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Do outcomes of ureteroscopic stone treatment vary with stone composition? A prospective analysis

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Introduction Urinary tract calculi are commonly treated with ureteroscopy and laser stone fragmentation (URSL). The composition of calculi depends on underlying patient factors. Stones associated with metabolic or infectious conditions are sometimes thought to be more difficult to treat. This analysis explores whether the composition of calculi impacts on stone-free and complication rates.

Material and methods A prospectively maintained database of patients undergoing URSL between 2012–2021 was used to explore records for patients with uric acid (Group A), infection (Group B) and calcium oxalate monohydrate (Group C) calculi. Patients who had undergone URSL to treat ureteric or renal calculi were included. Patient demographics, stone parameters and operative details were collected, with the principal outcomes being stone-free rate (SFR) and associated complications.

Results A total of 352 patients were included (58 Group A, 71 Group B and 223 Group C patients) and had their data analysed. SFR was >90% for all three groups and a single Clavien-Dindo grade III complication was noted. No significant differences were found between the groups for complications, SFR and day case rates.

Conclusions This cohort of patients demonstrated that outcomes were similar for three different types of urinary tract calculi, which form for differing reasons. URSL appears to be an effective, safe treatment for all stone types with comparable results.

Key Words: ureteroscopy ‹› urinary tract calculi ‹› laser ‹› stone composition

INTRODUCTION

Kidney stone disease (KSD) presents an increasing economic and logistical burden to healthcare services [1]. It also causes significant morbidity and is linked to conditions which can shorten life [2, 3, 4]. Upper urinary tract calculi are commonly treated with ureteroscopy and laser stone fragmentation (URSL). URSL is an established treatment option which is recommended for both ureteric and renal calculi [5, 6]. In most cases the chemical composition of calculi is not known prior to surgical extraction and biochemical analysis. Though measurements such as Hounsfield units (HU) may suggest the likely composition of a calculus, mixed composition is very common and stone subtypes may be treated or followed up differently [7]. The composition of calculi also depends on the underlying patient. Stones composed primarily of uric acid (UrA) occur commonly in diabetic and obese patients [8], stones composed of struvite or Magnesium Ammonium Phosphate (MAP) occur in patients with urinary infection caused by urease-producing bacteria [9] and stones composed of calcium oxalate monohydrate (CaOM) are commonly associated with dietary protein intake though may be associated with underlying conditions or be idiopathic [10].

The completeness of treatment using URSL can be measured using the reported stone-free rate (SFR) and this can vary between different stone

compositions [11]. Although societal guidelines recommend treatment based on stone size and location, they do not distinguish between differing stone compositions when recommending different treatment options [5]. This may be because outcomes for different stone compositions are similar, regardless of the treatment modality, but this is not well reported. It is becoming increasingly important to minimise variation between healthcare providers to achieve good outcomes, but without knowledge of the optimal treatment for differing stone types, this is difficult to achieve [12]. The aim of this study was to explore whether the outcomes of URSL vary with differing stone composition.

MATERIAL AND METHODS

A prospective database of consecutive patients undergoing ureteroscopy in a specialist endourology tertiary centre between March 2012 and December 2021 (10 years) was maintained and used to scrutinise patient outcomes. Those with UrA (Group A), MAP (Group B) and CaOM (Group C) calculi who had undergone ureteroscopy to treat ureteric or renal calculi ≤20 mm were included. Groups were assigned based on the largest representative component of each stone removed and analysed in the laboratory. Stones where no single component represented ≥70% of the stone on analysis were excluded. Stone data was reported based on pre-operative computed tomography imaging whilst intra-operative details were recorded contemporaneously with the operation reports. Clinical parameters recorded were gender, age, pre-operative renal function, pre-operative ureteric stent placement, stone diameter (mm), stone location, intra and post-operative complications, length of stay (LOS), retreatment rates and stone-free rates (SFR). Complications were stratified by whether the pre-operative stent dwell time was greater or lesser than 60 days [13]. Statistical computation was performed using Fisher's exact test or the Chi-Squared test and p-values were taken to be significant when $P < 0.05$.

All patients underwent URSL under general anaesthetic and stone fragments were sent for analysis. A protocol-led procedure was done under general anaesthetic. A semi-rigid URS was done using 4.5 or 6 French (Fr) Wolf or Storz semi-rigid ureteroscope and based on surgeon discretion a ureteral access sheath (UAS) was used (9.5 Fr/11.5 Fr or 12 Fr/14 Fr Cook Flexor sheath). A flexible ureteroscopy (Storz FlexX2) and holmium laser (Lumenis, LTD) stone treatment was then performed. Fragments were retrieved using Cook Ngage stone extractor (Cook Medical, USA), with a 6 Fr ureteral stent placed if indicated. Patients who had a complete treatment were seen in clinic at 2–3 months with their stone analysis results and repeat imaging with either plain film x-ray, ultrasonography or computed tomography depending on the opacity of the stone. Some patients underwent a staged URSL procedure for a large initial stone burden or retained stone fragments with symptoms. Others underwent further URSL later during the course of their treatment for stone recurrence uncovered during follow-up. The SFR was defined as the patient being both endoscopically and radiologically stone-free or with intrarenal fragments ≤2 mm. Post-operative complications were recorded classified as per Clavien-Dindo classification system.

Table 1. *Patient demographics*

	A (Uric Acid)	B (Magnesium Ammonium Phosphate)	C (Ca Oxalate Monohydrate)	All
n	58	71	223	352
Mean age (years)	64	58	63	62
Gender M/F %	69/31	33/67	77/23	60/40
Pre-operative Creatinine umol/L (mean)	110	89	94	98

n – number of patients; M – male; F – female

RESULTS

A total of 352 URSL procedures were performed for 318 patients (1.1 procedure/patient) with 58 patients in Group A, 71 patients in Group B and 223 patients in Group C. Of these, there were 20 staged procedures and 14 repeat treatments later in the study period. The mean age of the patients was 62 years, and female patients represented the majority of group B patients whilst male patients represented the majority for groups A and C (see Table 1). Overall, 50%, 54% and 42% of procedures were performed in the presence of a pre-operative stent with mean stent dwell times of 123, 157 and 143 days for groups A, B and C respectively. Pre-operative renal function was worse at baseline in group A. Baseline demographics are presented in Table 1.

Stones were located in the kidney in 35% of procedures, the mid/upper ureter in 27% and the lower ureter in 20%, with 17% of patients having stones in both the ureter and kidney. Group C stones tended to be smaller (mean 8.7 mm) compared to groups A and B (11.8 mm and 12.7 mm). A temporary post-operative stent was placed in 85% of procedures (see Table 2).

The SFR was ≥90% for all groups ($p = 0.83$). The number of procedures performed as a day-

case was lower for Group B patients who also had the most unplanned overnight stays, but this was not a significant difference (p = 0.25). The overall complication rate was 6% (n = 22), 21 of which were Clavien-Dindo grade 1–2 complications (see Table 3). There were similar complication rates in each group (p = 0.19). The patient with a grade 3 complication (Group C) required a return to theatre for ureteroscopy and stenting for an obstructing ureteric fragment. There were 10 complications in patients with a stent dwell time >60 days compared to 3 in the lower stent dwell time group with more of these occurring in the Group C patients with prolonged stent dwell time (p = 0.39). There were similar numbers of patients requiring a staged retreatment in each group.

Table 2. *Stone and operative characteristics*

	A (Uric Acid)	B (Magnesium Ammonium Phosphate)	C (Ca Oxalate Monohydrate)	All
Pre-operative stent	29 (50%)	38 (54%)	94 (42%)	161 (46%)
Pre-operative stent dwell time (mean days)	123	157	143	141
Post-operative stent	54 (93%)	63 (89%)	184 (83%)	301 (86%)
Mean single stone size (mm, range)	11.8 (4–23)	12.7 (4–33)	8.7 (2–27)	11.1 (2–33)
Location				
Ureter	21	30	115	166
Kidney	19	29	77	125
Both	18	12	31	61

Table 3. *Patient outcomes*

	A (Uric Acid)	B (Magnesium Ammonium Phosphate)	C (Ca Oxalate Monohydrate)	All
All complications n (%)	5 (8.6%)	5 (7%)	11 (4.9%)	21 (6%)
Infectious complications n (%)	3 (5.2%)	5 (7.0%)	6 (2.7%)	14 (4.0%)
Clavien-Dindo Grade 3+ complications n (%)	0	0	1 (0.4%)	1 (0.3%)
Stone-free rate n (%)	53 (91%)	64 (90%)	206 (92%)	323 (91.8%)
Daycase rate (%)	44 (76%)	45 (63%)	160 (72%)	249 (71%)
Unplanned overnight stay	7 (12%)	9 (13%)	18 (8%)	34 (9.6%)
Complications >60 days stent dwell time	2	2	6	10
Complications <60 days stent dwell time	2	1	0	3
Repeat treatments				
Staged procedure	Staged 6	Staged 6	Staged 8	20
Separate procedure	Separate 5	Separate 4	Separate 5	14

n – number of patients

DISCUSSION

This report details the outcomes for URSL procedures according to 3 different principal components of urinary tract stones. Other than the pre-operative renal function the patients in the study groups were well matched and the outcomes were similar. The study also supports findings from previous work showing that longer pre-operative stent dwell time may be associated with a higher rate of complications [13].

The main strength of this study is the large number of procedures available for analysis. It is clearly identified that offering URSL for three of the most common stone compositions, as in this cohort, does not result in variation in outcomes for patients. This has important implications for consent conversations with patients, pre-operative list planning and service delivery. The overall SFR and number of complications are consistent with previous studies indicating that this is a representative study and stone composition is not a significant predictor of outcome [14].

A few studies have explored differing stone types and surgical treatment previously. Seitz et al. report outcomes of laser lithotripsy for ureteric stones in 543 patients but did not include renal stones [14]. They report no difference in outcome according to stone composition. Nevo et al. report more recurrences and procedural interventions for uric acid calculi compared to calcium oxalate stones in parents treated with ureteroscopy or percutaneous nephrolithotomy [15]. Kadihasanoglu et al. compared laser to pneumatic lithotripsy for 114 patients and found no difference in outcomes for calcium oxalate and calcium phosphate stones [16]. Xue et al. found that calcium oxalate monohydrate and calcium phosphate renal stones had lower clearance rates compared to other stone compositions for stones greater than 1 cm in size [11]. Lastly, Wiener et al. report similar operative times for multiple stone types treated with URSL [17].

This study did not show that prolonged stent dwell time may be linked to post-ureteroscopy infections [13]. However, the overall number of complications was small and there was a trend towards more complications in patients with pre-operative ureteric stents. Future service delivery in Urology centres needs

to focus on prioritising patients with indwelling ureteric stents to reduce infectious complications. A more effective way of avoiding these is to also attempt to reduce the use of temporising ureteric stents [18]. The main limitations of this study are that it reports results from a single centre and the analysis of stone composition is based on the principal component only, not additional components. This may have implications for patients with mixed stone disease where there is equilibrium between components. Furthermore, this study cannot be generalised to all stone types. Rarer types of stone such as brushite and cystine will require further studies, which were not included due to small number of these stone types.
This cohort of patients demonstrated that complications, stone free rates and length of stay were similar for three different types of urinary tract calculi which form for differing reasons. Planned research to investigate surgical intervention for urinary tract stones, such as the PUrE randomised controlled trial, will provide high-level evidence to add to that from this study [19]. Ureteroscopy appears to be an effective, safe treatment for multiple types of stone. Further work should focus on improving daycase rates and reducing post-operative infectious complications as much as possible.

CONCLUSIONS

Our study demonstrates that outcomes of URSL were similar for three different types of urinary tract calculi, which form for differing reasons. URSL appears to be an effective, safe treatment for all stone types with comparable results.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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