World Journal of Urology (2025) 43:201
https://doi.org/10.1007/s00345-025-05574-9

RESEARCH

Endourological treatment of ureteral strictures with the use of self-expanding stents: is it possible to completely cure the stricture endoscopically? A report on the experience with implantation of 35 stents with a two-year follow-up period; a retrospective study

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Received: 22 June 2024 / Accepted: 13 March 2025

Abstract

Background The current results of endoscopic treatment of ureteral strictures are characterized by very divergent treatment results, which is due to a wide range of criteria for including patients in the analyses and different definitions of effective treatment. In this retrospect study we wanted to introduce a possibility of curing ureteral strictures depending on their type and degree with the use of self-expanding ureteral stents (SUS).

Methods 33 patients with ureteral strictures received endourological treatment with the use of Allium® SUS (2 patients with SUS placed on both sides). Patients were divided into 2 groups: patients with uncomplicated strictures (Grp 1) and patients with complicated strictures (Grp 2). Uncomplicated stricture was defined as a single stricture below 2 cm. A complicated stricture was defined as a stricture over 2 cm and/or multiple strictures. The follow-up time was 24 months. All patients were scheduled for renoscintigraphy during the treatment. A full therapeutic success was defined as no tight stenosis in renoscintigraphic furosemide test after SUS explantation.

Results In Grp 1, full therapeutic success was achieved in 80% of patients, which was statistically significant ($p < 0.001$). Serious complications (Clavien-Dindo > 3a) occurred significantly more often in Grp 2 ($p = 0.046$). Renal outflow during stenting was present in 70% of the patients in Grp 2.

Conclusions A full therapeutic success of endoscopic, SUS-assisted treatment can be considered among patients with short, single ureteral stricture. In long and/or multiple strictures, SUS can be used as drainage element, but full recovery of the stricture is unlikely.

Keywords Ureteral strictures · Endoscopy · Self-expanding stents · Allium · Metal stents

Abbreviations

Av	Average
BMI	Body mass index
SUS	Self-expanding ureteral stents
URS	Ureterorenoscope
QoL	Quality of life
Grp 1	Group 1 patients with uncomplicated strictures (single, short < 2 cm stricture)
Grp 2	Group 2 patients with complicated strictures (multiple and/or long > 2 cm strictures)

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Introduction

Ureteral strictures constitute an important clinical problem due to increasing number of cases, which may be related to the increasing use of high-power lasers in urological departments and, as a result, thermal narrowing of the ureters after endoscopic treatment of upper urinary tract stones [1]. The standard treatment for ureteral strictures is reconstructive surgery with complete excision of the narrowed ureter [2, 3].

Endoscopy has an established but limited role in the treatment of ureteral strictures due to the high recurrence rate [4]. According to the guidelines of the European Association of Urology, endoscopic procedures are recommended for treating single and short ureteral strictures [5]. So far, after the standard endoscopic treatment of a stricture by dilatation or incision, a DJ stent was implemented. However, the design of the DJ stent and its small diameter (3–8F) can lead to the failure of endoscopic therapy [6, 7]. Promising tools are metallic stents introduced on the urological market. There are three types of self-expanding stents (SUS) available: thermoexpandable Memokath™ stents, three-layer Uventa™ stents and Allium URS® stents. Studies based on a large number of patients proved the safety and effectiveness of SUS, however there is a lack of studies comparing SUS with each other and lack of description of the possibility of full recovery of ureteral strictures with the use of SUS [8, 9]. In the Department of Urology of A. Jurasz Memorial University Hospital No. 1 in Bydgoszcz, since 2020 we have been using SUS from Allium®. We performed a retrospect analysis of 33 patients with the intention of full recovery of ureteral strictures with the use of SUS. Our aim was to test the possibility of curing ureteral stricture depending on its type and degree of stenosis using SUS-assisted endoscopic methods with the use of reliable functional kidney test (renoscintigraphy).

Methods

Study population and method of treatment

Patients with diagnosed ureteral stricture and renal function over 20% in renoscintigraphy were included into the study. Patients with ureteral orifice strictures and after radiotherapy were excluded from the study. The study had a retrospect character and was conducted in a single centre.

In the Department of Urology of A. Jurasz Memorial University Hospital No. 1 in Bydgoszcz, since 2020, we have been using self-expanding ureteral stents from Allium® (SUS). For 33 patients (2 patients with both side ureteral strictures) we decided to apply an endoscopic management strategy in the treatment of ureteral strictures using a SUS. Our method was based on implantation of SUS after dilatating the stricture to make a scaffold which will lead to create a new, wide scar in the place of stricture. The use of such a technique is based on the design of a SUS, which, when released from the delivery system (and in the absence of external barriers), opens to a diameter of 27-30F. Therefore, after dilatating the stricture and releasing it in the ureter, the SUS will exert pressure on the newly forming scar, thus preventing the formation of a tight stricture in the previously widened place. The assumptions of this surgical technique required an appropriate functional assessment of the treated kidney and ureteral stricture, hence renal scyntygraphy was planned for all patients before, during and after treatment. The performance of renal scyntygraphy in the treated group is an advantage of this study because in the previous largest publications concerning the treatment of ureteral strictures, the main measure of treatment effectiveness was radiological imaging and there was no reliable assessment of the function and outflow of urine from the kidneys [2, 3, 9–11]. Stricture length was measured during surgery in ureteropyelography and confirmed after stent implantation. The patients were divided into 2 groups: uncomplicated strictures which was defined as a single stricture below 2 cm (Grp 1) (Fig. 1a) and those with complicated strictures which was stricture over 2 cm and/or as multiple strictures (Grp 2) (Fig. 2a). All patients had renoscintigraphy before SUS implantation. Based on previous reports regarding the recurrence of strictures in the urinary tract after over 12 months, patients were scheduled to have their SUS removed after 1 year [12–14]. During stenting, patients were controlled by 1 ultrasound and 1 renoscintigraphy. The follow-up time after stent explantation was 24 months. During follow-up all patients had 2 renoscintigraphys and 2 ultrasound examinations (in the first and the second year of follow-up). Hydronephrosis was measured in ultrasound, and its presence was reported in modified Society of Fetal Urology Grading, defining 1st grade of ultrasound hydronephrosis as significant (calices > 3 mm and renal pelvis > 5 mm). Improvement in quality of life (QoL) was assessed by authorial questioner during outpatient visits; no validated QoL questionnaires were used. The endpoint of the study was no stenting of the ureter after the treatment and no tight stenosis in control renoscintigraphy furosemide test after SUS explantation. No tight stenosis in control renoscintigraphy furosemide test without any stenting, was described as “full therapeutic success”. Patients after stent explantation with reccurence of the stricture described in renoscintigraphy furosemide test as tight, were qualified for different type of treatment; but SUS reimplantation was not considered. Approval: No. KB257/2024 was given by the local Ethics Committee.

Surgical technique

All SUS implantations and explantations were performed by the same surgeon. Implantation of the SUS was carried out in four stages: identification of the stricture (Figs. 1a and 2a), dilatation (Fig. 3a, b), the SUS implantation (Figs. 1b and 2b), control ureteropyelography. After placement of two hydrophilic guidewires, dilatation of the stricture was done with the use of URS 6/7,5F and followed by URS 7/9,5F. Such dilatation is performed under fluoroscopy and URS vision. Further dilatation was

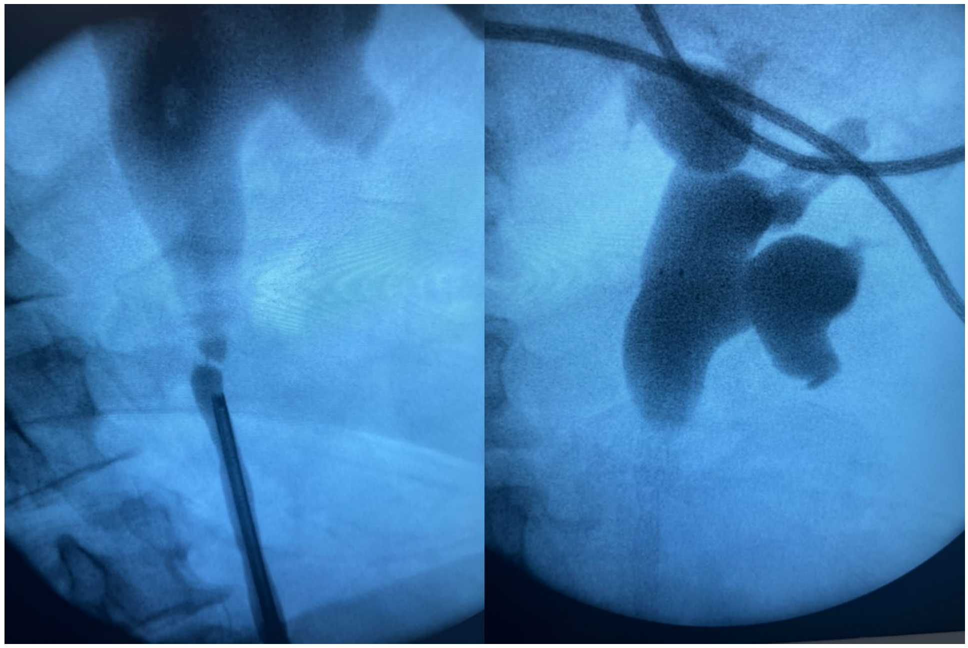

Fig. 1 **a**, **b** Radiological pictures of non-complicated (Grp 1) stricture during SUS implantation: Identification of the stricture in antegrade pyelography (**a**), stricture after dilatation and SUS implantation (**b**)

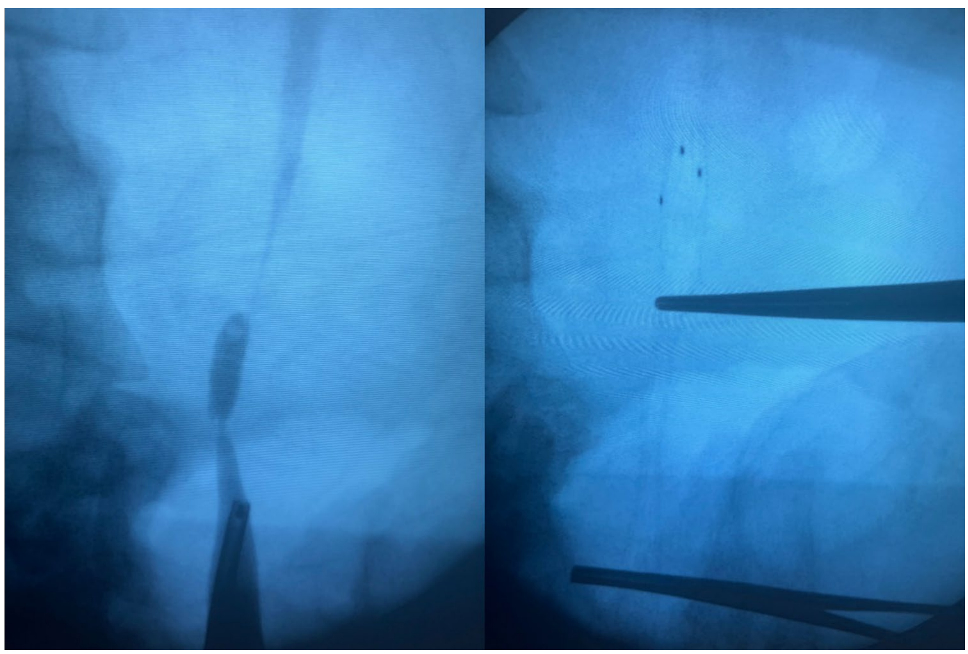

Fig. 2 **a**, **b** Radiological pictures of complicated (Grp 2) stricture during SUS implantation: Identification of the strictures in antegrade pyelography (**a**), stricture after dilatation and SUS implantation (**b**)

performed with the use of COOK disposable ureteral dilatators under fluoroscopy. Desired diameter of dilatation was 14F. Implantation of the SUS was done under C-arm after previous marking of the stricture using metal markers placed on the patient. The SUS was positioned to cover the stricture with the minimum margin of 2 cm above or below. During the SUS explantation procedure, DJ stent or nephrostomy was placed for 1 month due to the swelling of the ureter and the presence of blood clots in its lumen. After 1 month DJ stent or nephrostomy were removed.

Statistical analysis

Frequency was calculated by chi-square tests of independence. In the case of quantitative variables with a distribution close to normal, Student's t tests were used to compare independent samples for which the mean and standard deviation were assessed. In the case of quantitative variables with a distribution deviating from normal, the Mann–Whitney tests were used to calculate median

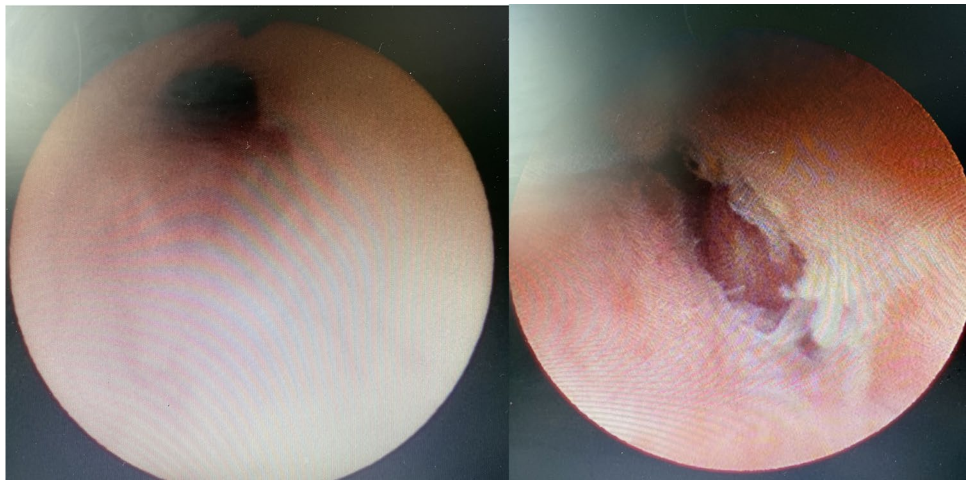

Fig. 3 **a**, **b** Endoscopic view of the stricture before (**a**) and after blunt dilatation (**b**)

and interquartile range were reported. Statistical analyses were performed using the IBM SPSS Statistics 26. The level of significance was $\alpha = 0.05$.

Results

The general characteristics of the patients, strictures and the endoscopic procedures are presented in Table 1. In Grp 2, two SUS were implemented in ureters after kidney transplant, so the side was not defined. Dilation above the diameter of the semi-rigid endoscope (7/9,5F) was possible in 60% of patients in both groups. The average duration of SUS in both groups was 10 months, although the assumed duration of maintaining SUS was 12 months, hence 33% (Grp 1) and 35% (Grp 2) of patients underwent earlier explantation of the SUS. There were no statistically significant differences in the compared groups in terms of the variables described above. In Grp 2, single strictures exceeding 2 cm occurred in 55% of patients, multiple strictures up to 2 cm long occurred in 35% of patients, and 10% had multiple strictures exceeding 2 cm. Primary ureteropelvic junction stricture was present in 1 patient Grp 1. In this case, reconstructive surgery was not performed due to the patient's high BMI and possible technical difficulties resulting from the surgical approach. The studied groups of patients did not differ statistically in terms of the etiology of the strictures.

The end point of the study was the achievement of a full therapeutic success. A statistically significant difference was obtained in the study groups ($p < 0.001$), with 80% a full therapeutic success in Grp 1 (12 patients) and 15% in Grp 2 (3 patients). Maintained urine flow during stenting, determined by renoscintigraphy during SUS implantation, was possible in all patients from Grp 1 and 70% of the patients from Grp 2, which was also a statistically significant difference ($p = 0.020$).

The characteristics of complications and treatment results are presented in Table 2. Serious complications (Clavien-Dindo 3a-4a) occurred statistically more often in Grp 2. Only 5 patients did not experience any complications (4 in Grp 2 and 1 in Grp 1). 2 patients (13.3%) in Grp 1 and 5 patients (25%) in Grp 2 experienced complications of grade 3a according to the Clavien-Dindo scale. All cases of grade 3a complications were related to pyonephrosis and nephrostomy was placed. 4 patients (20%) from Grp 2 required surgical treatment under general anesthesia (Clavien-Dindo 3b): 3 patients underwent reconstructive surgery for ureteropelvic junction stricture, and 1 patient underwent nephrectomy due to renal hypofunction and encrusted SUS. Renal failure during SUS implantation (Clavien-Dindo 4a) occurred in 3 patients (1 patient in Grp 1, and 2 patients in Grp 2; the average renal function in renoscintigraphy before SUS implantation was 23%). It should be noted that full renoscintigraphy schedule wasn't completed in patients who underwent nephrectomy. Improvement in QoL was reported by 60% of patients from Grp 1 during stenting and in 100% after the end of treatment. In Grp 2, 65% of patients reported improvement in QoL during treatment, and 40% improvement was reported after treatment. This was a statistically significant difference in the comparison of both groups ($p < 0.001$). No statistically significant differences were observed in relation to visible urinary retention in ultrasound examination and renoscintigraphy in both groups. It was assumed that hydronephrosis occurred in 100% of patients in both groups before the treatment.

Discussion

Endoscopic procedures include the treatment of ureteral strictures by blunt dilatation with the use of plastic or metal dilatators, balloon dilation or laser/diathermy incision. The standard procedure after widening the stricture is to leave

Table 1 Characteristics of the patients, surgery procedures and strictures

	Uncomplicated strictures (single, < 2 cm) Grp1 *N* = 15 stents *M* ± *SD*/*n* (%)/*MD* (*IQR*)	Complicated strictures (multiple and/or > 2 cm) Grp2 *N* = 20 stents *M* ± *SD*/*n* (%)/*MD* (*IQR*)	*p*
Age [years]	58.20 ± 13.60	51.85 ± 12.12	0.155
Sex (male/female)	9 (60.0%)/6 (40%)	9 (45.0%)/11 (65%)	0.380
Ureter (left/right)	6 (40.0%)/9 (60%)	9 (50.0%)[a]/9 (50%)[a]	0.566
Implantation time [min]	45.00 (30.00–55.00)	32.50 (26.25–40.00)	0.100
Explantation time [min]	25.00 (13.75–35.00)	26.00 (22.50–31.25)	0.593
Possible dilatation diameter over 9,5F	9 (60.0%)	12 (60.0%)	1.000
Time of stenting [months]	9.53 ± 4.39	10.06 ± 3.98	0.725
Necessity of explantation before scheduled time	5 (33.3%)	7 (35.0%)	1.000
Migration of SUS	4 (26.7%)	3 (15.0%)	0.430
Unplaiting of the SUS during explantation	8 (57.1%)	6 (33.3%)	0.283
Explantation with the use of cystoscope			
Single stricture	15 (100.0%)	11 (55.0%)	**0.011**
Stricture lenght [cm]			**< 0.001**
< 1 cm	11 (73.3%)	0 (0.0%)	
1–2 cm	4 (26.7%)	7 (35.0%)	
> 2 cm	0 (0.0%)	13 (65.0%)	
Iatrogenic strictures	12 (80.0%)	14 (70.0%)	0.700
- Stone treatment (URSL, RIRS, ureterolithotomy)	10 (66.6%)	8 (40%)	
- Stricture after ureteropelvic plastic surgery	0	2 (10%)	
- Gynecological procedures (without radiotherapy)	2 (13.3%)	0	
- Renal transplant	0	2 (10%)	
- Surgical procedures (without radiotherapy)	0	2 (10%)	
Non-iatrogenic strictures	3 (20%)	6 (30%)	0.300
- Endometriosis	1 (6.7%)	3 (15%)	
- Retroperitoneal fibrosis	0	1 (5%)	
- Inflamatory diseases	1 (6.7%)	2 (10%)	
- Primary stricture of ureteropelvic junction	1 (6.7%)	0	

M average, *SD* standard deterioration, *n* sample size, *MD* median *IQR* interquartile range, *p* statistical significance

[a]Two patients from Grp 2 were patients with after renal transplant so side was not defined

Bold values represents *p* 0,05

a drainage element such as a DJ stent, nephrostomy, and currently also SUS. In single, short strictures, the highest effectiveness is achieved by laser incision or dilation with a balloon of the stricture. In a review by Lucas et al., the effectiveness of the mentioned methods reaches 80% in a short follow-up (< 6 months) and decreases to 50% in longer follow-up (> 12 months) [15]. However, it should be mentioned that none of the studies included in the analysis by Lucas et al. consited of more than 50 patients. If we consider complicated ureteral strictures, the effectiveness of endoscopic methods drops to 15% which was reported by Ghali et al. and Kachrilas et al. [16, 17]. Reconstructive surgeries are most effective, reaching over 90%, but can be challenging for surgeons, being a time-consuming and often technically difficult procedures [18]. The reduced QoL of patients with ureteral strictures results from the frequent need for a long-term urinary tract stenting and struggling with recurrent urinary tract infections [19]. The ineffectiveness of treatment of ureteral strictures may result in the removal of the kidney or chronic stenting of the urinary tract, as May and his co-authors presented in their work analyzing the treatment of ureteral strictures in 4 urological centers over a period of 9 years [7]. Considering only complications after treatment of urinary tract stones, the frequency of strictures reaches 1–4%, hence the ureteral strictures scale is high [20].

The urinary tract is an unfavorable environment for tissue healing due to the irritating effect of urine, which ultimately leads to scarring and re-stenosis. When using DJ

Table 2 Complications and treatment outcomes

	Uncomplicated strictures (single, < 2 cm) Grp 1 $N = 15$ stents $M \pm SD/n$ (%)/MD (IQR)	Complicated strictures (multiply and/or > 2 cm) Grp 2 $N = 20$ stents $M \pm SD/n$ (%)/MD (IQR)	*p*
Serious complications (Clavien Dindo > 3a)	3 (20.0%)	11 (55.0%)	**0.046**
Complications [Clavien–Dindo]			0.088
0	1 (6.7%)	4 (20.0%)	
1	1 (6.7%)	0 (0.0%)	
2	10 (66.7%)	5 (25.0%)	
3A	2 (13.3%)	5 (25.0%)	
3B	0 (0.0%)	4 (20.0%)	
4A	1 (6.7%)	2 (10.0%)	
Renoscintigraphy [GFR] (before SUS implantation)	35.00 ± 11.68	34.29 ± 11.07	0.870
Renoscintigraphy [%] (before SUS implantation)	43.25 ± 11.17	47.60 ± 11.19	0.325
Renoscintigraphy [GFR] (during stenting)	38.50 ± 16.28	30.76 ± 10.21	0.140
Renoscintigraphy [%] (during stenting)	43.70 ± 14.48	45.27 ± 12.42	0.775
Renoscintigraphy [GFR] (after SUS explantation)	36.73 ± 11.41	29.00 ± 9.44	0.137
Renoscintigraphy [%] (after SUS explantation)	43.17 ± 14.17	43.88 ± 11.08	0.907
Better Quality of Life during stenting	9 (60.0%)	13 (65.0%)	1.000
Better Quality of Life after stenting	15 (100.0%)	8 (40.0%)	**< 0.001**
Hydronephrosis during stenting	8 (53.3%)	15 (75.0%)	0.282
Hydronephrosis after explantation < 12 months	10 (71.4%)	14 (87.5%)	0.378
Hydronephrosis after explantation 12–24 months	6 (60.0%)	6 (85.7%)	0.338
Full therapeutic success	12 (80.0%)	3 (15.0%)	**< 0.001**
Feasible renal outflow during stenting	15 (100.0%)	14 (70.0%)	**0.020**

M average, *SD* standard deterioration, *n* sample size, *MD* median *IQR* interquartile range, *p* statistical significance

Bold values represents *p* 0,05

catheters, we have limited possibilities of keeping the ureter open because the diameter of the thickest DJ catheters is 9F. Alternative for DJ stents are SUS, which can help in forming new stricture with a larger diameter. In our endoscopic technique, where SUS is used, the treatment of the stricture plays a more important role than the implantation of SUS itself. Dilatating stricture over 10F predicts treatment success. Unfortunately, in 40% of patients it was not possible to obtain a larger dilatation diameter than the diameter of the semi-rigid URS (9.5F). However it should be mentioned that we refrained from using any energy to achieve larger diameter of the treated stricture to avoid thermal tissue damage, hoping for less secondary scarring. Only blunt dilatation was used (Fig. 3a, b). SUS implantation time in Grp 1 was longer compared to Grp 2, which was related to the possibility of partial scar removal in short strictures with the use of URS forceps, which prolonged the procedure. Urinary tract infections and SUS migration accounted for the highest percentage of treatment complications. Migration of SUS occurred in 26.7% of Grp 1 patients. In this group, displacement of SUS often meant no longer, tight stricture thanks to implemented treatment so making it possible for SUS to migrate in the ureter. In the case of complicated strictures, migration occurred in 15% of patients, which was related to a persistent tight stenosis that prevented SUS from migration. Complications secondary to urinary tract infections and kidney obstruction were more serious because they could result in deterioration of kidney function [7, 19]. The number of infectious complications, migration and serious complications (Clavien-Dindo > 3) in our study was significantly higher compared to the study of Gao et al., which is the study on the largest population of patients treated with Allium® SUS. Such a big difference in complications is related to the fact that Gao et al. reported complications only during hospitalization when SUS was placed [9], while in our study complications are reported throughout the entire 2-year follow-up period. In approximately 1/3 of cases, it was necessary to remove SUS earlier, which was most often caused by urinary tract infections, bladder irritation symptoms or SUS migration. A statistically significant difference in serious complications in Grp 2 was related to the nephrectomies in that group. It should be mentioned that patients who underwent nephrectomy had borderline kidney function in renoscintigraphy (av.23%) before starting treatment. Statistically significant differences in the improvement of QoL in favor of Grp 1 resulted from the fact that in this group 80% of patients achieved a full therapeutic success. In Grp 1, in cases without full therapeutic success, one patient underwent nephrectomy due to its afunction revealed during stenting and two patients underwent reconstructive surgery. Importantly, in the cases of reconstructive surgery after SUS stenting, no significant differences that made the procedure difficult, such as adhesions or inflammation, were observed. After removal of SUS, a 3-month interval was maintained before reconstructive surgery.

In 80% of patients in Grp 1, postoperative renoscintigraphy resulted in ureter patency, without significant deterioration of kidney function which was described as a full therapeutic success. The high percentage of persistent hydronephrosis in the ultrasound examination after removal of SUS (71.4%), and signs of outflow disturbances in renoscintigraphy, but without tight stenosis in the furosemide test, indicate persistent stenosis, but with a larger diameter than before the treatment. This picture was observed endoscopically in two patients in whom endoscopic diagnostics were performed during the observation period due to suspicion of residual kidney stones. In Grp 2, the effectiveness of a full therapeutic success was low (15%), and the only possible way to use SUS in those cases is urinary tract drainage, which was measured by renoscintigraphy during stenting. The results of the Allium® SUS efficacy in full recovery of stricture are consistent with studies conducted on larger patient populations treated with Allium® SUS by Gao et al. [9], which confirm the potential of Allium®SUS as an element that can definitively cure uncomplicated ureteral strictures. The comparison of the use of Allium®SUS as a drainage element also is consonant with other studies, such as the study by Hu et al., where in both studies the patency of the ureter after stent placement was preserved in 88% [21]. However, using SUS as an element of urinary tract drainage can be problematic due to the difficult explantation procedure, which is much more complicated than exchanging DJ stent. In our center, we tried to use optical cystoscope forceps to remove SUS because of good pulling force when compared to URS forceps. When using URS forceps, SUS was often fragmented in the ureter, and this is why SUS was positioned approximately 1 cm into the bladder lumen or 1 cm into the renal pelvis lumen, which allowed to use optical cystoscope forceps during explantation. If SUS was positioned within the renal pelvis lumen, it was removed by creating a transrenal tract. The main limitations of the study are the small number of patients and its retrospect character which affects limited control over sampling of the population and limited control over the nature and quality of the predictor variables.

Despite the doubts raised by the retrospective nature of this study, we decided to publish our data to present the treatment results based on a reliable functional test of the kidney, i.e. renoscintigraphy. Our publication may constitute the basis for planning a prospective randomized study comparing DJ stents with SUS in modern endoscopic treatment of ureteral strictures. Developing an optimal method of endoscopic management of ureteral stricture may significantly improve treatment results.

Conclusions

SUS in a short, single strictures have potential as a supportive element for formation of a new, wider scar, and treatment in such cases may be successful resulting in the absence of any stenting after treatment with maintaining normal kidney function. It must be kept in mind that a scar is still present so renal function must be monitored, and patients are in high risk for infection complications due to common hydronephrosis. In long and/or multiple strictures a full therapeutic success of endoscopic treatment with SUS is unlikely, but SUS can be used as a drainage system. Drainage by SUS in long and/or multiple strictures can improve the quality of life, and SUS can be exchanged every 2–3 years, however, in that group of patient's serious complications are more common.

Acknowledgements Statistical consultation Urszula Kajewska ukajewska@pogotowiestatystyczne.pl Language consultation Prof. Aleksander Szwedek, A,Mickiewicz University in Poznań, Poland, szwedekaleksander@gmail.com

Author contributions Conflicts of interests: F.K. Paid lectures during company meetings for Allium Company. Paind hands-on training for Allium. Research registry UIN: researchregistry10261, www.researchregistry.com. Financial support and sponsorship: none. Approval of Ethics Committee: Collegium Medicum Ethics Committee in Bydgoszcz Approval No. KB257/2024 All authors reviewed the manuscript. F.K. Study design, writing the manuscript B.K. Collecting data M.P. Collecting data P.L. Collecting data M.Cz. Collecting data J.W. Preparing data and tables A.O. Statistical analysis J.A. Supervision of the manuscript T.D. Supervision of the manuscript.

Funding None.

Data availability Data sets generated during the current study are available from the corresponding author on reasonable request. E-mail contact: urologpolska@gmail.com.

Declarations

Conflict of interest F.K. Paid lectures during company meetings for Allium Company. Paind hands-on training for Allium.

Ethical approval Collegium Medicum Ethics Committee in Bydgoszcz Approval No. KB257/2024.

Research registry UIN Researchregistry10261, www.researchregistry.com.

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