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# The use of a string with a stent for self-removal following ureteroscopy: A safe practice to remain

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**ABBREVIATIONS**

PRN, as-needed (*pro re nata*);
URS, ureteroscopy

**Abstract** ***Abstract objectives:*** To examine the safety and effectiveness of the use of a stent with a string attached after ureteroscopy (URS) for self-removal of the stent by the patient.

***Patients and methods:*** After Institutional Review Board approval, a retrospective chart review was performed concerning patients who underwent URS and received an indwelling stent with or without a string attached to the stent (94 vs 349, respectively). Amongst the string group patients received a single- or a double-arm-stringed stent (31 vs 63, respectively). Statistical analyses included chi-squared and Student's *t*-tests.

***Results:*** The string group consisted of 94 procedures, in which 59.6% of the patients were male with a mean (SD) age of 50.0 (16.5) years. In the no-string group, 51.3% of the 349 procedures were performed in males and the mean (SD) age was 54.9 (18.1) years. Complication rates were 12.8% in the string group and 14.0% in the no-string group ($P = 0.867$). In the string group, 17.0% of the patients returned to the Emergency Department, whilst 15.8% of the no-string patients returned ($P = 0.753$). The complication rate in the single- and double-arm groups were 12.9% and 12.7%, respectively ($P > 0.910$). Self-removal of stents was successful in 94.7% of patients (89/94).

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***Conclusions:*** The use of a stent with a string after URS appears safe and effective. Few patients had difficulty removing their stents and complication rates were similar in the groups with and without a string attached to their stents. Single- and double-arm-stringed stents have similar complication rates.



## Introduction

Ureteroscopy (URS) is a common procedure for removing urinary tract stones, evaluating kidney anatomy, or evaluating upper urinary tract tumours. After URS, stents are commonly placed in the ureter. The purpose of these stents is to maintain patency in the event of ureteric oedema in response to instrumentation, to aid in the passage of small stones that remain following a procedure, and to prevent stricture formation in case of ureteric trauma [1]. Some studies suggest that patients, especially those meeting certain criteria, have a lower risk of complications after URS when a stent is placed [2–4]. These include patients with a history of renal failure, patients who have had a kidney transplant, patients with a solitary kidney and in instances of significant trauma during the URS procedure. The AUA Guidelines list stenting after URS as optional except in the setting of specific complications [5,6]. Thus, stent placement remains a common practice after a URS procedure.

Stents are removed 3–7 days after URS. Stent removal typically involves a return to the clinic or hospital and the removal of the stent in a procedure or operating room using a cystoscope. Patients thus bear the burden of an additional cost and trip to the hospital associated with their URS. The additional procedure can be avoided by inserting a stent with a string attached so that the stent can be removed by the patient at home. Even in patients who are unable to remove the stent themselves, the stent can be removed in the office without re-instrumentation of the bladder. It has been shown that adverse events and quality of life measurements are not affected by stents with attached strings [7]. Furthermore, it has been shown that there is less likely to be an extended delay in stent removal, presumably due to the convenience of being able to self-remove the stent. Additionally, in rural centres where patients may live a long distance from the hospital, a string may increase the chance of the stent being removed at the appropriate time. Thus, avoiding this extra procedure could reduce discomfort for patients and URS-related costs.

The purpose of the present study was to evaluate the safety and effectiveness of leaving a string attached to stents placed after URS. If determined to be effective and safe, the use of strings for self-removal has the potential to decrease costs and the necessity for a return to the clinic after stent placement.

## Patients and methods

After Institutional Review Board approval, a retrospective chart review was performed to evaluate patients who had stents placed with or without strings after URS. Inclusion criteria included: patients receiving a URS for any indication. Exclusion criteria included patients not receiving a stent after their URS. A total of eight surgeons performed cases included in this study and seven of the surgeons left strings in at least some of their cases. The decision to leave a stent with a string was made by the surgeon performing the procedure. Two surgeons in the data set left a string in every case unless there was a contraindication. Other surgeons occasionally left strings and these were included in the analysis as well. Amongst the string group some surgeons choose to remove one arm and leave a single-arm string after tying them together. The single-arm group included 31 patients and the double-arm group comprised 63 patients. Contraindications to leaving a string included a severe physical or mental disability that might lead to inability to pull the stent, stents that would be left for a prolonged duration, trauma to the ureter, and medical necessity of the stent meaning that loss of the stent could not be risked.

### *Stent procedure*

After a URS procedure, patients had an indwelling JJ ureteric stent (Cook Medical, Bloomington, IN, USA) placed in a standard fashion. In patients in whom a string was left, the stent remained with a string attached for self-removal. The double arm of the string was cut and tied to form a single arm to ease the removal process. This string extended from the end of the stent, which resides in the bladder, through the urethra. The string was not secured to the patient's skin to prevent a loop that could easily be entangled and lead to premature extraction. In both the string and no-string groups, stents ranged in diameter from 4.7 to 7 F and in length from 24 to 28 cm. Patients in the string group were instructed to remove their stents at home 3 days after their URS. Stents of patients in the no-string group were

removed by cystoscopy in the clinic. After URS, all patients in the study received as-needed (PRN, *pro re nata*) NSAID medication, pyridium, oxybutynin, tamsulosin and a PRN narcotic as initial therapy after their procedures.

### *Data collected*

Adverse events, including early stent removal, stent migration, retained stent, UTI, Emergency Department visits were collected.

### *Statistics*

Statistics were performed using GraphPad Prism (GraphPad Software Inc., La Jolla, CA, USA). Statistics included means with standard deviations (SDs). Chi-squared tests and Student's *t*-tests were used where appropriate with significance indicated by $P < 0.05$.

## Results

### *Patients*

In all, 453 charts were reviewed dating between February 2014 and June 2016, which represented 499 URS procedures. Patients' characteristics and demographics and indications for URS are shown in Table 1. In the string group, there were no intraoperative complications. In the no-string group, there were nine intraoperative complications, including two ureteric perforations, one distal ureteric tear, one ureteric laceration, one failure of the procedure, one procedure in which residual stones could not be recovered, one in which an incidentally encountered small stricture remained even after dilatation to remove stones, and one basket malfunction.

### *Outcomes*

Complications of the procedure are given in Table 2. Complication were encountered in 51 patients when a string was left and 155 patients when a stent was left without a string, which was not statistically significantly different ($P = 0.867$). Patients were statistically more likely to encounter complications if they had either procedures removing stones in both the kidney and the ureter (19.2% had complications) or procedures that encountered no stones (29.0% had complications) ($P = 0.012$). However, there was no difference between patients who had only a ureteric or only a kidney stone (in both 11.2% had complications). Postoperative complications, which included urinary retention or obstruction and stent migration, were relatively rare in both groups. Patients' ability to self-remove stents was adequate. Of the 94 patients in the string group, two were unable to remove their stents, due to fear of removing their stents, and required a return to the office for stent removal, which was performed by a nurse without requiring an operative suite. Three patients removed their stents too early. One of these patients returned to the Emergency Department for significant flank pain, requiring cystoscopy, blood clot evacuation, and stent replacement. Another returned to the Emergency Department due to flank pain after their premature stent removal but decided to use analgesics instead of stent replacement. In the final patient, who was already hospitalised, we elected to observe rather than replace

**Table 1** Patients' characteristics and indications.

| Characteristic | String | No string | *P* |
|---|---|---|---|
| Age, years, mean (SD) | 50.0 (16.5) | 54.9 (18.1) | 0.018* |
| Sex (% male) | 59.6 | 51.3 | 0.164 |
| BMI, kg/m$^2$, mean (SD) | 29.9 (7.2) | 30.2 (7.2) | 0.713 |
| Indications, *n* | | | |
| Stone ureter only | 60 | 173 | 0.119 |
| Stone kidney only | 14 | 75 | |
| Stone both ureter and kidney | 16 | 67 | |
| No stone | 4 | 34 | |

* $P < 0.05$.

**Table 2** Complications.

| Complication | String, *n* | No string, *n* | *P* |
|---|---|---|---|
| Total number of patients | 94 | 349 | |
| Return to Emergency Department | 16 | 55 | 0.753 |
| Post-procedure pain | 12 | 28 | 0.159 |
| Post-procedure complications (detailed below) | 12 | 82 | 0.867 |
| Pulled stent early | 3 | N/A | N/A |
| Unable to remove stent | 2 | N/A | N/A |
| Urinary obstruction or retention | 4 | 3 | 0.040* |
| Stent migration | 1 | 5 | >0.100 |
| Stricture requiring intervention | 0 | 1 | >0.100 |
| Ureteric perforation | 0 | 1 | >0.100 |
| Retained stone | 1 | 2 | 0.512 |
| UTI | 2 | 13 | 0.748 |
| Pyelonephritis | 1 | 2 | 0.512 |
| Sepsis | 0 | 3 | >0.100 |
| Acute abdomen | 0 | 1 | >0.100 |
| *C. difficile* infection | 0 | 1 | >0.100 |
| Fever | 1 | 5 | >0.100 |
| Anaemia | 1 | 1 | 0.380 |
| Bleeding requiring intervention | 2 | 9 | >0.100 |
| Acute myocardial infarction | 0 | 1 | >0.100 |
| Palpitations | 0 | 2 | >0.100 |
| Chest pain | 0 | 2 | >0.100 |
| Deep vein thrombosis/pulmonary embolism | 0 | 1 | >0.100 |
| Shortness of breath | 0 | 1 | >0.100 |
| Syncope | 0 | 1 | >0.100 |
| Acute kidney injury/acute renal failure | 1 | 1 | 0.380 |
| Nausea/vomiting | 2 | 2 | 0.199 |
| Allergic reaction | 0 | 1 | >0.100 |

* Statistical significance with $P < 0.05$.

**Table 3** Complications for the single- and double-arm-stringed stent groups.*

| Complication | Single-arm string ($n$ = 31), $n$ | Double-arm string ($n$ = 63), $n$ |
|---|---|---|
| Pulled stent early | 0 | 3 |
| Unable to remove stent | 1 | 1 |
| Urinary obstruction or retention | 2 | 2 |
| Stent migration | 0 | 1 |
| Retained stone | 0 | 1 |
| UTI | 0 | 2 |
| Pyelonephritis | 1 | 0 |
| Fever | 0 | 1 |
| Anaemia | 0 | 1 |
| Bleeding requiring intervention | 0 | 2 |
| Acute kidney injury/ acute renal failure | 0 | 1 |
| Nausea/vomiting | 1 | 0 |
| Total | 5 | 15 |

* No significant differences between the single- and double-arm-stringed stent groups, with $P > 0.100$ for all comparisons.

the stent. These five patients who were unable to self-remove their stents or removed them prematurely were early in the cohort. Thus, it appears anecdotally that patient training improved as the clinic's experience with this management strategy increased.

*Single-arm vs double-arm strings*

The single-arm group consisted of 31 procedures and the double-arm group included 63 procedures. The complication rate in the single- and double-arm groups were 12.9% and 12.7% respectively ($P > 0.100$). Thus, these strategies appear to have equivalent complication rates. Notably, three individuals in the two-arm group pulled their stents early, whilst no one in the single-arm group had this complication. In each group, one individual was unable to remove their stent and required a trip to the clinic. Stent migration only occurred in one individual in the two-arm group and did not occur in the single-arm group. These complications were not frequent enough to be analysed for statistical significance within the cohort (Table 3). However, stent migration and early removal did occur more frequently in the two-arm group, possibly indicating that single-arm-stringed stents are less difficult to retain in place. More work is needed to determine whether the single-arm-stringed stent approach is truly superior in preventing migration and early removals.

## Discussion

Placement of an indwelling ureteric stent after uncomplicated URS for stone disease is common, with over three-quarters of urologists reporting this practice [8–11]. Prophylactic stent placement may reduce the risk of ureteric obstruction, symptoms such as clot/fragment colic, and stricture formation following ureteric inflammation from ureteroscopic stone retrieval [12]. However, less than a quarter of practitioners (19–23%) use stent extraction strings, so that patients can remove their own stents at home [12–14]. This may be due to concerns over perceived risks, including increased LUTS from string irritation, stent dislodgement, infection, stent retention due to patients forgetting to remove stents, broken strings, and lack of strong evidence relating to its safety and tolerability [7,12,13]. Stent placement and subsequent removal also resulted in higher procedural costs than when a stent was not used [15–19].

Cost savings, decreased travel, and minimising care are important considerations in the changing healthcare environment and methods such as stents with self-removal strings may represent an opportunity to minimise the healthcare burden on patients undergoing URS. For this reason, several studies have identified the use of a string for self-removal of stents after URS as a cost-saving measure [20].

An advantage of stent extraction strings is that they reduce healthcare costs, and when used to remove stents at home, it reduces costs associated with patient travel and time taken off work [7]. Barnes et al. [7] estimated avoiding the need for a second hospital visit and cystoscopy for stent removal resulted in savings of ~£97 000 in their study population. Bockholt et al. [12] reported an estimated $1300 (American dollars)/patient cost associated with cystoscopic stent removal, which would be avoided by patients performing home stent extraction using strings. Based on an average 285 km (177 mile) round trip made by patients for cystoscopic stent removal and the cost of driving at $0.15–0.35/km ($0.40–0.90/mile; based on American Automobile Association estimates), Barnes et al. [7] estimated a $68–185 saving per patient on travel costs if patients removed their own stents at home. Recently, Okullo et al. [21] reported the overall cost of care was (in Australian dollars) a mean (SD) of $3603.6 (1896.7) vs $4468.1 (820.8) ($P = 0.042$) for string vs no-string stents, respectively. Such savings may have less impact in smaller countries where distances travelled by patients to their healthcare provider are far less.

Complication rates in our present study were similar in the string and no-string groups, at 12.8% of the string group and 14.0% of the no-string group ($P = 0.867$); compared to rates of 5–15% reported in the literature [20]. The present study sought to determine whether the use of a stent with a string attached for self-removal at home after URS procedures would be safe compared with a traditional stent removed in a procedure room. This management strategy appears to be safe and effective.

Additionally, the rate of dislodgement of stents with strings in our present study was lower than other studies

have reported; our present study demonstrated stent migration in only 1.1% of patients. There were no reported cases of stent dislodgement occurring in patients with stents without extraction strings.

Both Barnes et al. [7] and Althaus et al. [13] reported similar rates of stent dislodgement (15% and 13.3%, respectively), but Bockholt et al. [12] reported significantly lower rates (4.7%). Limitations to the Bockholt et al. [12] study include the retrospective study design and lack of validated outcome measures. Also, the majority of stents with strings were inserted by one surgeon, which could result in selection bias [12].

In our present study, 94.7% of patients were able to remove their own stents at home without incident, which is comparable to other studies [7,12]. Five of the 94 patients in the string group had difficulty removing their stents, with three removing their stent too early and two failing to remove their stent due to fear of doing so and requiring a return to the clinic for removal by a member of the nursing staff. However, these patients were early in the cohort, likely indicating improved instruction with experience.

Althaus et al. [13] reported two patients removing their stents prematurely without consulting a doctor, emphasising the need for preoperative patient education about the reason for stent placement and aftercare instructions, including contacting their urologist if premature stent removal is contemplated. Securing stent extraction strings to the patient did not appear to affect dislodgement rates; although this was not subject to statistical analysis. Althaus et al. [13] described securing the extraction strings to the penis in men and mons pubis or thigh in women. A systematic review analysis of eight randomised clinical trials indicated that an average of 10% of patients in the string group had prematurely dislodged stents [20].

Furthermore, the low rate of stent migration probably resulted from improved patient education about the strings on the stents. The low migration rate may also be a result of tying the strings together.

No significant differences in rates of infection or proximal stent migration were reported in any of the studies, suggesting that perceived risks by clinicians of such complications are unsubstantiated [7,12,14].

It has been suggested that strings may cause physiological changes, such as trigonal oedema, which leads to delayed pain after stent removal; however, there are no studies confirming this [14]. The Loh-Doyle et al. [14] study is limited by potential response bias, as survey respondents may not be representative of the stone population. Also, selection bias may have occurred with regard to reported pain outcomes, as those with higher anxiety may opt for doctor-stent removal using strings, although this was associated with higher pain scores on removal in their series. Loh-Doyle et al. [14] have compared this to a study on patients undergoing prostate biopsy, in which patients with greater pre-procedure anxiety experienced greater pain during the procedure to increased adrenergic response resulting in hyperalgesia and hypersensitisation of pain receptors.

York et al. [22] reported that 75% of patients would happily remove their own stent again using extraction strings if the need arose in the future. Similarly, a Californian group found that when patients self-removed their stents, 60% would choose this option again [14]. However, due to the absence of a control group for comparison, it is difficult to determine the effect of certain findings in the York et al. [22] study, such as pain and retained stones, as it is unclear how much of this was due to the presence of a stent itself rather than extraction strings.

There was no statistically significant difference in pain at stent removal between those who removed their stent independently vs those who underwent cystoscopy for stent removal, or in the rate of UTIs and Emergency Department visits between groups.

The present analysis also showed that a majority of patients preferred to remove their stents and that, contrary to the findings in the Barnes et al. [7] study, the pain was diminished in the string group. Thus, whilst these studies, like our present study, indicate a risk of premature stent removal when a string is left for self-removal, it appears that this technique is well-tolerated, does not increase pain, and results in cost savings. Furthermore, based on several studies, it may be preferred by well-trained patients. Thus, the use of ureteric stents with strings warrants further study and exploration. Additionally, the best techniques for training patients on when and how to remove their own stents should be explored.

The complication rate in the single- and double-arm-stringed stent groups was 12.9% and 12.7%, respectively ($P > 0.100$). However, stent migration and early removal did occur more frequently in the two-arm-stringed stent group, possibly indicating that single-arm-stringed stents are less difficult to retain in place. More work is needed to determine whether the single-armed-stringed stent approach is truly superior in preventing migration and early removals.

The strengths of the present study include the large heterogeneous sample with stents with strings left after procedures by multiple surgeons. A weakness of the present study is that only a single centre participated and that the study was not a randomised controlled trial. More studies, especially randomised trials, are needed to further examine the safety of this procedure and in what situations it should be employed. This technique should not be attempted in patients who will have difficulty removing their stents, including those with altered mental status or physical incapacitation that would prevent stent removal.

## Conclusions

The use of a stent with a string attached for self-removal after URS appears safe and effective for patients. If patients are appropriately selected this method can be used to decrease healthcare utilisation and the related financial burden. Single- and double-arm-stringed stents have equivalent complication rates. However, more work is needed to determine whether the single-armed stringed stent approach is truly superior in preventing migration and early removals.

## Conflict of interest

None.

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