

## Comparison of the Flush-out Technique and the Basket for Retrieving Stone Fragments in Distal Ureteral Stones After Ureterolithotripsy: A Prospective Randomized Study

Üreterolitotripsi Sonrası Distal Üreter Taşlarında Taş Fragmanlarının Çıkarılması İçin Flush-out Tekniği ve Basketin Karşılaştırılması: Prospektif Randomize Çalışma

Metin Savun<sup>1\*</sup>, Ertuğrul Arıkız<sup>1</sup>, Harun Özdemir<sup>1</sup>, Emin Taha Keskin<sup>1</sup>, Murat Şahan<sup>2</sup>, Halil Lutfi Canat<sup>1</sup>

<sup>1</sup> University of Health Sciences, Başakşehir Çam and Sakura City Hospital, Department of Urology, İstanbul, Türkiye

<sup>2</sup> University of Health Sciences, İzmir City Hospital, Department of Urology, İzmir, Türkiye

### ABSTRACT

**Objective:** This prospective randomized study evaluated the efficacy and safety of the flush-out technique in comparison with conventional basket retrieval for the clearance of stone fragments during semi-rigid ureteroscopy in patients with distal ureteral stones.

**Materials and Methods:** Eighty-four patients diagnosed with distal ureteral stones were randomly assigned to two equal groups. Group 1 underwent stone retrieval using a nitinol basket. In contrast, group 2 was treated with the flush-out technique, which entails passive fragment expulsion facilitated by irrigation pressure and strategic withdrawal of the ureteroscope. Demographic data, stone characteristics, operative outcomes, and complication rates were recorded.

**Results:** Demographic data and stone characteristics were comparable between the two groups. The Group 2 exhibited a significantly reduced median operation time (30 vs. 45 minutes,  $p=0.020$ ) and stone retrieval time (1 vs. 10 minutes,  $p=0.001$ ) in comparison to the Group 1. The stone-free rates on postoperative day one were similar between the groups (97.6% vs. 100%,  $p=1.000$ ). Intraoperative and postoperative complication rates were analogous, with no significant differences observed in the distribution of the Satava and Clavien-Dindo classifications.

**Conclusion:** The flush-out technique is a safe and efficacious alternative to basket retrieval for managing distal ureteral stones, yielding comparable clinical outcomes while reducing both operative and stone retrieval times. Its simplicity and cost-effectiveness may facilitate broader adoption in routine urological practice, particularly in high-volume and resource-constrained settings.

**Keywords:** lithotripsy, laser, surgical instruments, ureteral calculi, ureteroscopy

**Cite As:** Savun M, Arıkız E, Özdemir H, Keskin ET, Şahan M, Canat HL. Comparison of the Flush-out Technique and the Basket for Retrieving Stone Fragments in Distal Ureteral Stones After Ureterolithotripsy: A Prospective Randomized Study. Endourol Bull. 2025;17(3):157-163. <https://doi.org/10.54233/endourolbull-1744397>

**Corresponding Author:** Metin Savun, University of Health Sciences, Başakşehir Çam and Sakura City Hospital, Department of Urology, İstanbul, Türkiye

**e-mail:** [metinsavun@hotmail.com](mailto:metinsavun@hotmail.com)

**Received:** July 20, 2025

**Accepted:** September 15, 2025



**ÖZET**

**Amaç:** Bu prospektif, randomize çalışmada, distal üreter taşı olan hastalarda semi-rigid üreteroskopi sırasında taş fragmanlarının çıkarılması için basket ve flush-out tekniği karşılaştırılmıştır.

**Gereç ve Yöntemler:** Distal üreter taşı olan 84 hasta eşit olarak iki gruba ayrıldı. Grup 1'e nitinol basket kullanılarak taş çıkarma işlemi uygulanırken, Grup 2'ye irrigasyon basıncıyla üreteroskopun geri çekilmesi yoluyla pasif olarak taş fragmanlarının çıkarılmasını içeren flush-out tekniği uygulandı. Demografik veriler, taş özellikleri, operasyon sonuçları ve komplikasyon oranları kaydedildi.

**Bulgular:** Demografik veriler ve taş özellikleri iki grup arasında benzerdi. Grup 2, Grup 1'e kıyasla anlamlı derecede daha kısa median operasyon süresi (30'a karşı 45 dakika,  $p=0,020$ ) ve taş çıkarma süresi (1'e karşı 10 dakika,  $p=0,001$ ) gösterdi. Ameliyat sonrası birinci gündeki taşsızlık oranları gruplar arasında benzerdi (%97,6'ya karşı %100,  $p=1,000$ ). Ameliyat sırasında ve sonrasındaki komplikasyon oranları benzerdi ve Satava, Clavien-Dindo sınıflandırmalarının dağılımında anlamlı bir fark yoktu.

**Sonuç:** Flush-out tekniği, distal üreter taşları için basket yöntemine güvenli ve etkili bir alternatif olup, daha kısa ameliyat süresi ve taş çıkarma süreleri ile karşılaştırılabilir klinik sonuçlar sunmaktadır. Basitliği ve uygun maliyeti, özellikle yüksek hacimli ve sınırlı kaynaklara sahip kliniklerde günlük üroloji pratiğinde daha yaygın bir şekilde uygulanmasını destekleyebilir.

**Anahtar Kelimeler:** cerrahi aletler, lazer litotripsi, üreteral taşlar, üreteroskopi

**INTRODUCTION**

Distal ureteral stones constitute a prevalent category of urolithiasis cases that are typically addressed using ureteroscopic (URS) intervention. The combination of semi-rigid ureteroscopy with holmium: yttrium–aluminum–garnet (YAG) laser lithotripsy has emerged as the standard method for fragmentation of distal ureteral stones, offering high efficacy and safety with minimal invasiveness (1,2). Following laser fragmentation, management of residual fragments remains a crucial step in achieving optimal stone-free outcomes.

Traditionally, stone fragments are extracted using ureteroscopic stone retrieval devices such as nitinol baskets. Although effective, basket retrieval presents several potential disadvantages, including prolonged procedural time, elevated equipment costs, and the risk of device malfunction or complications related to entrapment (3,4). These limitations have led to the investigation of alternative fragment clearance techniques that are both efficient and cost-effective.

The flush out technique, previously documented in percutaneous nephrolithotomy (PNL) and retrograde intrarenal surgery (RIRS), employs irrigation pressure in conjunction with advantageous patient positioning to facilitate the passive migration of stone fragments into the bladder, thereby obviating the need for active retrieval (5,6). Nonetheless, its application in the context of distal ureteral stones during URS has not been sufficiently investigated in the existing literature.

The objective of this study was to evaluate the flush-out technique in comparison with conventional basket retrieval in terms of stone-free rates, operative duration, and complication rates in patients undergoing semi-rigid URS for distal ureteral stones. We hypothesized that the flush-out technique would provide comparable stone-free and complication rates to basket retrieval while reducing operative time and cost.

**MATERIALS AND METHODS**

This prospective, randomized study was conducted by the principles outlined in the Declaration of Helsinki by the World Medical Association, titled "Ethical Principles for Medical Research Involving Human Subjects." The study protocol was approved by the institutional ethics committee (approval number: 2021-287). Assuming an alpha level of 0.05 and a statistical power of 80%, the required minimum total sample size was calculated to be 84 patients, with 42 patients allocated to each group.

Patients who underwent semi-rigid URS for distal ureteral stones between April 2022 and January 2023 were included in this study. The inclusion criteria specified patients with distal ureteral stones who were deemed suitable for semi-rigid URS. The distal ureter was defined as the segment of the ureter below the sacroiliac joint. The exclusion criteria included a history of previous urological stone surgery or extracorporeal shockwave lithotripsy (ESWL), preoperative indwelling double-J stent or nephrostomy tube, age < 18 years, or anatomical abnormalities. Randomization into two groups was performed using computer-generated random number sequences.

All patients underwent standard preoperative assessments. Demographic data, including age, gender, and body mass index (BMI), as well as stone-specific parameters such as size and location, were documented. The presence of ureteral stones was confirmed using non-contrast-enhanced computed tomography (NCCT). Stone size was determined by measuring its longest diameter. Preoperative laboratory evaluation included a complete blood count and serum creatinine levels. Prior to the procedure, patients with positive urine cultures received targeted antibiotic therapy based on antimicrobial susceptibility.

All URS procedures were conducted under spinal or general anesthesia. A 6/7.5 Fr semi-rigid ureteroscope (Richard Wolf, Knittlingen, Germany) was introduced into the bladder following the insertion of a feeding catheter and placement of a safety guidewire (Boston Scientific, Marlborough, Massachusetts, USA) into the ureter. Stone fragmentation was accomplished using a Holmium: YAG laser (Sphinx, Katlenburg-Lindau, Germany). In Group 1 (basket group), stone fragments were actively retrieved using a 1.9 Fr nitinol stone basket (Boston Scientific, Marlborough, Massachusetts, USA). In Group 2 (flush-out group), fragments were expelled passively using the flush-out technique. After complete fragmentation, the ureteroscope was advanced proximal to the stone location, and continuous irrigation was applied while the scope was slowly withdrawn. The ureteroscope was advanced proximal to the stone location, and continuous irrigation was applied while the scope was slowly withdrawn. This maneuver created a unidirectional flow that facilitated the movement of the fragments into the bladder. Maintaining a low intravesical pressure during this process is essential to facilitate fragment expulsion.

The postoperative placement of the double-J stent was determined at the discretion of the surgeon. Intraoperative complications were categorized using the Satava classification system (7). All patients underwent kidney, ureter, and bladder (KUB) radiography on the first postoperative day. Patients who achieved complete stone clearance were designated as stone-free, whereas those who did not achieve this status received additional treatment as clinically indicated. Postoperative complications were assessed and graded according to the Clavien–Dindo classification system (8).

Statistical analyses were performed utilizing SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean  $\pm$  standard deviation or median (interquartile range (IQR)), depending on the distribution determined by the Shapiro–Wilk test. Comparisons were made using either the Student's t-test or the Mann–Whitney U test, as appropriate. Categorical variables were assessed using the chi-square test or Fisher's exact test. Statistical significance was established at  $p < 0.05$ .

## RESULTS

A total of 84 patients participated in the study, with an equal allocation of 42 patients to each group. No statistically significant differences were observed between the two groups regarding baseline characteristics. The median age was 44 years in the basket group and 35 years in the flush-out group ( $p = 0.172$ ). Gender distribution, BMI, stone size, number of stones, stone side, and the presence of impacted stones were also comparable between the groups ( $p > 0.05$  for all) (Table 1).

In terms of perioperative and postoperative outcomes, the mean duration of operation was significantly shorter in the flush-out group compared to the basket group (45 vs. 30 minutes,  $p = 0.020$ ). Additionally, the mean time for stone retrieval was markedly reduced in the flush-out group (1 vs. 10 minutes,  $p = 0.001$ ).

**Table 1.** Demographic data and stone characteristics according to groups

Number of patients	Group 1 (basket)	Group 2 (flush-out)	p
	42	42	
<b>Gender</b>			0.512
Male	18 (42.9%)	22 (52.4%)	
Female	24 (57.1%)	20 (47.6%)	
<b>Age* (year)</b>	44 (32-49)	35 (31-47)	0.172
<b>Body mass index* (kg/m<sup>2</sup>)</b>	27.6 (26.1-29.7)	27 (23.6-30.2)	0.867
<b>Stone size* (mm)</b>	13 (6-14)	8 (7.0-10.8)	0.439
<b>Number of stones</b>			0.405
Soliter	36 (85.7%)	32 (76.2%)	
Multiple	6 (14.3%)	10 (23.8%)	
<b>Stone side</b>			0.827
Right	24 (57.1%)	22 (52.4%)	
Left	18 (42.9%)	20 (47.6%)	
<b>Impacted stone</b>	10 (23.8%)	10 (23.8%)	1.000

\*: median (interquartile range)

Intraoperative complications were observed in five patients (11.9%) in the basket group and six patients (14.3%) in the flush-out group ( $p = 1.000$ ). According to the Satava classification, the majority of complications in both groups were classified as grade 1, including mucosal tears and mild bleeding. In the basket group, a device malfunction occurred in one patient. 3%) in the flush-out group ( $p = 1.000$ ). According to the Satava classification, most complications in both groups were grade 1, including mucosal tears and mild bleeding. In the basket group, a device malfunction occurred in one patient. In the flush-out group, one patient experienced a grade 2b complication, specifically a mucosal injury necessitating re-URS, while no such complications were noted in the basket group ( $p = 0.602$ ). No severe complications, such as ureteral avulsion, were reported in any case.

The stone-free rate on the first postoperative day was 100% in the basket group and 97.6% in the flush-out group, with no statistically significant difference between the groups ( $p = 1.000$ ). Postoperative complications were similarly distributed, occurring in three patients (7.1%) in the basket group and two patients (4.8%) in the flush-out group ( $p = 1.000$ ). According to the Clavien–Dindo classification, all complications were minor (grade 1: hematuria, renal colic, or grade 2: urinary tract infection (UTI)), with no significant difference in distribution between the two groups ( $p = 0.841$ ) (Table 2).

**Table 2.** Perioperative and postoperative outcomes according to groups

	Group 1 (basket)	Group 2 (flush-out)	p
<b>Number of patients</b>	42	42	
<b>Operation time (min)*</b>	45 (15-50)	30 (15-38)	0.020
<b>Stone retrieval time (min)*</b>	10 (5-13)	1 (1-4)	0.001
<b>Peroperative complications</b>	5 (11.9%)	6 (14.3%)	1.000
<b>SATAVA classification</b>			0.602
<b>Grade 1</b>	5 (11.9%)	5 (11.9%)	
<b>Grade 2a</b>	0	0	

<b>Grade 2b</b>	0	1 (2.4%)	
<b>Stone-free rate</b>	42 (100.0%)	41 (97.6%)	1.000
<b>Postoperative complications</b>	3 (7.1%)	2 (4.8%)	1.000
<b>Clavien - Dindo classification</b>			0.841
<b>Grade 1</b>	2 (4.8%)	1 (2.4%)	
<b>Grade 2</b>	1 (2.4%)	1 (2.4%)	

\*: median (interquartile range)

## DISCUSSION

Effective clearance of stone fragments is a crucial aspect of URS because residual fragments can result in recurrent symptoms, infection, or necessitate additional procedures. Traditionally, stone retrieval devices such as nitinol baskets and graspers have been employed for fragment removal, particularly in the distal ureter. These devices facilitate active extraction under direct visualization; however, they are associated with extended operation times and increased costs. Furthermore, their use may be constrained by anatomical limitations or risk of ureteral trauma (9,10).

The flush-out technique, which uses irrigation pressure to mobilize stone fragments into the bladder passively, has been primarily described in the context of PNL and RIRS (5,6). In these contexts, it has been demonstrated to reduce instrument manipulation and operation time. We have previously presented preliminary findings on the adaptation of this method for distal ureteral stones, suggesting that this approach may be both effective and efficient in the context of semi-rigid URS (11). To our knowledge, very few studies have specifically addressed this setting, underscoring the novelty of our investigation.

One potential concern associated with the flush-out technique is the transient increase in intrarenal pressure during active irrigation, which could theoretically increase the risk of complications such as mucosal injury, intraoperative bleeding, pyelovenous backflow, and postoperative infection (12). However, in our study, the incidence rates of mucosal injury, intraoperative bleeding, and postoperative UTI were comparable between the flush-out and basket groups. Postoperative UTIs are recognized as a complication of endourological procedures. Several prognostic factors have been associated with an increased risk, including patients with a higher Charlson comorbidity index, older age, female gender, prolonged duration of pre-procedural indwelling ureteric stents, neurogenic bladder, and BMI (13).

Ureteral avulsion is a rare, yet significant complication associated with URS procedures. This condition typically arises from the application of excessive force or the improper utilization of surgical instruments. The identified risk factors for ureteral avulsion include the presence of symptomatic stones for a duration exceeding three months, stones with a diameter greater than 5 mm, hydronephrosis of the proximal ureter, and impacted stones (14). Notably, no instances of ureteral avulsion were observed in our study.

An additional consideration is the suitability of the flush-out technique for surgeons with limited experience. Due to its straightforward nature, this technique does not necessitate advanced endourological expertise beyond fundamental ureteroscopic skills. Nevertheless, we advise that novice surgeons first attain proficiency in standard semi-rigid URS prior to adopting this method, as meticulous control of irrigation and scope manipulation is crucial to mitigate pressure-related risks and ensure safety.

While the basket device is effective, it is not without limitations, including potential malfunction, increased cost, and extended manipulation time (15). In our study, both the operation and stone retrieval durations were notably reduced in the flush-out group. In one instance, a basket malfunction required a change of devices, further prolonging the procedure. In addition to these practical benefits, the flush-out technique offers a significant economic advantage by obviating the need for disposable retrieval devices. This cost-effectiveness is particularly advantageous for high-volume centers and resource-constrained healthcare systems, where minimizing reliance on costly disposables can

substantially reduce overall treatment costs without compromising safety or efficacy.

This study has several limitations. The relatively small sample size may have limited the generalizability of our findings. The absence of stone composition analysis could result in variations in the data, such as fragmentation behavior and operation time. A cost analysis comparing the two methods was not conducted. Additionally, the lack of long-term follow-up data limits our ability to assess stone recurrence and late complications. Furthermore, although the clinical outcomes were monitored, intrarenal pressure was not measured directly. Given the theoretical concerns regarding pressure-related complications, future research should aim to quantify intrarenal pressures during the flush-out technique using pressure-monitoring systems.

## CONCLUSION

The flush-out technique is a safe and effective alternative to conventional nitinol baskets for retrieving stone fragments in patients undergoing semi-rigid ureteroscopic lithotripsy for distal ureteral stones. While achieving comparable stone-free and complication rates, the flush-out method significantly reduced both the total operation and stone retrieval times. These findings suggest that the flush-out technique may offer procedural efficiency and economic advantages, particularly in high-volume and resource-limited settings. Further studies with larger cohorts and direct measurement of intrarenal pressure are warranted to validate these outcomes and to explore long-term efficacy and safety.

**Funding:** The authors did not receive support from any organization for the submitted work.

**Acknowledgments:** None declared

**Data Availability:** The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

**Disclosure Statement:** The authors declare that they have no conflicts of interest.

**Ethics Committee Report:** Başakşehir Çam and Sakura City Hospital Clinical Research Ethics Committee Date: December 29, 2021 Decision No: 287.

## Authors' Contribution:

MS: Conception and design, Data analysis, Drafting the manuscript

EA: Data acquisition, Data analysis

HÖ: Data analysis, Manuscript editing

ETK: Statistical analysis

MŞ: Data analysis, Manuscript editing

HLC: Manuscript editing

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