and hospital re-admission. Sepsis was diagnosed according to international consensus definitions.[16] All complications and re-presentations during 6 weeks after the surgery were captured.

Statistical analyses

Chi-square and Fisher exact tests were used for categorical variables and unpaired Student's *t*-test and Mann–Whitney *U* test for continuous variables. Multivariate logistic and linear regressions were used to assess impact of ureteroscope type on perioperative and postoperative outcomes. All statistical analyses were performed using R. Data are expressed as mean ± standard deviation or percentage with *p*-values.

Results

Of 991 patients identified, 500 (50.4%) patients underwent surgery with a single-use ureteroscope and 491 (49.6%) with a reusable ureteroscope. Six hundred eighty-three (69%) patients were seen at the follow-up clinic. There was no significant difference in age, American Society of Anesthesiology (ASA) score, comorbidities, use of steroids, history of urinary reconstruction, prior stone procedure, prior UTIs, preoperative urine culture positivity, presence of preoperative tube, stone burden, or operative time between those who underwent surgery with a single-use *vs* reusable ureteroscope. Body mass index (BMI) was lower, and male patients and the procedure for bilateral stones were more often in the single-use ureteroscope group (Table 1). No difference was noted in terms of types of bacteria detected, antibiotics used, and length of antibiotics used in patients with a positive culture (Supplementary Table S1).

Rates of postoperative UTI were lower in those undergoing ureteroscopic stone removal with a single-use ureteroscope compared to a reusable ureteroscope (6.5% *vs* 11.9%, $p = 0.018$; Table 2).

After adjusting for several factors, use of a single-use ureteroscope was associated with lower odds of postoperative UTI (037, 95% CI 0.17–0.82, $p = 0.015$) compared to a reusable ureteroscope in multivariable analysis (Table 3).

Subjective stone clearance rate was higher in the single-use group compared to reusable ureteroscope group (83.9% *vs* 90.0%, $p = 0.005$; Table 1). On multivariate regression, use of single-use ureteroscope was associated with increased subjective stone clearance compared to reusable ureteroscope (3.20, 95% CI 1.31–7.82, $p = 0.011$; Supplementary Table S3).

Table 2. Postoperative Outcomes

	Reusable, n = *360*	*Single use,* n = *323*	p
Postoperative stent, *n* (%)	308	323	0.082
Length of indwelling stent, *n* (%)			
<1 week	78 (25.3)	74 (28.5)	0.660
1 ≦ <4 weeks	220 (71.4)	179 (68.8)	
≦4 weeks	10 (3.2)	7 (2.7)	
Clavien-Dindo, *n* (%)			
0	313 (86.9)	280 (86.7)	0.588
1	17 (4.7)	9 (2.8)	
2	27 (7.5)	30 (9.3)	
3	2 (0.6)	2 (0.6)	
4	1 (0.3)	2 (0.6)	
Date of discharge, *n* (%)			
POD0	301 (83.6)	278 (86.1)	0.763
POD1	40 (11.1)	30 (9.3)	
POD2	7 (1.9)	4 (1.2)	
>POD2	12 (3.3)	11 (3.4)	
Postoperative UTI, *n* (%)	43 (11.9)	21 (6.5)	0.018
Postoperative sepsis, *n* (%)	7 (1.9)	4 (1.2)	0.552
Re-presentation, *n* (%)			
to the hospital			
Telephone call	105 (29.2)	62 (19.2)	0.002
ED visit	60 (16.7)	48 (14.9)	0.530
Re-admission	19 (5.3)	26 (8.0)	0.165
Main stone component, *n* (%)			
Calcium oxalate	186 (51.7)	150 (46.3)	0.831
Calcium phosphate	30 (8.3)	35 (10.8)	
Struvite	34 (9.4)	30 (9.3)	
Uric acid	16 (4.4)	16 (4.9)	
Cysteine	14 (3.9)	12 (3.7)	
Other	8 (2.2)	9 (2.8)	
no data	72 (20.0)	72 (22.2)	
Interval procedures, *n* (%)	7 (1.9)	3 (0.9)	0.347

ED = emergency department; POD = postoperative day.

Table 3. Multivariate Analysis for Postoperative Urinary Tract Infection and Sepsis

	UTI		*Sepsis*	
Factor	*Odds ratio (95% CI)*	p	*Odds ratio (95% CI)*	p
Age	0.96 (0.94–0.99)	0.009	0.93 (0.86–1.01)	0.095
BMI	0.99 (0.95–1.04)	0.74	1.03 (0.93–1.14)	0.61
Male	1.16 (0.49–2.74)	0.73	0.33 (0.01–7.85)	0.49
ASA score >2	1.79 (0.72–4.46)	0.21	16.60 (1.04–266.00)	0.047
Prior stone intervention	1.01 (0.61–1.68)	0.96	1.62 (0.30–8.78)	0.58
Prior UTIs	2.15 (0.94–4.95)	0.071	0.45 (0.03–6.72)	0.56
Preoperative positive urine culture	13.60 (5.81–32.10)	<0.001	2.48 (0.28–21.80)	0.41
Strive stone	38.80 (15.50–97.30)	<0.001	144.00 (6.90–3000.00)	<0.001
Pre-existing stent or nephrostomy tube	0.45 (0.20–1.01)	0.054	0.19 (0.02–1.83)	0.15
Stone burden >2 cm	0.79 (0.26–2.42)	0.68	0.34 (0.01–9.17)	0.52
Procedure for both kidney and ureteral stone	0.52 (0.17–1.64)	0.26	0.00 (0.00–Inf)	1
Procedure for bilateral stones	0.63 (0.28–1.41)	0.26	0.09 (0.01–1.58)	0.10
Access sheath use	1.85 (0.77–4.43)	0.17	24.60 (1.46–415.00)	0.026
Use of single use ureteroscope	0.37 (0.17–0.82)	0.015	0.18 (0.02–2.08)	0.17
Operative time	1.00 (0.98–1.01)	0.73	0.97 (0.92–1.02)	0.25
Stone clearance	0.61 (0.16–2.31)	0.47	0.29 (0.01–11.70)	0.51
Length of postoperative stent				
<1 week (*vs* no stent)	0.53 (0.14–1.93)	0.33	1.56 (0.06–40.00)	0.79
1–4 weeks (*vs* no stent)	0.67 (0.20–2.24)	0.52	0.26 (0.01–6.87)	0.42
>4 weeks (*vs* no stent)	1.32 (0.19–9.15)	0.78	0.00 (0.00–Inf)	1

CI = confidence interval.

There was no difference in operative time, use of access sheaths, overall complication rate, postoperative sepsis rate, readmission, or ED visits between those who underwent ureteroscopy with single-use ureteroscopes compared to reusable ureteroscopes (Tables 1–3 and Supplementary Tables S2 and S3). There was increased provider phone calls for those undergoing ureteroscopy with a reusable compared to single-use ureteroscope (29.2% *vs*. 19.2%, $p = 0.002$; Table 2). On multivariate regression, use of a single-use ureteroscope remained a significant factor associated with fewer telephone calls (0.50, 95% CI 0.34–0.75, $p < 0.001$; Table 4).

Discussion

Although there is evidence that reusable ureteroscopes can harbor bacteria even after sterilization, the impact on development of infectious complications after ureteroscopy has

Table 4. Multivariable Analysis for Telephone Calls, Emergency Department Visits, and Re-Admission

	Telephone call		*ED visit*		*Re-admission*	
Factor	*Odds ratio (95% CI)*	p	*Odds ratio (95% CI)*	p	*Odds ratio (95% CI)*	p
Age	0.99 (0.98–1.00)	0.19	0.96 (0.95–0.98)	<0.001	0.96 (0.93–0.98)	0.002
BMI	0.99 (0.96–1.02)	0.42	1.01 (0.98–1.04)	0.56	1.04 (1.00–1.09)	0.054
Male	0.66 (0.43–1.00)	0.051	1.33 (0.79–2.26)	0.28	1.48 (0.64–3.46)	0.36
ASA score >2	1.23 (0.74–2.05)	0.43	1.13 (0.60–2.12)	0.70	1.22 (0.47–3.19)	0.68
Prior stone intervention	0.92 (0.68–1.23)	0.56	1.05 (0.76–1.45)	0.77	0.86 (0.49–1.50)	0.59
Prior UTIs	0.79 (0.44–1.41)	0.42	0.98 (0.50–1.93)	0.95	1.75 (0.68–4.51)	0.25
Preoperative positive urine culture	2.26 (1.32–3.89)	<0.001	3.64 (1.97–6.72)	<0.001	3.71 (1.55–8.87)	0.003
Strive stone	1.33 (0.70–2.54)	0.38	2.30 (1.11–4.74)	0.025	8.77 (3.41–22.60)	<0.001
Pre-existing stent or nephrostomy tube	0.35 (0.22–0.54)	<0.001	0.44 (0.26–0.76)	0.003	0.37 (0.15–0.87)	0.023
Stone burden >2 cm	0.83 (0.44–1.59)	0.58	0.99 (0.44–2.21)	0.98	1.26 (0.42–3.78)	0.68
Procedure for both kidney and ureteral stone	0.90 (0.49–1.65)	0.74	0.52 (0.22–1.23)	0.14	0.32 (0.06–1.59)	0.16
Procedure for bilateral stones	1.13 (0.75–1.69)	0.56	1.21 (0.74–1.97)	0.46	1.13 (0.53–2.40)	0.76
Access sheath use	1.12 (0.71–1.77)	0.62	1.04 (0.60–1.80)	0.89	1.33 (0.55–3.18)	0.52
Use of single use ureteroscope	0.50 (0.34–0.75)	<0.001	0.76 (0.47–1.22)	0.26	1.40 (0.65–2.98)	0.39
Operative time	1.01 (1.00–1.01)	0.053	1.00 (0.99–1.00)	0.31	1.00 (0.99–1.01)	0.75
Stone clearance	0.93 (0.40–2.16)	0.87	0.60 (0.21–1.68)	0.33	1.82 (0.30–11.00)	0.51
Length of postoperative stent						
<1 week (*vs* no stent)	1.30 (0.65–2.59)	0.45	1.39 (0.66–2.96)	0.39	0.42 (0.13–1.35)	0.15
1–4 weeks (*vs* no stent)	1.23 (0.64–2.35)	0.53	0.73 (0.35–1.53)	0.41	0.28 (0.10–0.84)	0.023
>4 week (*vs* no stent)	2.21 (0.64–7.64)	0.21	0.55 (0.10–3.14)	0.50	0.37 (0.03–4.19)	0.42

previously not been investigated. We compared infectious complications among those who underwent ureteroscopic stone surgery with single-use *vs* reusable ureteroscopes in a large retrospective study of 991 patients. We found that rates of postoperative UTI were lower in those undergoing ureteroscopic stone removal with a single-use ureteroscope compared to a reusable ureteroscope (6.5% *vs* 11.9%, $p = 0.018$). On multivariate analysis, use of a single-use ureteroscope was associated with a twofold decreased risk of UTI compared to a reusable ureteroscope. These results suggest that utilizing single-use ureteroscopes may be one method to decrease infectious complications after stone surgery.

Consistent with recent literature,[17] using single-use ureteroscopes was associated with higher stone clearance. Some possible reasons for improved stone clearance with single-use ureteroscopes may be improved deflection and optical properties and greater consistency between uses. The deflection of single-use ureteroscopes is reported to be in the range of 276° to 295° compared to 219° to 285° for most reusable ureteroscopes.[18]

Dale et al reported that LithoVue was also found to have a greater field of view (15.75 mm) than the digital Flex-X^c (10.5 mm; Karl Storz & Co. KG, Tuttlingen, Germany) and fiber-optic Cobra (14.25 mm; Richard Wolf, Knittlingen, Germany).[19] With continued use, reusable ureteroscopes can often lose deflection ability, making stone clearance more difficult. Given that surgeons are much more likely to expect patients to be stone free after ureteroscopy stone removal,[20] we recognize that visual stone clearance as not accurate as that of CT-confirmed stone-free rate after surgery. This highlights the need for future prospective studies in this area.

There was no difference in postoperative sepsis rates, ED visits, or re-admission between those who underwent surgery with single-use *vs* reusable ureteroscopes. Interestingly, there was an increase in unanticipated provider phone calls for those who underwent surgery with a reusable ureteroscope. It is possible that increased provider calls occurred because of UTI symptoms or mild refractory stone passage symptoms that did not necessitate presentation to hospital.

Although some evidence of improved sepsis rates was seen in patients undergoing surgery with a single-use ureteroscope (1.2% *vs* 1.9%), differences between groups did not meet conventional levels of statistical significance. It is possible that our study was not powered adequately to evaluate this outcome. Future studies comparing single-use and reusable ureteroscopes should include postoperative sepsis as an outcome to further elucidate the impact of ureteroscope type on this important outcome.

These results suggest single-use ureteroscopes could be favorable for patients. A potential barrier to uptake of single-use ureteroscopes is increased cost. Our previous micro-cost analysis demonstrated that total cost per case was comparable between single-use and reusable ureteroscopes once additional factors such as increased labor, consumables, and repair costs were taken into account.[21] Other reports found that after 99 cases, cost–benefit analysis favored reusable ureteroscopes.[22] In general, single-use ureteroscopes appear to be more cost-effective at lower volume centers and when used for cases that have a high chance of ureteroscope damage such as lower pole stones or steep infundibulopelvic angle.[23,24]

Limitations of this study include the retrospective study design, which could introduce confounding and bias. Since there was a period of time early in the study in which only reusable ureteroscopes were used, this could have introduced selection bias if patients differ in some way over the study time period. It is also possible that there were unaccounted procedural differences between the early study period in which only reusable ureteroscopes were used. To examine this, we performed a sensitivity analysis of patients who underwent reusable ureteroscopy during the same time period as single-use ureteroscopy and who had data collected prospectively (Supplementary Table S4). In this sensitivity analysis, rates of UTI after single-use ureteroscopy remained significantly lower than with reusable ureteroscopes.

Patient demographics, medical comorbidities, and stone characteristics were largely comparable between groups. Our definition of subjective stone clearance was at surgeons' discretion and not confirmed by postoperative images, which would have given a more accurate assessment. Also, there was an absence of data on postoperative urine culture and the timing of UTIs. Although we confirmed that patients without a urine culture had no pyuria and bacteriuria in their pre-urinalysis, there could be a possibility that these patients had positive urine culture, affecting the results. Finally, follow-up data were only available for 69% of patients. With these limitations in mind, future work with a randomized control trial is warranted to confirm these results.

Conclusion

Single-use ureteroscopes were associated with a twofold decreased risk of UTI after ureteroscopy for urolithiasis compared to reusable ureteroscopes. In addition, their use was associated with increased subjective stone clearance rates and fewer postoperative patient phone calls. These results suggest that utilizing single-use ureteroscopes may be one method to decrease infectious complications after stone surgery, although improving clinical outcomes and lowering health care service utilization.

Authors' Contributions

Data collection, data analysis, article writing, and revision by R.U. Data collection, article writing, and revision by G.H. and F.H. Data collection, review data analysis, and review by D.B.B. and M.L.S. Supervision of the entire project by T.C.

Author Disclosure Statement

No competing financial interests exist.

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Supplementary Material

Supplementary Table S1
Supplementary Table S2
Supplementary Table S3
Supplementary Table S4

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Abbreviations Used

ASA = American Society of Anesthesiology
BMI = body mass index
CI = confidence interval
CT = computed tomography
DM = diabetes mellitus
ED = emergency department
HL = hyperlipidemia
HTN = hypertension
PCNL = percutaneous nephrolithotomy
POD = postoperative day
ReSKU = Registry of Stones of the Kidney and Ureter
SWL = shock wave lithotripsy
UCSF = University of California, San Francisco
URS = ureteroscopy
UTI = urinary tract infection