



# Residual fragment size following retrograde intrarenal surgery: a critical evaluation of related variables

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## Abstract

Given the limited data on the predictive factors of residual kidney stone size after flexible ureteroscopy (fURS), this study aims to investigate the variables affecting residual stone size. The medical records of 642 patients without complications being treated for kidney stones with fURS between July 2014 and May 2022 were reviewed retrospectively, and the information of the 170 patients in whom residual stones were found was recorded. In addition to patient-specific factors and stone characteristics, length of postoperative hospital stay, postoperative fever, and preoperative antiaggregant use were evaluated. Of the 170 patients ultimately included in the study. The mean age was 51.56 ( $\pm 14.70$ ). The mean stone size was 14.01 mm ( $\pm 5.75$ ), the mean residual stone size was 7.04 mm ( $\pm 2.51$ ), and the mean stone density was 829 Hounsfield units ( $\pm 395.06$ ). The mean infundibulopelvic angle (IPA) was 49.37° ( $\pm 15.37$ ), and 41.2% of the stones were non-opaque. The mean parenchymal thickness was 22.88 mm ( $\pm 5.55$ ). 34 patients were on antiaggregant therapy. Preoperative stone size increases in stone density and decreases in IPA were found to be correlated with increase residual stone size ( $p < 0.001$ ,  $p < 0.001$ , and  $p < 0.001$ , respectively). In addition, larger residual stones were observed after the fURS procedure in patients using anticoagulants and those without hydronephrosis ( $p = 0.02$  and  $p = 0.016$ , respectively). Use of reliable predictive factors to forecast residual stone size after fURS may help to inform those treated and enable urologists to design rational surgical strategies.

**Keywords** Residual · Stone · Size · Retrograde · Flexible

## Introduction

Many factors are considered in deciding whether a patient should undergo surgery for kidney stones. These factors include patient symptoms, the presence of urinary obstruction, decline in kidney function, and relevant risk [1]. Tremendous technological advances in imaging methods have increased the rate of diagnosis of urinary stone disease in the last three to four decades [2]. Currently, minimally invasive treatment options for kidney stones include extracorporeal shock wave lithotripsy (ESWL), flexible ureteroscopy (fURS), and percutaneous nephrolithotomy (PCNL).

The European Association of Urology's urolithiasis recommendations state that ESWL and fURS are equally

effective treatment techniques for the management of kidney stones smaller than 2 cm in diameter. For stones greater than 2 cm in diameter, PCNL is the treatment of choice, due to its superior rate of achievement of "stone-free" status. However, given the severe complications associated with PCNL procedures, including bleeding, perforation, and infection, the safety and effectiveness of the fURS method has gained increasing attention from endourologists [3]. Furthermore, as a result of advances in ureteroscope technology, the use of holmium:yttrium–aluminum–garnet lasers and efficient use of accessory instruments has led to the application of fURS in moderate and, to some extent, larger stones on a worldwide basis. The safety and comparable success rate of the technique relative to other available modalities has led many endourologists to apply this method on a more frequent basis [4, 5].

Present day endourological procedures have two primary goals: maximizing the removal of stone load and providing high stone-free rates in a single session. The need for secondary intervention to address residual stones could lead to greater morbidity among patients and pose additional costs

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to the healthcare system. Residual stone size is a major determinant of whether or not further treatment is called for after an initial procedure [6, 7].

Stone-free rates (SFRs) are an indicator of the success of retrograde intrarenal surgery (RIRS). Although many studies have investigated the factors affecting SFR, no study currently exists to explore the factors affecting residual stone size. This study seeks to fill this hole in the literature. Estimating residual stone size before operation will enable surgeons to develop a rational plan for treatment and follow-up and facilitate patient participation in the process.

## Materials and methods

This study observed strict adherence to the guidelines on research ethics laid out in the Helsinki Declaration and was approved by the institute's ethics review board (Approval No.: 80576354-050-99/210).

The medical records of 642 patients treated for kidney stones with RIRS between July 2014 and May 2022 in this clinic were reviewed retrospectively. Patients with preoperative ureteral stents, ureteral stenosis, intraoperative ureteral rupture or avulsion, or in whom a solitary kidney, ectopic kidney, or other anatomical anomaly was detected, were excluded from this study. Kidney–ureter–bladder radiography (KUB) and non-contrast computed tomography (NCCT) were performed in all cases to evaluate stone characteristics and the renal collecting system. Urinary system ultrasonography (USG) was performed when necessary. Preoperative stone size and postoperative residual stone size were measured using NCCT (for non-opaque stones) and KUB (for opaque stones). The infundibulopelvic angle (IPA) was calculated using the El-Bahnasy technique: i.e., measuring the internal angle between the ureteropelvic axis and the central axis of the lower pole infundibulum [8]. Parenchymal thickness was obtained by measuring the thickest region of transverse sections imaged in preoperative NCCTs.

Patients' urine cultures were checked prior to operation. Patients with positive urine cultures were operated on after antibiotic treatment. All patients received a routine single dose of second-generation cephalosporins prophylactically during surgery. To evaluate the presence and size of residual stones 3 months after treatment, KUB and USG were used for opaque stones, and NCCT was used for non-opaque stones. Patients were considered stone-free if there were no residual stone fragments or if stone fragments were < 3 mm in diameter.

Based on evaluations made 3 months after surgery, 170 patients with residual stones were ultimately included in this study. Pre- and postoperative laboratory and radiological parameters were compared.

All surgeries were performed under general anesthesia and in the lithotomy position. Under fluoroscopic guidance, a 0.038 Fr guide wire was inserted into the renal pelvis using a 9.5 Fr semi-rigid ureteroscope. The pelvicalyceal system was evaluated by retrograde pyelography. A 9.5/11.5 Fr ureteral access sheath (Cook Medical, Bloomington, IN, USA) was placed over the guidewire under fluoroscopy. The collecting system was entered by passing a 7.5 Fr fiber optic flexible ureteroscope (Storz FLEX-X2) through the UAS. Stones were fragmented using a holmium laser (273  $\mu$  fiber), and fragments > 3 mm in diameter were removed from the body using a nitinol basket (ZeroTip™, Cook Urological Inc.). One hundred seventy patients with residual stones > 3 mm in the third month after surgery, based on control results, had their laboratory and radiographic data examined.

SPSS v. 22.0 software was utilized for statistical analysis (SPSS Inc., Chicago, IL, USA). Means and standard deviations were displayed for continuous variables. The Spearman correlation test was applied between groups, and the Mann–Whitney *U* test was applied between categorical variables. The odds ratio and corresponding 95% confidence interval were used to express impact significance. In all statistical analyses,  $p < 0.05$  was considered significant.

## Results

Evaluation of the data obtained produced the following findings: of the 170 patients included in the study, 113 were male and 57 were female, and the mean age was 51.56 ( $\pm 14.70$ ). The mean Charlson Comorbidity Index of the patients was 1.78 (0–8). Right-side RIRS was applied to 78 patients and left-side RIRS was applied to 92 patients. The mean stone size was 14.01 mm ( $\pm 5.75$ ), the mean residual stone size was 7.04 mm ( $\pm 2.51$ ), and the mean stone density was 829 Hounsfield units ( $\pm 395.06$ ). The mean IPA was 49.37° ( $\pm 15.37$ ), and 41.2% of the stones were non-opaque. The mean parenchymal thickness was 22.88 mm ( $\pm 5.55$ ). Postoperative fever was observed in seven patients. Thirty-four patients were on antiaggregants, and 14 were on alpha-blockers (Table 1).

When the Spearman correlation test was performed between groups, residual stone size was observed to correlate positively with preoperative stone size and Hounsfield (stone) density (HU) ( $p < 0.01$ ). A negative correlation was observed between IPA and residual stone size ( $p < 0.01$ ). No correlation was observed between parenchymal thickness, body mass index, and residual stone size (Fig. 1).

When the Mann–Whitney *U* test was applied for categorical variables, it was observed that residual stone size increased significantly in the absence of hydronephrosis ( $p = 0.015$ ) and in antiaggregant users compared with

**Table 1** Patients’ characteristics and clinical findings

	Count	% or ± SD
Gender	113	66.5%
Male	57	33.5%
Female		
Age	51.56	± 14.70
Antiaggregants/anticoagulant use	34	20%
Body mass index (kg/m <sup>2</sup> )	28.38	± 4.52
Lateralization	78	45.9%
Right	92	54.1%
Left		
Stone size (mm)	14.01	± 5.75
Residual stone size (mm)	7.04	± 2.51
Infundibulopelvic angle (°)	49.37	± 15.37
Presence of hydronephrosis	71	41.8%
Localization	92	54.1%
Lower calyx	78	45.9%
Others		
Stone density (hounsfield unit)	829	± 395.06
Parenchymal thickness (mm)	22.88	± 5.55
Opacity status	100	58.8%
Opaque	70	41.2%
Non-opaque		
Hospitalization time (day)	2.82	± 2.87
Postoperative fever	7	4.11%

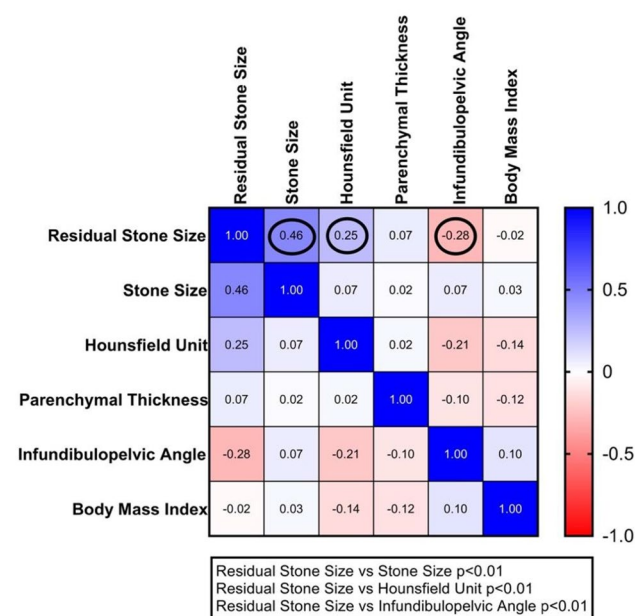
nonusers ( $p = 0.02$ ). It was determined that stone opacity, lower calyx localization, number of stones, and previous stone surgery did not affect residual stone size ( $p = 0.059$ ,  $p = 0.56$ ,  $p = 0.86$ , and  $p = 0.13$ , respectively) (Fig. 2).

### Discussion

Following its clinical introduction in the 1970s, the fURS method has enjoyed tremendous technical improvements and has grown to inhabit a pivotal role in the minimally invasive management of upper urinary tract calculi. The lower complication rates of fURS relative to both ESWL and PCNL have led to its offering as the first-line option in stone management guidelines, and its popularity has increased significantly among practising urologists [4, 9]. However, the increasing application of this modality, particularly in moderate and large stones, has highlighted the importance of improving SFRs. Studies on this marker of success in recent years have resulted in the development of scoring systems to predict SFRs after fURS [10, 11]. However, while these scoring systems have attempted to predict the occurrence of residual fragments following surgery, the factors affecting residual stone size have not been examined. The main finding of this study is that larger residual stone sizes correlate with larger preoperative stone size, higher HU, and lower IPA. The use of antiaggregants and the absence of hydronephrosis were also found to result in larger residual stone size.

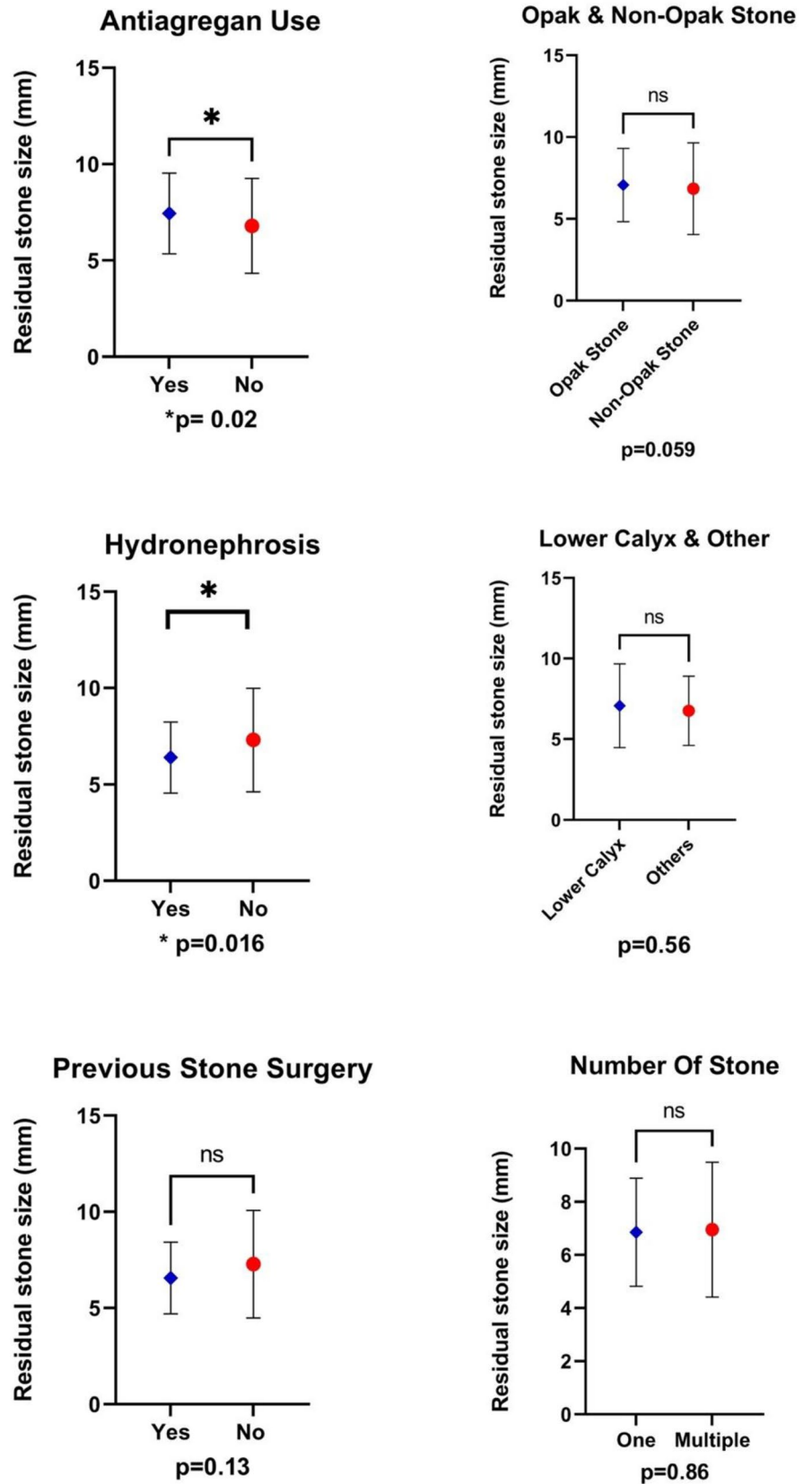
Data from well-conducted studies indicate that larger stone size and higher HU values decrease SFRs and increase the need for auxiliary procedures after fURS. [12–14]. This investigation found that residual stone size increased alongside preoperative stone size and HU. Koç and Yıldırım found that SFRs decreased as kidney parenchymal thicknesses rose [15, 16]. However, no significant correlation was observed between parenchymal thickness and residual stone size in the current study. Reşorlu, Jesseb, Danilovic, and Dresner found that a decrease in IPA correlated with an increase in the SFRs of patients with lower pole stones who underwent RIRS. In their literature review, Karim et al. likewise showed that a decrease in IPA corresponded to an increase in SFR [17–21]. The current study confirms this observation once more, and an increase in the mean size of residual stones was noted in those with lower IPA values. Using the potential effect of hydronephrosis on final SFR values after fURS as another parameter, the S.T.O.N.E. scoring system [size, topography (location), obstruction, number, and evaluation (of HU)] defined by Molina and Ito et al.’s nomogram indicate a negative correlation between SFR and the degree of hydronephrosis [22, 23]. In the current study, it was observed that a reduction in residual stone size was

### Spearman R-Correlation



**Fig. 1** Relationship between mean residual stone size and other parameters as a result of the Spearman correlation test

**Fig. 2** Relationship between mean residual stone size and other parameters as a result of the Mann–Whitney *U* test



significant in patients with hydronephrosis. Yıldırım and Tanik showed that SFRs were not affected by stone opacity. [16, 24]. The current study corroborates these findings. A meta-analysis by Özman et al. conjectured that the number of stones, and of lower calyx stones in particular, had an effect on the SFR; however, an evaluation of the findings of the current study did not indicate any correlation between the mean size of residual stones and the number of stones. Finally, while Altay and Turna could not show any positive correlation between the use of anticoagulants and SFRs after fURS, Yıldırım et al. demonstrated that the use of anticoagulants reduced SFRs. [25, 26]. The current study did not find that mean residual stone size was significantly larger in those using anticoagulants.

This study is not free from limitations. Major limitations may include the retrospective nature of the study design and the relatively low number of cases included and evaluated. However, considering the limited number of publications focusing on the factors that could affect the presence and size of residual stones after fURS, it is the authors' belief that these findings will contribute to the existing literature and represent reliable clinical implications for practising urologists.

As the first study to evaluate the predictive factors of residual fragment size after fURS, these findings hold a certain value in that they enable surgeons to make reliable and rational management plans by choosing appropriate alternatives. This approach will not only increase SFRs but also decrease the need for additional interventions, improving the health of those treated and minimizing the economic impact such procedures would entail.

## Conclusion

The findings of this study show that increases in preoperative stone size and HU and decreases in IPA are all associated with larger residual stone sizes. Residual stone fragments were likewise larger in patients on anticoagulant therapy and those without hydronephrosis following this procedure. These findings may help endourologists using fURS to foresee larger residual fragments, the presence of which could affect patients' quality of life and necessitate additional procedures. These factors could be considered good predictors of stone-free status and assist individuals in making rational treatment decisions.

**Author contributions** All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Mehmet Uslu, Ümit Yıldırım, Mehmet Ezer, İsmet Bilger Erihan, Kemal Sarıca. The first draft of the manuscript was written by

Mehmet Uslu and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Data availability** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

## Declarations

**Conflict of interests** The authors declare no conflict of interests.

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