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ORIGINAL RESEARCH

Analysis of the Value of Flexible Ureteroscopy in the Treatment of Renal Calculi

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ABSTRACT

Objective • Kidney stones (renal calculi) are a prevalent medical condition, causing significant pain and discomfort to patients. The existing treatment options for kidney stones include extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and flexible ureteroscopy. It is crucial to evaluate the effectiveness of different treatment modalities, including flexible ureteroscopy, to ensure optimal patient outcomes. This study aims to assess the effectiveness of flexible ureteroscopy in treating renal calculi and determine its value in managing this condition.

Methods • The study involved a total of 106 patients with kidney stones admitted to the hospital. The patients were divided into an experimental group and a control group. In the control group, percutaneous nephrolithotomy was performed on the patients. The procedure involved placing the patient in the lithotomy position, making an opening at the urethra, inserting a ureteral catheter retrograde to the affected side, and performing puncture under ultrasound guidance. Postoperative anti-infection treatment was given and the results were evaluated through imaging.In the experimental group, ureteral lithotripsy was performed with the patient under general anesthesia. The procedure included dilating the patient's ureter, exploring the location of the kidney stone, using a laser lithotripter to crush the stone, and clearing the fragments. A double J tube was placed at the end of the procedure, and the patient received appropriate antibiotics. Treatment and care continued until the patients were discharged. Clinical efficacy, clinical indicators, renal function, coagulation function, complications, and other factors were observed and recorded.

Results • The experimental group showed higher rates of treatment effectiveness (98.11%) and significance (79.25%) compared to the control group, while the treatment failure rate (1.89%) was lower in the experimental group ($P < .05$). In terms of surgical outcomes, the experimental group had lower intraoperative bleeding volume, catheter removal time, hospitalization time, and postoperative activity time compared to the control group. The time to get out of bed after surgery and drainage tube removal time were also lower in the experimental group. However, the operation time was longer in the experimental group ($P < .05$). Regarding postoperative indicators, the experimental group exhibited lower levels of KIM-1, Cys-c, and NGAL compared to the control group ($P < .05$). The experimental group also had lower MA and α values, but higher R and K values during the postoperative period compared to the control group ($P < .05$). Overall, the experimental group had a significantly lower complication rate (11.32%) compared to the control group (28.30%) ($P < .05$).

Conclusion • The use of ureteroscopic lithotripsy in the treatment of kidney stones can effectively improve the efficiency of patient treatment, with better intraoperative conditions and better prognosis, and less impact on the patient's renal function and coagulation function, as well as reducing the occurrence of postoperative complications in patients, which is worthy of wide application and promotion in clinical practice. (*Altern Ther Health Med.* 2024;30(7):202-206).

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INTRODUCTION

Kidney stones, a prevalent disease of the urinary system characterized by the accumulation of crystals in the kidney, can have diverse clinical manifestations depending on the stone's location, shape, and size. Symptoms include lower abdominal swelling, pain, haematuria, urination difficulties, and the need for stone removal.[1] Aside from affecting surrounding tissues and organs, kidney stones can significantly impact patients' physical and mental well-being.[2] With an incidence rate ranging from 1.61% to 20.54% in China, kidney stones are a common urological condition, more frequently occurring among men, in southern regions, and during the summer.[3] Current treatment approaches

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encompass a combination of symptomatic, etiological, and other therapies, with surgical intervention considered for larger stones or cases where medication fails to alleviate pain. However, traditional surgical methods involving incisions pose limitations, including substantial damage to renal parenchyma and perirenal tissues, intraoperative bleeding, post-operative infections, and fever, hindering the recovery process.[4] Urology is now witnessing the rise of minimally invasive techniques, such as percutaneous nephrolithotomy, which offer advantages such as reduced trauma and faster recovery, gradually replacing traditional open surgery as a common kidney stone treatment.[5] Despite these advancements, addressing multiple kidney stones through a single channel remains challenging and may cause damage to the renal pelvis and parenchyma. The widespread clinical adoption of flexible ureteroscopy, enabled by advancements in medical technology and lithotripsy equipment, provides a promising alternative. This technique involves retrograde access to the renal pelvis and calyces via the natural lumen of the urinary system, combined with Holmium laser lithotripsy, enabling direct visualization and minimally invasive, safe, and efficient stone removal.[6]

Nevertheless, the safety and effectiveness of flexible ureteroscopic lithotripsy for kidney stones require further investigation. Therefore, this study aims to explore the safety and application value of flexible ureteroscopic lithotripsy compared to traditional lithotripsy surgery, addressing the existing research gap and providing essential insights for improving treatment outcomes.

INFORMATION AND METHODS

General information

A total of 106 patients with kidney stones admitted to our hospital between February 2020 and February 2023 were selected as the study subjects and divided equally into an experimental group (53 cases) and a control group (53 cases) according to the method of drawing lots. In the experimental group, there were 28 males and 25 females; the average age was (43.62±5.59) years; all patients had unilateral kidney stones, 33 on the left side and 20 on the right side; the average diameter of the stones was (1.53±0.44) cm; in the control group, there were 30 males and 23 females; the average age was (41.94±6.34) years; all patients had unilateral kidney stones, 28 on the left side and 25 on the right side; the average diameter of the stones was (1.53±0.44) cm.

Inclusion criteria: (1) Patients all met the diagnostic criteria for renal calculi in the Chinese Guidelines for the Diagnosis and Treatment of Urological Diseases[7]; (2) None of the patients were contraindicated to surgery; (3) All patients were over 18 years of age; (4) Mental status is normal, and they are able to communicate and interact normally.

Exclusion criteria: (1) Patient has other malignant neoplasms; (2) Patient with concomitant immune system disorders; (3) the patient has a combination of other organic diseases; (4) the patient voluntarily abandons treatment in the middle of the course; (4) Pregnant or breastfeeding women.

The study was approved by the hospital ethics committee and the patients all signed an informed consent form.

For the general data, the differences were not statistically significant and comparable ($P > .05$).

Methodology

Control Group (Percutaneous Nephrolithotomy):

1. Place the patient in the lithotomy position and make an opening at the urethra.
2. Insert a ureteral catheter retrograde to the affected side's ureter, and place the patient in the prone position.
3. Perform puncture under ultrasound guidance
4. Administer postoperative anti-infection treatment.
5. Evaluate the results of lithotripsy using imaging.[8]

Experimental Group (Flexible Ureteroscopic Lithotripsy):

1. Place the patient in a general anaesthetic position with a cystostomy.
2. Dilate the ureter by inserting a hydrophilic ultra-smooth guidewire via the urethral orifice.
3. Explore the location of the kidney stone consultatively, starting from the ureter and working upwards to the renal pelvis.
4. Confirm that there is no ureteral stenosis or other disease.
5. Withdraw the rigid scope and push in the flexible scope into the calyces and pelvis of the kidney.
6. Connect laser fibre to the Holmium laser lithotripter and hold it against the kidney stone for lithotripsy, crushing it to as much powder as possible.
7. Use a lithotripter blue to grasp and clear stones if the number of stones is large or the size of the stone fragments significant.
8. Place a double J tube in the patient, closely monitor their vital signs, and administer antibiotics.
9. Continue treatment and care until the patient is discharged.[9]

Observation indicators

Comparison of clinical efficacy: B ultrasound was shot 2d after surgery, and its efficacy was determined by whether the residual stones or the size of the stones[10]: Significant: the patient's clinical symptoms completely or partially disappeared. When ultrasound was taken 2d after surgery, there was no stone residue; effective: the patient's clinical symptoms improved significantly. The residual stone was <4mm when the ultrasound was taken 2d after surgery; ineffective: no significant change in clinical symptoms. Total effective rate = number of cases (Show effect + effective) / total number of cases × 100%.

Comparison of clinical indicators: observation and recording of patients' operative time, intraoperative bleeding, catheter removal time, hospital stay, postoperative bed activity time, and drainage tube removal time.

Comparative renal function: Urinary kidney injury molecule-1 (KIM-1), serum cystatin-c (Cys-c), and

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neutrophil gelatinase-associated lipid transport protein (NGAL) levels were measured using an enzyme-linked immunoassay.

Comparison of coagulation function: Coagulation function was measured using a thromboelastography coagulation analyzer, where parameters included clot formation rate (K), reaction time (R), clot aggregation rate (α), and platelet function (MA).

Comparison of complications: compare the incidence of fever, severe haematuria, infection, renal colic, and subperitoneal haematoma complications in the two groups after undergoing surgical treatment.

Statistical methods

SPSS26.0 statistical software was used for statistical analysis of the data, and Excel software was used for data collation and calculation. Clinical efficacy, complication rate, and other count data were expressed as percentages (%), and χ^2 test was used for comparison between groups; clinical indicators, renal function indicators, coagulation function indicators, and other measurement data were expressed as ($\bar{x} \pm s$), and student *t* test and $P < .05$ was considered significant.

RESULTS

Comparison of clinical outcomes between the two groups of patients

The total effective rate of 98.11% and a significant rate of 79.25% were found to be higher in the experimental group than in the control group, and the treatment failure rate of 1.89% was lower in the experimental group than in the control group, $P < .05$, as shown in Table 1.

Comparison of clinical indicators between the two groups of patients

Intraoperative bleeding (12.74±3.67) ml, catheter removal time (1.62±0.53) d, hospital stay (5.03±1.63) d, postoperative time to bed (2.81±0.86) d, and drainage tube removal time (3.27±0.34) d were all lower in the experimental group than in the control group, but the operative time of patients in the experimental group (69.38±9.25) min was longer than that of the control group, $P < .05$, as shown in Table 2.

Comparison of renal function between the two groups

The postoperative indexes of KIM-1 (79.48±10.67) ng/L, Cys-c (679.12±85.67) μg/L and NGAL (4.31±0.62) μg/L were lower than those of the control group in the experimental group, $P < .05$; the differences between the preoperative indexes of the two groups were not statistically significant, $P > .05$, as shown in Table 3.

Comparison of coagulation function (TEG) between the two groups

The postoperative indexes of MA (49.48±6.17) mm and α (46.21±6.67) μg/L were lower in the experimental group than in the control group, and the postoperative indexes of R (5.61±0.62) min and K (2.35±0.29) min were higher in the experimental group than in the control group, $P < .05$; the differences between the preoperative indexes of the two groups were not statistically significant, $P > .05$, as shown in Table 4.

Comparison of complications between the two groups

The overall complication rate of 11.32% was significantly lower than that of 28.30% in the control group, $P < .05$, as shown in Table 5.

Table 1. Comparison of clinical outcomes between the two groups (n, %)

Group	Number	excellence	Effective	Invalid	total effective rate
Experimental group	53	42 (79.25)	10 (18.87)	1 (1.89)	52 (98.11)
Control group	53	26 (49.06)	19 (35.85)	8 (15.09)	45 (84.91)
χ^2	-	10.502	3.845	4.371	4.371
P value	-	.001	.049	.037	.037

Table 2. Comparison of clinical indicators between the two groups ($\bar{x} \pm s$)

Group	Operating time (min)	Intraoperative bleeding (ml)	Catheter removal time (d)	Length of stay in hospital (d)	Time in bed after surgery (d)	Time to drainage tube removal (d)
Experimental group (n = 53)	69.38±9.25	12.74±3.67	1.62±0.53	5.03±1.63	2.81±0.86	3.27±0.34
Control group (n = 53)	51.53±6.82	88.36±6.62	2.12±0.71	7.75±2.01	3.67±0.92	4.01±0.68
t	11.308	72.732	7.652	4.839	4.972	7.086
P value	.000	.000	.001	.000	.000	.000

Table 3. Comparison of renal function between the two groups ($\bar{x} \pm s$)

	KIM-1 (ng/L)		Cys-c (μg/L)		NGAL (μg/L)	
Group	Pre-operative	Postoperative	Pre-operative	Postoperative	Pre-operative	Postoperative
Experimental group (n = 53)	75.17±9.31	79.48±10.67	508.03±62.31	679.12±85.67	3.41±0.29	4.31±0.62
Control group (n = 53)	75.53±8.82	90.62±13.26	501.53±65.82	786.29±96.62	3.47±0.32	4.98±0.68
t	0.204	4.765	0.522	6.042	1.012	5.301
P value	.836	0.000	.603	.000	.314	.000

Table 4. Comparison of coagulation function (TEG) between the two groups ($\bar{x} \pm s$)

	MA (mm)		α (μg/L)	
Group	Pre-operative	Postoperative	Pre-operative	Postoperative
Experimental group (53)	46.17±7.31	49.48±6.17	44.03±6.31	46.21±6.67
Control group (53)	45.93±6.82	54.62±8.26	43.53±5.82	49.29±7.62
t	0.175	3.630	0.424	2.214
P value	.862	.001	.672	.029

	R (min)		K (min)	
Group	Pre-operative	Postoperative	Pre-operative	Postoperative
Experimental group (53)	6.84±0.89	5.61±0.62	2.70±0.39	2.35±0.29
Control group (53)	6.77±0.72	4.98±0.58	2.72±0.41	2.01±0.23
t	0.445	5.402	0.257	6.687
P value	.657	.000	.797	.00

Table 5. Comparison of adverse reactions between the two groups (n, %)

Group	Number	Fever	Severe haematuria	Infections	Renal colic	Subperitoneal haematoma	Total complications
Experimental group	53	1 (1.87)	3 (5.66)	0 (0)	1 (1.87)	1 (1.87)	6 (11.32)
Control group	53	2 (3.77)	5 (9.43)	1 (1.87)	5 (9.43)	2 (3.77)	15 (28.30)
χ^2	-	-	-	-	-	-	4.810
P value	-	-	-	-	-	-	.028

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DISCUSSION

Kidney stones, a prevalent clinical condition, can arise from metabolic abnormalities, prolonged drug use, and urinary tract pathology.[11] Low urine output leading to the formation of small stones in the urine is a primary cause, along with climatic factors and dietary habits. Most stones are composed of metabolic byproducts, reflecting abnormal metabolism of corresponding components in the body. The common components that contribute to stone formation are calcium, oxalic acid, uric acid, and cystine.[12] Physiological disorders involving any of these components can trigger stone formation and promote their growth. Metabolic abnormalities result in increased excretion of stone-forming substances, alterations in urinary pH, reduced urinary inhibitors of crystal formation and aggregation, and decreased urinary output. Certain drugs, such as aminopterin, indinavir, silicones, and sulphonamides, which are constituents of stones themselves, increase the likelihood of kidney stone formation due to high urinary concentrations and low solubility.[13] Moreover, long-term use of stone-inducing drugs like acetazolamide, vitamin D, vitamin C, and corticosteroids can contribute to stone formation from other components during metabolism. Urinary tract obstruction caused by various factors leads to urine stasis and urinary tract infections. Notably, certain bacteria can break down urea into ammonia, alkalizing the urine and facilitating the deposition of phosphates and carbonates, which contributes to stone formation. As the urinary tract is narrower in men, stone removal is more challenging, resulting in greater stone accumulation and a higher incidence of kidney stones in men. Additionally, increased water loss through sweating and breathing due to rising temperatures, coupled with inadequate water consumption, can lead to concentrated urine and promote kidney stone formation.[14]

In clinical treatment, traditional incisional lithotripsy has several limitations, including large surgical incision areas and poor prognosis, yielding unsatisfactory results. Minimally invasive procedures like percutaneous nephrolithotomy offer advantages such as minimal trauma, favorable outcomes, and rapid recovery. However, inexperienced operators and patients' physical conditions can lead to complications like postoperative infections and severe hematuria.[15] With the continuous development of minimally invasive surgery, ureteral flexible scopes are widely employed for kidney stone treatment. Ureteroscopy enables precise detection of stone location, significantly improving stone extraction accuracy. Additionally, the primary independent nature and superior flexibility of ureteral flexible scopes allow for effective detection of anatomical abnormalities and excellent results in obese individuals or those prone to bleeding. A study by Kaiyun Wang et al.[16] demonstrated that soft ureteral lithotomy for kidney stone surgery provides shorter intervals, less trauma, reduced body stress response, and no increase in the complication rate. This research provides ideas and a research basis for further exploration. Flexible ureteroscopy is commonly embraced by clinicians and patients alike due to its therapeutic advantages, leading to excellent clinical outcomes.[17] In this study, the experimental group exhibited a higher total effective rate (98.11%) and significant rate (79.25%) compared to the control group, with a lower treatment failure rate of 1.89% in the experimental group ($P < .05$). These findings suggest that ureteroscopy yields better treatment outcomes for patients with kidney stones, resulting in improved stone expulsion.

When comparing clinical indicators, the experimental group had lower levels of intraoperative bleeding, shorter catheter removal time, reduced hospital stay, earlier postoperative mobilization, and quicker drain removal time compared to the control group. However, the operative time was longer in the experimental group, indicating that flexible ureteroscopy for kidney stone patients leads to better intraoperative patient condition and prognosis, albeit with increased demands on the operator. These findings align with those of Reed et al.[18] The active bending characteristics of the flexible ureteroscope enable easier access to the calyces, improving stability and operability and facilitating thorough stone investigation. High-resolution, clear images provided by the flexible ureteroscope enhance precise stone localization, thereby reducing intraoperative bleeding and expediting catheter removal time. Combining ureteroscopy with holmium laser lithotripsy significantly reduces stone residuals and enhances the one-time stone removal rate. Ureteric access offers advantages of minimal damage and faster recovery, enhancing patient prognosis and considerably shortening postoperative bed rest and hospital stay. Additionally, preoperative examination through ureteroscopy offers comprehensive stone removal, effectively relieving clinical symptoms, shortening extubation time, and promoting faster patient recovery. Holmium laser plays an indispensable role in ureteroscopy-assisted kidney stone treatment. Its shallow tissue penetration and absorption by surrounding aqueous humor minimize damage to surrounding tissues, ensuring safe and accurate surgery. The high instantaneous peak energy of the holmium laser enables effective crushing of dense stones, including high-hardness cystine stones and calcium oxalate monohydrate stones. Holmium laser lithotripsy yields smaller stone fragments that are easier to pass than those crushed using pneumatic ballistics or ultrasound.[19]

High-pressure water irrigation is employed to maintain a clear field during kidney stone removal. However, if the physiological pressure of the renal pelvis is lower than the irrigation pressure, fluid regurgitation can occur, potentially damaging the kidneys.[20] Although flexible ureteroscopy combined with holmium laser lithotripsy effectively removes kidney stones in clinical practice, it necessitates skilled physicians who are well-versed in the procedure and equipment usage.

Cystatin C (Cys-c), a marker of renal metabolism, has been found to increase in the presence of glomerular damage.[21] Neutrophil gelatinase-associated lipocalin (NGAL), which promotes iron transfer into proximal tubular

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cells and provides protection, has been identified as a sensitive indicator of acute renal impairment.[21] In our study, postoperative renal function indicators, including kidney injury molecule-1 (KIM-1), Cys-c, and NGAL levels, were observed to be lower in the experimental group compared to the control group. While renal function indicators increased in both groups, the control group exhibited lower levels, suggesting that ureteral flexible scopy exerted a lesser impact on renal function. This may be attributed to the fact that the establishment of percutaneous nephroscopic renal access resulted in renal parenchymal destruction and kidney damage, while ureteral flexible scopes utilized natural channels for stone fragmentation, causing less damage.

Furthermore, during the kidney stone removal process, higher perfusion pressure can lead to compromised blood flow in small arteries, affecting coagulation and resulting in ischemic renal parenchyma. In severe cases, this can lead to kidney infection.[22] Thromboelastography (TEG), a dynamic assessment of blood coagulation, serves as an effective reflection of the body's coagulation function. Our study revealed that postoperative maximum amplitude (MA) and α indicators were lower in the experimental group, while postoperative reaction time (R) and clot formation time (K) indicators were higher in the experimental group compared to the control group. These findings suggest that the changes in these indicators were relatively minor in the experimental group, indirectly indicating a lesser influence on the body's coagulation function.

In terms of complications, the overall incidence rate was significantly lower in the experimental group compared to the control group. Percutaneous nephrolithotripsy, despite being associated with more severe intraoperative bleeding, carries a higher risk of infection and certain limitations, such as its inapplicability in patients with ectopic kidney disease or abnormal coagulation function. Ureteroscopy, based on a lumpectomy technique, offers improved access to the renal calyces and is considered a minimally invasive procedure, resulting in smaller surgical wounds and reduced intraoperative bleeding. Consequently, the chances of complications are minimized, allowing for faster patient recovery.[23] However, ureteroscopy has its limitations, as it can be time-consuming for stones larger than 2 cm in diameter, potentially increasing the risk of kidney damage, infection, and wear and tear on the flexible scopes.

In conclusion, ureteroscopic lithotripsy in the treatment of kidney stones can effectively improve the success rate of stone surgery, shorten the treatment time, improve the high rate of stone removal, and reduce the occurrence of postoperative adverse reactions, which has high clinical application value and deserves to be widely used and promoted in clinical practice. However, the patients enrolled in this study all had renal stones < 2cm in diameter, so there is a lack of analysis and comparison of the surgical outcomes of those with stones above 2 cm.

Due to the small number of subjects in this study, the experimental data are not generally representative, so it is appropriate to expand the sample size for an in-depth study.

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