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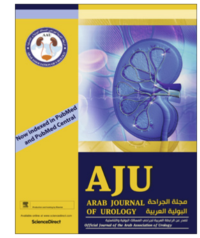


STONE/ENDOUROLOGY
ORIGINAL ARTICLE

# Is the 4.5-F ureteroscope (Ultra-Thin) an alternative in the management of ureteric and renal pelvic stones?

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**KEYWORDS**

Ultra-Thin;
Lithotripsy;
Ureteroscopy

**ABBREVIATIONS**

BMI, body mass index;
NCCT, non-contrast computed tomography;
SFR, stone-free rate;
Ultra-Thin, 4.5–6.5F ureteroscope;
URS, ureteroscope

**Abstract** ***Objectives:*** To compare the 7.5–9.5F ureteroscope (URS) with the 4.5–6.5F URS (Ultra-Thin) in terms of success and complication rates in adult patients with ureteric and renal pelvic stones.

***Patients and methods:*** In all, 41 patients treated with 7.5–9.5F semi-rigid URS (Group 1) and 33 patients treated with the Ultra-Thin (Group 2) were prospectively included in the study. All patients underwent holmium laser ureteroscopic lithotripsy. In each group, when the selected ureteroscopic intervention failed to reach or disintegrate the stone, the URS was replaced with the other one. Outcome criteria were: success and complication rates, stone size and stone surface area, operative time, laser time, usage of guidewire, and postoperative JJ-catheter placement.

***Results:*** The ureteroscopic lithotripsy in 36 of 41 (87.8%) and 24 of 33 (72.7%) patients was completed without a need to replace the URS with the other one in groups 1 and 2, respectively ($P = 0.67$). After replacement of the 7.5–9.5F URS with the Ultra-Thin for patients who failed in Group 1, the overall stone-free rate (SFR) improved to 97.5% ($P = 0.014$). In Group 2, after replacement of the Ultra-Thin with the 7.5–9.5F URS for the failed patients, the overall SFR improved to 96.9% ($P = 0.02$). There was no significant difference between the groups for complications. Postoperative JJ stenting was significantly less in Group 2 (21.2%) in comparison to Group 1 (46.3%) ($P = 0.02$).

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***Conclusions:*** The Ultra-Thin has a similar success rate as the 7.5–9.5F URS in the treatment of ureteric stones and is a feasible option in patients in whom a conventional URS cannot be advanced through any segment of the ureter.



## Introduction

Ureteroscopic lithotripsy has been the most widely applied treatment for urinary tract stones, with high success and low complication rates. The holmium laser has facilitated the disintegration of stones and increased the effectiveness of ureteroscopic lithotripsy [1,2].

The calibre of the ureteroscopes (URSs) has been gradually decreased to improve success rates and to reduce complications. However, the failure and complication rates of the procedure are still 8–10% [3–5] and 9–25% [6–8], respectively. The most frequent cause of the failure is the inability to advance the URS through the ureteric orifice or any ureteric segment [3,4]. In these patients a balloon catheter can be used to dilate the ureter [9] or a JJ-catheter can be inserted for passive dilatation upon postponing the operation [3–5]. However, balloon dilatation may not be successful in all cases and increases the costs of the procedure and also prolongs the operative time. Placement of a ureteric catheter and reoperation also increases the surgical costs and the risk to and anxiety of the patients. Furthermore, larger size URSs can be associated with complications including: mucosal injury (1.5%), ureteric perforation (1.7%), significant bleeding (0.1%), and ureteric avulsion (0.1%) [7], which are reported at a lesser incidence with small-calibre URSs [10,11].

In the present study, we aimed to compare the 7.5–9.5F URS with 4.5–6.5F URS (Ultra-Thin) in terms of success and complication rates in adult patients with ureteric and renal pelvic stones.

## Patients and methods

In all, 41 patients treated with a 7.5–9.5F semi-rigid URS (Karl Storz, Tuttlingen, Germany) with a mean (SD) age of 50.66 (14.85) years (Group 1); and 33 patients treated with a 4.5–6.5F URS (Ultra-Thin, Richard Wolf GmBH, Knittlingen, Germany) with a mean (SD) age of 49.09 (12.26) years (Group 2) were prospectively included in the study. This study followed the tenets of the Declaration of Helsinki and the protocol was approved by the Local Ethics Committee. All patients were informed about the goals of the study and written informed consent was obtained. Exclusion criteria were: ipsilateral ureteric stricture, multiple

**Table 1** Demographics and baseline characteristics.

| Variable | Group 1<br>7.5–9.5F URS | Group 2<br>Ultra-Thin | *P* |
|---|---|---|---|
| Number of patients | 41 | 33 | |
| Age, years, mean (SD) | 50.66 (14.85) | 49.09 (12.26) | 0.309 |
| Gender, *n* (%) | | | 0.44 |
| Male | 23 (56.1) | 19 (57.5) | |
| Female | 18 (43.9) | 14 (42.5) | |
| Hypertension, *n* (%) | | | 0.325 |
| No | 24 (58.5) | 22 (66.6) | |
| Yes | 17 (41.5) | 11 (33.3) | |
| Diabetes mellitus, *n* (%) | | | 0.419 |
| No | 36 (87.8) | 29 (70.3) | |
| Yes | 5 (12.2) | 4 (29.7) | |
| BMI, kg/m$^2$, mean (SD) | 30.26 (4.83) | 30.45 (6.68) | 0.17 |
| Lateralization, *n* (%) | | | 0.36 |
| Right | 20 (48.8) | 18 (54.5) | |
| Left | 21 (51.2) | 15 (45.4) | |
| Stone location, *n* (%) | | | |
| Proximal ureter | 12 (29.3) | 11 (33.3) | |
| Mid-ureter | 7 (17) | 7 (21.2) | |
| Distal ureter | 10 (24.4) | 11 (33.3) | |
| Pelvis renalis | 12 (29.3) | 4 (12.2) | |
| Stone size, mm, mean (SD) | 11.9 (3.75) | 10.27 (3.13) | 0.212 |
| Stone surface area, mm$^2$, mean (SD) | 80.93 (55.88) | 55.4 (34.72) | 0.158 |

stones, horseshoe or ectopic kidney, previous ureteric intervention including ureteroscopy or ureteric stent insertion, and active urinary infection. The characteristics of the patients are shown in Table 1.

Non-contrast CT (NCCT) was the diagnostic imaging used in all patients. Stone size was measured and stone surface area was calculated using the formula: length × width × 3.14 × 0.25 [12]. The groups were compared with respect to stone size and stone surface area, operative time, laser time (time to disintegration of the stones by holmium laser), usage of guidewire, postoperative JJ-catheter placement, and success and complication rates. Other matching parameters were lateralisation and location of the stones, patient age, gender, body mass index (BMI), hypertension and diabetes mellitus. Cephtriaxone 1 g was administered to all patients for prophylaxis.

All ureteroscopic interventions were performed under spinal or general anaesthesia. Initially, the URS was introduced into the bladder and directed to the ureteric orifice. Then, the URS was advanced through the ureteric orifice (with the guidance of a 0.089 cm [0.035 inch] or 0.097 cm [0.038 inch] standard hydrophilic soft guidewire, as needed). The stones were fragmented with holmium (Ho):yttrium–aluminium-garnet (YAG) laser (StoneLight, Minnetonka, MN, USA) in all cases, with an energy level of 0.8–1.0 J and a frequency of 8–12 Hz. Stone fragments were either left for spontaneous passage or removed with a 3-F basket catheter or stone forceps. A 4.7-F JJ-catheter was inserted postoperatively according to the stone burden, duration of the procedure, and presence of mucosal injury (Table 2). A 550-µm and 273-µm probe were used for 7.5–9.5F URS and Ultra-Thin, respectively. In Group 1, in patients in which the 7.5–9.5F URS failed to introduce through the ureteric orifice or any ureteric segment to reach the stone, it was replaced with the Ultra-Thin during the operation to disintegrate and remove the stone. Afterwards, if the Ultra-Thin also failed, a 4.7-F JJ-catheter was inserted and the operation was postponed for 2 weeks. In Group 2, if the Ultra-Thin failed to disintegrate and remove the stone, it was replaced with the 7.5–9.5F URS. In case of failure with the 7.5–9.5F URS, again a JJ catheter was inserted and the operation was postponed.

The patients were followed-up with plain abdominal radiograph and urinary ultrasonography to detect residual stone fragments and hydroureteronephrosis at 1 month postoperatively. NCCT was performed for uncertain residual fragments on plain radiograph or in the patients with non-opaque stones. The success of treatment was defined as stone free.

*Statistical analyses*

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPPS®) software, version 23 (SPSS Inc., IBM Corp., Armonk, NY, USA). Categorical variables were statistically compared between the groups using chi-squared and McNemar's tests. Continuous variables were analysed with Mann–Whitney $U$ or independent $t$-tests according to the results of the Kolmogorov–Smirnov test. A $P \leq 0.05$ was considered to indicate statistical significance.

## Results

The demographic and preoperative data of the patients are shown in Table 1. There was no significant difference between the groups in terms of age, gender, hypertension, BMI, stone size and surface area, lateralisation and location of the stones. The mean (range) stone diameter in groups 1 and 2 was 11.9 (7.2–23.1) mm and 10.2 (5.8–13.5) mm, respectively ($P = 0.212$).

Ureteroscopic lithotripsy was carried out under spinal anaesthesia in 69 patients and only five patients underwent general anaesthesia. There were no statistically significant differences between the groups for both operative and laser time. Guidewire use during the operation was needed in 40 patients (97.5%) in Group 1 and in nine patients (27.2%) in Group 2 ($P = 0.001$). We did not need to use a guidewire after conversion to 7.5–9.5F URS in any of nine failed patients initially treated with Ultra-Thin, which caused an active dilatation at the ureteric orifice. The need of postoperative JJ stenting was also significantly less in patients treated with Ultra-Thin (21.2%) in comparison to patients treated with 7.5–9.5F URS (46.3%) ($P = 0.02$). The operative data for both groups are shown in Table 2.

The ureteroscopic lithotripsy in 36 of 41 (87.8%) and 24 of 33 (72.7%) patients was completed without a need to replace the URS with the other one in groups 1 and 2, respectively ($P = 0.67$). After replacement of the 7.5–9.5F URS with the Ultra-Thin for patients who failed in Group 1, the overall stone-free rate (SFR) improved to 97.5% ($P = 0.014$). In Group 2, after replacement

**Table 2** The operative data of patients for both groups.

| Variable | Group 1 7.5–9.5F URS $N = 41$ | Group 2 Ultra-Thin $N = 33$ | $P$ |
|---|---|---|---|
| Operative time, min, mean (SD) | 20.69 (17.07) | 23.55 (16.08) | 0.41 |
| Laser time, s, mean (SD) | 100.62 (67.17) | 122.14 (58.15) | 0.75 |
| Guidewire use, $n$ (%) | 40 (97.5) | 9 (27.2) | 0.001 |
| Postoperative stenting, $n$ (%) | 19 (46.3) | 7 (21.2) | 0.02 |

**Table 3** Outcomes of the procedures in each group.

| | Group 1 7.5–9.5F URS $N = 41$ | | Group 2 Ultra-Thin $N = 33$ | |
|---|---|---|---|---|
| $n/N$ (%) | (1) | (2) | (3) | (4) |
| Total | 36/41 (87.8) | 40/41 (97.5) | 24/33 (72.7) | 32/33 (96.9) |
| Pelvis renalis | 12/12 | – | 0/4 | 4/4 |
| Proximal ureter | 9/12 | 11/12 | 6/11 | 10/11 |
| Mid-ureter | 5/7 | 7/7 | 7/7 | – |
| Distal ureter | 10/10 | – | 11/11 | – |

(1) SFR after ureteroscopic lithotripsy with 7.5–9.5F URS; (2) SFR after replacement with Ultra-Thin; (3) SFR after ureteroscopic lithotripsy with Ultra-Thin; (4) SFR after replacement with 7.5–9.5F URS.

of the Ultra-Thin with the 7.5–9.5F URS for the failed patients, the overall SFR improved to 96.9% and the difference was statistically significant ($P = 0.02$). Whilst all the patients with stones localised in the renal pelvis were successfully treated in Group 1, all four patients in Group 2 failed ($P = 0.001$). The success rates in the groups according to stone localisation are shown in Table 3.

*Causes of failure*

In Group 1, five patients were failures and the URS was replaced with Ultra-Thin during the operation. The cause of failure was physiological ureteric narrowing, thus the 7.5–9.5F URS could not be advanced through the ureter. The stones were localised in the proximal (two patients) and mid-ureter (two patients) in four of these five patients; and were successfully treated with the Ultra-Thin. However, in one of these four patients the Ultra-Thin caused an active dilatation and was again replaced with the 7.5–9.5F URS, which successfully disintegrated the stone. The last failed patient in Group 1 had a proximal ureteric stone. The cause of the failure was stone migration during the procedure and the operation was postponed after a postoperative JJ stenting. The patient was successfully treated 2 weeks later with a 7.5–9.5F URS.

In Group 2, nine of 33 patients were failures. All patients with renal pelvic stones (four of the nine) in this group were not adequately visible for disintegration with Ultra-Thin and thus failed. Ultra-Thin was replaced with 7.5–9.5F URS and all the stones were successfully disintegrated in these four patients. In the other failed patients (five of the nine) the stones were localised in the proximal ureter. During the operation, stones migrated to the renal pelvis in three of these five patients and the Ultra-Thin was replaced with 7.5–9.5F URS. Two of them were successfully treated but the other patient failed due to a ureteric kink, which prevented reaching the stone and the operation was postponed after JJ-catheter insertion. The stone was disintegrated 2 weeks later with the 7.5–9.5F URS and removed. The cause of stone migration in these three patients was the inability to visualise the stones, which probably caused the stone to migrate into the renal pelvis. The cause of failure for in the remaining two patients with proximal ureteric stones was invisibility of the stones with Ultra-Thin. These patients were stone free after replacement with the 7.5–9.5F URS.

There was no significant difference between the groups for overall intraoperative and postoperative complications categorised according to the Clavien–Dindo system. Three patients had renal colic in each group and were treated with analgesics and hydration. One patient in Group 1 had fever and underwent antibiotic therapy. Mucosal injury was observed in four (9.7%) and one (3%) patients in groups 1 and 2, respectively; and were managed with JJ-stent insertion. Postoperative haematuria was detected in five patients (12%) in Group 1 and in one patient (3%) in Group 2, which resolved with hydration. Neither ureteric perforation nor ureteric avulsion occurred in either group (Table 4).

## Discussion

Semi-rigid URS has recently been the first choice for ureteric stone treatment with a 85–100% [1,13] success rate and a 9–25% [6–8] complication rate. The diameter of the semi-rigid URSs has been reduced in comparison to previous scopes. However, there are still some patients in which the semi-rigid URSs cannot be advanced through the ureter. This limitation is also responsible for the complications that are reported at low incidence (5–9%) after the use of small-calibre URSs [10,11]. On account of this, we used a smaller size URS for stone disintegration (Ultra-Thin), which is generally reserved for diagnostic purposes. In our present study, we found that patients treated with either 7.5–9.5F URS or Ultra-Thin have similar success and complication rates. Both of these URSs were highly effective for managing distal and mid-ureteric stones. Conversely, Ultra-Thin frequently failed for stones located in the proximal ureter and renal pelvis. However, the Ultra-Thin played a major role in attaining a stone-free status in the patients in which

**Table 4** The intraoperative and postoperative complications according to the Clavien–Dindo system for both groups.

| Variable, $n$ (%) | Group 1 7.5–9.5F URS $N = 41$ | Group 2 Ultra-Thin $N = 33$ | Clavien–Dindo grade | $P$ |
|---|---|---|---|---|
| Intraoperative and postoperative complications | 14 (34.1) | 8 (24.2) | | 0.19 |
| Stone migration | 1 (2.4) | 4 (12.1) | III | |
| Mild haematuria | 5 (12.1) | 1 (3) | I | |
| Mucosal injury | 4 (9.7) | 1 (3) | I | |
| Febrile UTI | 1 (2.4) | 0 (0) | II | |
| Renal colic | 3 (7.3) | 2 (6) | III | |

the 7.5–9.5F URS failed due to physiological ureteric narrowing.

The diameter of the ureter in the paediatric age group is < 3 mm [14] and rigid URSs used in adults have lower success rates in children [15]. A limited number of studies have found Ultra-Thin effective with high success (82.3–97.5%) and lower complication rates in comparison to 7.5-F or 8.5-F URSs in this age group [16–18]. Conversely, two retrospective studies compared Ultra-Thin with conventional semi-rigid URSs in adults with similar results [19,20]. Atis et al. [19] reported an 88.5% SFR with Ultra-Thin in comparison to 8.5–11.5F URS with a reduced need for ureteric balloon dilatation and reported less complications, such as mucosal injury and haematuria. Soylemez et al. [20] evaluated the outcome of operations with Ultra-Thin in adult patients in whom the conventional semi-rigid URS could not be advanced through the ureteric orifice. Some patients in that study had previously undergone a JJ-catheter insertion or percutaneous nephrostomy. They found a 94.8% success rate in 43 patients with mild haematuria in two patients [20]. In our present study, although the overall complication rate was not significantly different between the groups, mucosal injury and mild haematuria were more common in patients treated with the 7.5–9.5F URS. The low incidence of such complications in Group 2 is probably related to the smaller size of the Ultra-Thin.

SFRs with Ultra-Thin according to stone localisations, which in the present study we found to be lower (SFR 45.5%) for the proximal ureter, were not analysed in these two retrospective studies. Additionally Ultra-Thin failed in all patients with renal pelvic stones. The cause of failure in six of 11 patients with proximal ureteric stones and all patients with renal pelvic stones was the inability to visualise or direct the laser probe onto the stones. Whilst the 7.5–9.5F URS had a 12° lens with an angled offset eyepiece, the Ultra-Thin had a 6° lens with a movable offset eyepiece [17], and we assume that this is probably the cause of the inadequate stone visualisation.

Bassiri et al. [21] reported that as the size of the URS reduces, the need for balloon dilatation decreases in the paediatric age group. The requirement of a balloon catheter was decreased from 23% using 11.5-F URS to 0–2% when replaced with 9.0-, 8.5- and 8.0-F URSs [21]. In our present series, the 7.5–9.5F URS could not be advanced in ~10% (four of 41) of the patients. We did not use dilators, instead we replaced the 7.5–9.5F URS with the Ultra-Thin. Although we found the success rate of the Ultra-Thin to be similar to the large-calibre URS, particularly for distal and mid-ureteric stones, with fewer complications, we still initiate ureteroscopic lithotripsy with the 7.5–9.5F URS. The Ultra-Thin has only one central channel of 3.3F, which results in slower irrigation flow, which impairs visibility and results in a smaller field of view [17]. We achieve better image quality with the conventional URSs with a 5.5-F central channel and faster irrigation flow. The advantage of the Ultra-Thin is the easier access through the ureter. Furthermore, guidewire use and postoperative stenting were needed significantly less in patients treated with Ultra-Thin, which decreases the intervention time and costs of the operation. Moreover, it is claimed that forceful mechanical dilatation with large-calibre URSs can lead to ischaemic damage and stenosis [22,23]. Ultra-Thin may lead to a lower rate of postoperative ureteric strictures.

The limited number of patients for the each ureteric localisation is our main limitation. In addition, postoperative SFRs were evaluated with urinary radiography and ultrasonography. NCCT was obtained only in symptomatic patients due to radiation exposure and low likelihood of clinical significant residual fragments. To the best our knowledge, our present study is the first prospective series to report the role of the Ultra-Thin in the treatment of stones at different ureteric localisations and the renal pelvis. The Ultra-Thin is a reliable and practical alternative to conventional URSs and may have a role for active dilatation.

## Conclusions

The Ultra-Thin has a similar success rate as the 7.5–9.5F URS in the treatment of ureteric stones and is a feasible option in patients in whom the conventional URSs cannot be advanced through any segment of the ureter.

## Conflict of interest

All the authors can confirm that they have no conflict of interests.

## Research involving human participants and/or animals

This study followed the tenets of the Declaration of Helsinki and the protocol was approved by the Local Ethics Committee.

## Informed consent

Informed consent was obtained from all patients.

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