

Do ureteral stent diameter and length or patient demographics play a role in stent encrustation?

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Cite as: Connelly ZM, Pilet H, Reese CD, et al. Do ureteral stent diameter and length or patient demographics play a role in stent encrustation? *Can Urol Assoc J* 2022;16(9):E479-83. <http://dx.doi.org/10.5489/cuaj.7815>

Published online April 11, 2022

Abstract

Introduction: Retained ureteral stents may constitute a technical challenge. The purpose of this study was to analyze the patient population with retained ureteral stents with regards to stent sizes to better understand if these factors could play a pivotal role in their encrustation.

Methods: After institutional review board approval, we retrospectively analyzed the data of patients who underwent multimodal surgical procedures for the removal of retained ureteral stents from 2010–2018. The primary outcomes analyzed were ureteral stent length and diameter, location of stent placement, and patients' demographics as potential etiologies for encrustation.

Results: We included 30 patients with 32 encrusted ureteral stents and 37 patients with 46 forgotten non-retained ureteral stents. Indications for stenting included urolithiasis, malignancy, pregnancy, ureteral stricture, and ureteropelvic junction obstruction. Stent diameters ranged from 6–8.5 Fr. Stent lengths ranged from 22–30 cm, and multilength stents were used too. Smaller diameter stents were less likely to be retained when compared to larger diameter stents (>6 Fr) ($p=0.002$). Overall stent length was not found to be significant ($p=0.251$); however, the difference in stent surface area differed by over 1 cm ($p<0.001$). Patients who were uninsured were more likely to have retained stents ($p=0.003$). Patients who reside with longer commuting distance to the main academic medical center were more likely to have retained stents ($p=0.010$).

Conclusions: Retained ureteral stents could be avoided. Taking into consideration ureteral anatomical variation among patients, smaller diameter stents and smaller surface area may prevent encrustation. Uninsured patients with farther distance to seek medical care and females are the most at risk.

Introduction

Ureteral stents represent a minimally invasive alternative to preserve urinary drainage and play a vital role in relieving urinary obstruction due to urolithiasis, malignancy, pregnancy, stricture, trauma, and any obstructive uropathy. The vast majority of stents are removed by urologists in outpatient clinics, in the operating room (OR), or sometimes by the patients (stent on a string), 1–2 weeks after placement;^{1,2} however, patients with chronic indwelling stents would require stent exchanges at 3–6-month intervals.^{1,2} Ureteral stents are generally well-tolerated by patients but complications, such as flank and suprapubic pain, hematuria, dysuria, and increased frequency, are seen.^{1,2} Retained stents and stent encrustation are uncommon and more severe complications may be avoided with timely follow-up. Divakaruni et al identified significant associations with forgotten stents in males and patients without insurance.³ With encrustation, urologists often witness an increased difficulty in stent removal, morbidity, and sometimes mortality. A multimodal approach is then often required for management, including shockwave lithotripsy, percutaneous nephrolithotomy, and ureteroscopy.

Previously published studies analyzing retained ureteral stents emphasize the complication rates, complexity in management, and possible preventive measures.^{4,5} Several studies have also investigated the correlation between stent length and diameter with stent-related symptoms and factors associated with encrustation;⁴ however, the association between patient and stent characteristics on the development of retained stents remains unclear.

The purpose of this study was to analyze a patient population with retained stents at a major university-based academic medical center in order to better understand if patient or stent characteristics are correlated with stent encrustation.

Methods

After institutional review board approval, we retrospectively reviewed all charts of patients who underwent adjunctive surgical procedures for the removal of retained ureteral stents and patients who had ureteroscopic procedures with uncomplicated stent removals from January 2010 to June 2018 at a single academic institution. Patients were included if they had an indwelling stent that could not be removed via cystoscopy in the clinic and required additional multimodal procedures.

Patient demographics, relevant past medical history, including insurance type, and details regarding surgery were obtained from the hospital and clinic charts. Stent characteristics, including diameter and length, indication for placement, date of insertion, and date of removal, were also recorded from charts. Preoperative imaging records were reviewed to determine the presence of encrustation. All patients underwent surgery after negative urine cultures were obtained. Surgical data included the procedure type, number of procedures, operative time, stone location, and length of hospital stay.

The primary outcomes were to analyze ureteral stent length and diameter, location of stent placement, and patients' demographics as potential etiologies for stent encrustation requiring adjunctive surgical approaches. Stent surface area was calculated using $2\pi(1/2 \text{ Fr})(\text{length}) + 2\pi(1/2 \text{ Fr})^2$.

All statistical analyses were conducted using a combination of SPSS version 26 and Microsoft Excel. Univariate analysis included Pearson's Chi-squared test for categorical variables and t-test and one-way ANOVA for continuous variables.

Results

There were 30 patients with 32 retained ureteral stents and 37 patients with 46 non-retained ureteral stents totaling 67 patients and 78 stents over the eight-year study span. Among patients with retained stents, 12 were male and 18 were female. The control group consisted of 22 females and 15 males. Three patients presented at two separate occasions with retained stents, and two patients had bilateral retained stents. Females were more likely to have retained stents

($p=0.492$) but there was no statistical difference. There was a significant difference between the average age of those patients with a retained stent, where females were younger (40.9 ± 15.1 years) vs. males (53.9 ± 10.5 years) ($p=0.016$) (Table 1). Indications for stent placement included urolithiasis, malignancy, pregnancy, stricture, and ureteropelvic junction obstruction. Half our patients with retained stents had a prior history of urolithiasis. Seventeen patients had stents placed at our institution and 11 patients had stents placed at outside hospitals. The average duration of retained stents were 11.2 ± 11.3 months (range 2–264) (Table 2).

Patients with non-retained stents had them removed in the clinic, in the OR, or self-removed them. Stent diameters ranged from 6–8.5 Fr and stent lengths ranged from 22–30 cm. Nine patients in the control group received multilength stents. Smaller diameter stents were less likely to be retained as compared to larger diameters ($p=0.002$). The average stent length for a non-retained stent was 26.5 cm vs. a retained stent of 27.33 cm ($p=0.251$) (Table 2); however, Chi-squared analysis showed that 24 cm stents were strongly associated with non-retention compared to the 30 cm stents ($p=0.054$). Additionally, we found that 28 cm stents were less likely to be retained than 30 cm stents (0.094) (Table 2). Although this is not statistically significant, it may be clinically relevant when selecting a stent length. Stent surface area was also compared in the two populations, where non-retained stents had a surface area average of 604.8 mm^2 compared to those who were retained at 706.6 mm^2 ($p<0.001$). The average time of forgotten non-retained ureteral stents was 21.4 ± 30.8 months.

All patients with retained stents had encrustation visible on imaging and required procedures in the OR for their removal. Mean operating time was 109 ± 84 minutes (Table 3). The most common procedure performed was cystolitholapaxy (25 patients, 80.6%), with 21 patients requiring more than one procedure. Isolated upper coil encrustation occurred in three patients with retained stents and only required one procedure

Table 2. Stent characteristics

	Retained	Non-retained	Significance
Average duration, months \pm SD (range)	11.2 ± 11.3 (2–264)		
Diameter (French)	7.1	6.4	0.001
Length (cm)	27.3	26.6	0.251
Surface area (mm^2)	706.6 ± 119.2	604.8 ± 73.0	0.001
Length (cm)			
24 vs. 26			0.633
24 vs. 28			0.681
24 vs. 30			0.054
26 vs. 28			0.901
26 vs. 30			0.178
28 vs. 30			0.094

Stents time retention, diameter, length, and surface area is all compared when retained. Length was further analyzed into subgroups of each size and compared. SD: standard deviation.

Table 1. Patient demographics

	Retained	Non-retained	Total	Significance
Sex, n (%)				
Male	12 (44.4)	15 (55.6)	27	0.492
Female	18 (45.0)	22 (55.0)	40	
Age (years)				
Male	53.9			0.016
Female	40.9			

Sixty-seven patients were analyzed in our study. The sex percentages and age differences in groups based on stent status is shown

Table 3. Operation characteristics

Time \pm SD (minutes)	109 \pm 84
Procedure, n (%)	
ESWL	19 (61.3)
Cystolitholapaxy	25 (80.6)
Ureteroscopy	7 (22.6)
PCNL	1 (3.2)

The operating total time and type of procedure needed to remove the retained stent. ESWL: extracorporeal shockwave lithotripsy; PCNL: percutaneous nephrolithotomy; SD: standard deviation.

for clearance. Patients with isolated lower coil encrustation and upper and lower encrustation were more likely to require multiple procedures for stent clearance (Figures 1, 2, Table 3): shockwave lithotripsy (SWL) combined with cystolitholapaxy (13), ureteroscopy (URS) combined with cystolitholapaxy (4), percutaneous nephrolithotomy (PCNL) combined with URS (2), PCNL combined with URS and cystolitholapaxy (1), SWL

combined with bilateral tandem stents, cystolitholapaxy, URS, right laparoscopic ureterolithotomy (1) (Figures 3, 4).

Fifteen percent of patients with retained stents had a prior history of stones. Body mass index (BMI) did not correlate with retention rates. Patients who were uninsured were more likely to have retained stents as compared to insured patients ($p=0.003$) and the distribution of insurance types was significantly different (Table 4). Patients who lived further away from our institution were more likely to have retained stents compared to patients who lived closer (93.6 vs. 53.5 miles, $p=0.010$).

Discussion

Ureteral stents play a vital role in preserving urinary drainage in numerous urological conditions. Retained ureteral stents can form encrustations and difficulties in their removal. Some stents can even fracture if left for a prolonged time, leading to unnecessary injury risk in the kidney.⁶ Removal often requires a multimodal treatment approach with an increased morbidity and mortality. A better understanding of patients who have an increased likelihood for developing retained stents may allow for earlier identification of those at risk and better communication for optimal followup.

We analyzed the patient population with retained stents to better understand if patient or stent characteristics are correlated with retained stents. Patients who are female, have a past medical history of stones, those who are uninsured, and those who live further away from our institution were more likely to have retained stents when compared to our control group. Age and BMI did not correlate with retained stents. Larger diameter and larger surface area of stents also had higher retention



Figure 1. Retained ureteral stent that had severe proximal and distal encrustations removed with a trimodal approach. The indwelling stent was fractured within the ureter for a prolonged time. The proximal end (shown in the right bottom corner) had severe encrustations and was retrieved separately via percutaneous nephrolithotomy (PCNL). The remainder of the stent (distal end) was retrieved via retrograde ureteroscopy and laser lithotripsy. In the center of the picture, a white nephrostomy catheter is seen; it was retained as well and retrieved at the time of PCNL. In the upper portion of the picture, numerous stone fragments are seen; they were all encasing the distal end of the ureteral stent and a cystolitholapaxy was also performed.



Figure 2. Retained ureteral stent that had severe proximal encrustation. An attempt of retrograde ureteroscopy and laser lithotripsy failed to retrieve the stent and the patient required a percutaneous nephrolithotomy for complete retrieval.

Table 4. Insurance coverage, patients with retained stents

	Confirmed	Stent removal	Total
	Yes	No	
Insurance	0	4	4
None	11	16	27
Medicaid	23	4	27
Medicare	2	4	6
Free care	1	1	2
Workers' comp	1	0	1
Private	5	3	8
Prisoner	2	0	2
Total	45	32	77

rates. All patients with retained stents had encrustation visible on imaging. The most common procedure in our retained stent population was cystolitholapaxy, with 75% of patients requiring more than one procedure. Patients with lower coil encrustation were more likely to require multiple procedures.

In our study, female patients were more likely to have retained stents when compared to the control group but this was not statistically significant. This finding differs from Divakaruni et al, who found that men were almost three times more likely to have retained stents.³ Other studies have found no significant differences in gender when comparing retained and non-retained stents.⁵⁻⁷ Jin et al performed a meta-analysis from 1970 and 2005 reviewing patient noncompliance with medical therapy. They found that gender had no effect on compliance.⁸ Our finding may be limited by the small sample size of retained stent patients. Altogether, gender may not have a significant impact in this setting.

Half of our patients with retained stents had a prior history of urolithiasis. Patients with history of urolithiasis have almost a three times increased risk of encrustation of ureteral

stents.⁹ Jain et al found that 93% of patients with severe encrustations had history of urolithiasis.⁷ The early identification of patients that are more likely to develop encrusted retained stents may help reduced the burden of multiple endoscopic procedures often required to successfully treat these patients.

Our study found that uninsured patients and those who live further away from our academic medical center were more prone to develop retained stents. Divakaruni et al found that those without health insurance were six times more likely to have forgotten stents.³ Patients who have financial or geographic restraints, in addition to transportation issues are therefore at higher risk. Communication about the importance of timely removal of stents is critical. The present study found no significant difference in age and BMI between retained and non-retained stent groups. These findings are consistent with other studies comparing retained and non-retained stents.^{5,8}



Figure 3. Retained ureteral stent that had severe encrustations in its middle portion. Prolonged ureteroscopy and holmium laser lithotripsy was needed to chip away all the surrounding encrustations and retrieve the stent.



Figure 4. Retained ureteral stent showing distal encrustations (brownish color), in addition to separate encrustations that were found to be encasing the distal coil (white in color), noted to be particularly adherent to the string knot, and formed a large bladder stone.

We found that 75% of patients in the retained stent group required more than one procedure. In comparison, Jain et al found 17.65% of patients in the retained stent group required at least two endoscopic procedures for stent removal.⁷ Aravantinos et al reported a median of 2.1 procedures per patient for removal of retained stents.^{10,11} These findings highlight the significance of identifying high-risk patients prior to presenting with a retained stent.

In our study, patients with isolated lower coil encrustation and upper and lower coil encrustation were more likely to require multiple procedures for stent clearance as compared to isolated upper coil encrustation. Jain et al reported that isolated lower coil encrustations were less likely to require multiple procedures for clearance and are often sufficiently treated with cystolitholapaxy or cystolithotripsy alone.⁷ Prior studies have reported that encrustation is more common and dense in the upper coil^{12,13} due to better peristalsis in the lower urinary system.¹¹ Proximal stent encrustation often predicts the need for multiple procedures due to the need for more complex ureteroscopy or the need to convert to PCNL, as well-described by Weedon et al.¹⁴ In the Jain et al study, all patients requiring multiple procedures for retained stent removal had upper coil involvement.⁷ Our findings are limited by our small sample size of three patients with isolated upper coil encrustation.

The present study found that smaller diameter stents were less likely to be retained as compared to those with larger diameters. Stent length also showed longer stents had higher retention rates when compared to the control group. To our knowledge, this is the first study comparing stent length and diameter with retention rates.

Limitations

The retrospective nature of this study presents a limitation that relies on the accuracy of data within patient charts. Stone chemical analysis was not reported, as stone extraction and sampling was not performed in all patients. The small cohort and single-institution review may prevent generalizability to other settings. Future research could include a prospective analysis of various prevention strategies, including SMS messaging notification systems for patients, the implementation of biodegradable stents, or a standardized protocol of discharge instructions for patients with ureteral stent placement. In parallel, urologists should be able to predict ureteral length based on preoperative computed tomography imaging or based on intraoperative findings (retrograde pyelograms, measurements noted on open-ended catheters that are inserted or upon withdrawing the ureteroscope). Longer stents and wider stents have a larger contact surface where urine and chemical deposits may perhaps induce encrustation more extensively. Future studies would be needed to possibly evaluate newer stent material and coil configurations allowing for reduced contact surface and encrustation rates.

Conclusions

Retained ureteral stents could be avoided. Taking into consideration ureteral anatomical variation among patients, using shorter stents with smaller diameter stents may prevent encrustation. Uninsured patients with farther distance to seek medical care and patients with transportation issues are at higher risk. Identifying patients who are at high risk of developing retained stents may aid healthcare providers in properly allocating time and resources to help prevent this iatrogenic condition.

Competing interests: The authors do not report any competing personal or financial interests related to this work.

This paper has been peer-reviewed.

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