The Forgotten Ureteral Stent in Children: From Diagnosis to Treatment

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Purpose: We conducted a multicenter pediatric study of ureteral stents unintentionally left in situ.

Materials and Methods: A total of 22 patients with encrusted Double-J® ureteral stents unintentionally left in situ were treated at 4 centers between January 2007 and March 2012. Stone burdens were estimated using plain radiography and computerized tomography. Treatment decision was made based on clinical and radiological findings or stone burden.

Results: Nine girls and 13 boys with a mean age of 9.5 years (range 2 to 16) were analyzed. Mean indwelling time of ureteral stent was 21.7 months (range 6 to 60). Stents were inserted for the indication of urolithiasis (17 patients) and reconstructive urological intervention (5). In 2 patients stents had been placed bilaterally. Mean stent stone burden was 184 mm^2 on plain radiography and 247 mm^2 on computerized tomography, a difference that was statistically significant ($p = 0.002$). Shock wave lithotripsy was done in 6 cases. Endoscopic procedures were performed in all patients, including ureteroscopy in 8, simple stent removal in 7, endoscopic cystolithotripsy in 6, percutaneous nephrolithotomy in 5, retrograde intrarenal surgery in 3 and percutaneous cystolithotripsy in 2. Surgical removal of each stent required a mean of 1.5 interventions and a mean hospital stay of 4.4 days.

Conclusions: At experienced centers combined endourological techniques can achieve successful and safe management of forgotten stents even in the pediatric age group. Thus, routine preprocedural tomography is a must in children with forgotten ureteral stents.

Key Words: case management, child, foreign bodies, stents, ureter

Abbreviations and Acronyms

CaOx = calcium oxalate
CaP = calcium phosphate
CT = computerized tomography
DJS = Double-J stent
EnCL = endoscopic cystolithotripsy
FUS = forgotten ureteral stent
IVP = excretory urography
KUB = plain x-ray of the kidneys, ureters and bladder
PCCL = percutaneous cystolithotripsy
PCN = percutaneous nephrostomy
PCNL = percutaneous nephrolithotomy
RIRS = retrograde intrarenal surgery
SCSR = simple cystoscopic stent retrieval
SWL = shock wave lithotripsy
URS = ureteroscopy

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ALTHOUGH their numerous indications make Double-J stents frequently preferred in the armamentarium of the pediatric urological practice, their fields of diagnostic and therapeutic applications in children and adults differ in some respects. During childhood treatment modalities for urolithiasis and surgical interventions for congenital urinary system anomalies are applied at a higher rate.[1] The pediatric kidney is small, with restricted mobility and friable parenchyma.[2] The small collecting system, mobility of the pediatric ureter, and the friable and narrow ureteral orifice present challenges for stent implantation. In addition, especially in male

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children, the urethra is brittle and extremely vulnerable to trauma, leading to significant ureteral damage with dire consequences.[3,4] Due to the relatively small ureterorenal unit in the pediatric age group, management of forgotten ureteral stents might exhibit some differences compared to adults. We shed light on this neglected issue by presenting the outcomes of a multicenter study of forgotten ureteral stents in children.

MATERIALS AND METHODS

We retrospectively evaluated treatment modalities for FUS in children 16 years or younger performed at 4 Turkish referral urology departments with comparable levels of technical experience. Patient data were collected from hospital records. A total of 22 patients with encrusted stents unintentionally left in situ were treated between January 2007 and March 2012. Indwelling time of the stent was calculated from the time of insertion to removal.

Preoperative evaluation included measurements of serum creatinine, white blood cell counts and urine culture with susceptibility tests. All patients were evaluated for stent encrustation and associated stone burden with KUB and noncontrast enhanced stone protocol CT and/or IVP. In patients with kidneys that were not visualized on IVP diethylenetriamine pentaacetic acid renography was performed to estimate renal function.

Stone burdens were estimated on KUB and CT. A treatment decision was made based on clinical and radiological findings or stone burden. Urine culture negativity was documented for all patients before any endourological intervention was performed, and preoperative antibiotic prophylaxis was given for all patients. Empirically parenteral antibiotic therapy was initiated for all patients with a first-generation cephalosporin. Patients with a positive urine culture preoperatively were treated with culture specific antibiotics.

For stents with no encrustation detected on CT a gentle nontraumatic retrieval was attempted with the help of grasping forceps passed through the cystoscope under sedoanesthesia and fluoroscopic guidance. Noninvasive alternatives were instituted first. For some patients with mild to moderate encrustation on the intrarenal segment of the DJS shock wave lithotripsy was performed, and then successively according to medical necessity SCSR, endoscopic or percutaneous cystolithotripsy, URS, retrograde intrarenal surgery and percutaneous nephrolithotomy or nephrostomy. Ultrasonography was performed routinely in all patients at 1 to 3 months postoperatively. Patients with hydronephrosis were evaluated with IVP.

URS was performed using a 4.5Fr or 7.5Fr semirigid ureteroscope under fluoroscopic guidance. PCNL was carried out using a 17Fr or 24Fr rigid nephroscope. SWL was performed with an electromagnetic shock wave lithotripter (Siemens® Modularis Lithostar). For PCCL the bladder was filled with saline solution delivered through a Foley catheter, and then a guidewire was inserted into the bladder via a suprapubic route dilated up to 20Fr caliber. Afterward a lithotripter was inserted through a nephroscope placed into the bladder percutaneously to fragment and retrieve residual bladder stones.

We performed RIRS in patients with fragmented stents in kidneys and in those whose stents were distal from the ureters. The operation technique of RIRS was as follows. Children were placed in the lithotomy position on an endoscopy table with fluoroscopic imaging capability. Cystoscopy or rigid ureteroscopy was performed to place a hydrophilic guidewire to the renal pelvis under fluoroscopic guidance. After passing a 0.035 inch guidewire into the renal pelvis a ureteral access sheath (9.5Fr or 11.5 Fr, 35 cm, Cook® Medical) was placed to allow for optimal visualization and maintain low intrarenal pressure.

Ureteral orifice dilation was performed in selected cases with coaxial or balloon dilators when the rigid/flexible ureteroscope could not be advanced easily. The stones were fragmented with holmium:YAG laser until they were deemed small enough to pass spontaneously. Postoperatively a Double-J stent was placed when necessary to avoid ureteral damage. The decision for stenting was made based on the duration of the procedure and the degree of visible ureteral trauma or edema at the end of the procedure.

The degree of hydronephrosis was assessed according to the Society for Fetal Urology classification.[5] Only encrustation/stones immediately adjacent to the encrusted tube were used to calculate stone burden with the formula, stone burden = length × width of stone on plain x-ray.[6] The stone burden was also calculated using the formula, stone burden (mm^2) = length × width of calcification surrounding stent on CT.[7] The encrustation was graded based on the calculated area on CT as light (less than 100 mm^2), moderate (100 to 400 mm^2) or severe (greater than 400 mm^2).

Pearson chi-square test was used. P values less than 0.05 were considered statistically significant. All data were processed using SPSS®, version 15.0 for Windows.

RESULTS

Nine girls and 13 boys with a mean age of 9.5 years (range 2 to 16) were analyzed. Mean indwelling time of DJS was 21.7 months (range 6 to 60). Mean followup was 2.2 years (range 6 months to 5 years). No additional intervention was required in any patient due to ureteral stenosis.

Initial indications for stenting, patient demographic characteristics, indwelling time of stent, degree and site of encrustation, type of procedure and length of hospital stay are outlined in table 1. Stents were inserted with the indications of urolithiasis in 17 patients (77%) and reconstructive urological intervention in 5 (23%). In 2 patients DJSs had been placed bilaterally. Stone analysis was available for only 10 of the 17 stone formers in the urolithiasis group. Most stones were composed of CaOx or CaP, although 3 patients had cystine encrustations.

When first evaluated, most of the patients complained of chronic flank, suprapubic or genital pain. The most prevalent complaint was flank pain. A total of 11 patients presented with dysuria, severe

Table 1. *Patients and characteristics*

Pt No.—Age*—Sex	Indication for Stent	FUS Duration (mos)†	Encrustation Degree by Location on CT			Procedures	Length of Stay (days)‡	Stone Composition at Initial Surgery
			Renal	Ureter	Bladder			
1—5—F	Pre-SWL	26	Light	Light	Moderate	EnCL + URS	6	Cystine
2—12—M	Pyelolithotomy	60	Severe	—	Moderate	EnCL + PCNL	12	CaP
3—7—F	URS	32	Moderate	—	Moderate	EnCL + PCNL	4	CaOx-CaP
4—14—M	Pre-SWL	16	Light	—	—	URS	3	CaOx
5—2—M	Initial pre-SWL, other side pre-SWL	6,6	Severe, moderate	Light, —	Light, —	URS + PCNL, SCSR	7,5	Cystine, cystine
6—9—F	Pre-SWL	14	—	—	—	SCSR	1	CaOx
7—11—M	URS	19	Light	Moderate	—	URS	4	CaP
8—16—F	URS	19	Moderate	—	Light	PCN + SWL + SCSR	7	CaOx
9—3—M	Initial pre-SWL, other side pre-SWL	8,8	Severe, light	Light, —	Light, light	PCH + PCNL, SWL + EnCL + URS	6,4	Cystine, cystine
10—8—F	Nephrolithotomy	15	Light	—	Light	SWL + SCSR	3	CaOx
11—14—M	PCNL	24	Light	—	Light	EnCL + RIRS	2	Unknown
12—7—M	URS	29	Moderate	—	—	RIRS	4	Unknown
13—15—M	Pyelolithotomy	13	—	—	—	SCSR	3	Unknown
14—7—F	URS	17	Light	—	—	SWL + URS	6	Unknown
15—9—M	URS	29	—	—	Severe	PCCL	3	Unknown
16—15—F	Ureterolithotomy	47	Severe	Light	Light	PCNL	3	Unknown
17—12—M	PCNL	23	—	Light	—	SWL + URS	4	Unknown
18—12—M	Pyeloplasty	22	Moderate	—	—	RIRS	4	—
19—4—M	Pyeloplasty	30	Light	Light	Moderate	PCCL + URS	3	—
20—12—M	Pyeloplasty	16	—	—	—	SCSR	2	—
21—12—F	Ureteroneocystostomy	30	Light	Light	Moderate	SWL + EnCL	4	—
22—5—F	Ureteroneocystostomy	13	—	—	—	SCSR	6	—

* Mean patient age was 9.5 years.
† Mean FUS duration was 21.7 months.
‡ Mean length of stay was 4.4 days.

infection/sepsis and/or anuria. All patients with FUS were hospitalized. Appropriate replacement of fluid/electrolyte deficiency and parenteral antibiotic therapy were initiated. Urine culture was positive in 13 patients (59%), revealing Escherichia coli in 6, Klebsiella in 2, Pseudomonas aeruginosa in 2, Proteus mirabilis in 2 and Candida albicans in 1. Nine patients had negative urine cultures.

All patients demonstrated hydronephrosis, which was grade I in 8, grade II in 9, grade III in 5 and grade IV in 2 renal units. Of the stents 4 had no encrustation and 1 had light, 12 moderate and 7 severe encrustation on CT. Mean stent stone burden was 184 mm^2 on KUB and 247 mm^2 on CT, a difference that was statistically significant ($p = 0.035$). Stone burden values derived from radiological scans are outlined in table 2.

Initial treatment consisted of SWL in 6 patients. PCN was carried out under antibiotic therapy in 2 patients who presented with pyonephrosis. SCSR of the stent under fluoroscopic guidance was done in 6 cases. EnCL was required to treat the distal end of the stent in 6 cases. PCCL was performed in 2 males with severe encrustation on the intravesical segment of the DJS. PCNL was performed on the encrusted proximal segment of the stent in 5 cases. URS with intracorporeal lithotripsy was performed in 8 cases. RIRS was done in 3 cases.

A total of 12 patients (55%) were stent-free after more than 1 session, and the remainder required a single session. Surgical removal of each stent required a mean of 1.4 interventions and a mean hospital stay of 4.4 days. After removal of FUS implantation of temporary ureteral catheters was required in 12 ureters and reinsertion of DJS in 5.

Hematuria developed in 1 patient after PCN without requirement for transfusion. Sepsis developed in 1 patient after a URS procedure, necessitat-

Table 2. *Stone burden identified on imaging studies*

	No. Cases	KUB Burden (mm^2)*	CT Burden (mm^2)†
Nonstone disease stents	5	130	148
Stone disease stents:			
Cystine	5	208	398
CaOx	4	130	155
CaP	2	340	365
CaOx + CaP	1	240	200
Unknown	7	210	232
Total/av	24	184	247

* $p = 0.472$ for nonstone vs stone disease stents.
† $p = 0.254$ for nonstone vs stone disease stents.

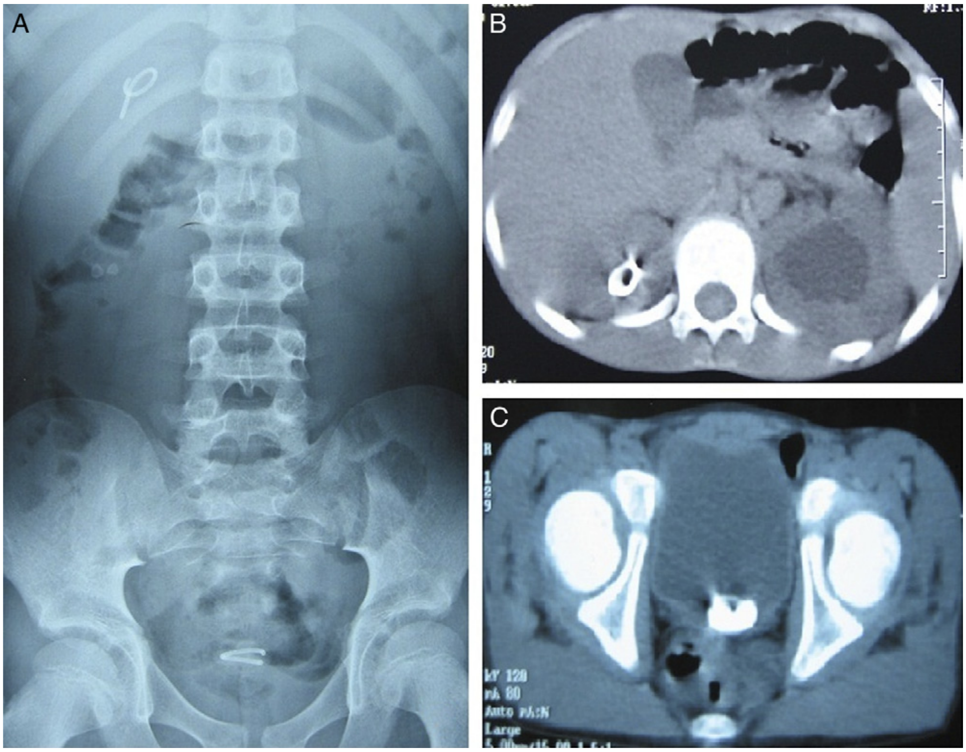

Figure 1. *A*, spontaneous fragmentation of DJS that was forgotten for 19 months. *B*, nonencrusted part of DJS in kidney (RIRS was performed in this patient). *C*, encrusted part of DJS in bladder.

ing intensive care. One patient who underwent PCNL required blood transfusion during the early postoperative period because of heavy bleeding. All 22 patients were relieved of the stents/stones with multimodal therapy.

We were extremely attentive during DJS extraction procedures. We closely scrutinized the removed stents for their integrity. We attributed the widespread use of these modalities to the complicated and selective nature of the presented cases. Data regarding these special cases are shown in figures 1 and 2. Our approach toward management and treatment of these difficult cases is based on the algorithm illustrated in figure 3.

DISCUSSION

Encrustation of forgotten stents associated with large stone burden is a serious problem due to complications such as recurrent urinary tract infection, hematuria, urinary tract obstruction and renal failure.[8] The cause of encrustation is multifactorial. Known risk factors for stent encrustation are long indwelling time (often because of poor compliance), urinary sepsis, previous or concurrent stone disease, chemotherapy, chronic renal failure and metabolic or congenital abnormalities.[9] In our series the predominant causative factor was lithogenic history and cystinuria.

There are conflicting reports about whether the composition of the stent is a factor in the degree of encrustation. Tunney et al observed that the risk of encrustation and fragmentation is dependent on the type of stent material, with silicone being the least prone to encrustation, followed by polyurethane, Silitek®, Percuflex™ and hydrogel coated polyurethane.[10] In contrast, Wollin et al reported that stent type and duration of insertion do not correlate significantly with the amount of encrustation observed from stents retrieved.[11] The data in the literature are inadequate regarding whether there is a difference in findings between children and adults. Thus, more studies are needed to clarify this issue. In the present series we did not know what material the stents consisted of because the study was designed retrospectively.

A report by el-Faqih et al indicates that the stent encrustation rate increases from 9.2% for an indwelling time of less than 6 weeks to 47.5% for 6 to 12 weeks and 76.3% for more than 12 weeks.[12] In our study a statistically significant correlation was detected between DJS indwelling time and stent stone burden (fig. 4). In the 4 cases in which no stent encrustation was detected the stents were forgotten for an average of 11 months, while in 9 cases with severe stent encrustation the interval was approximately 22 months.

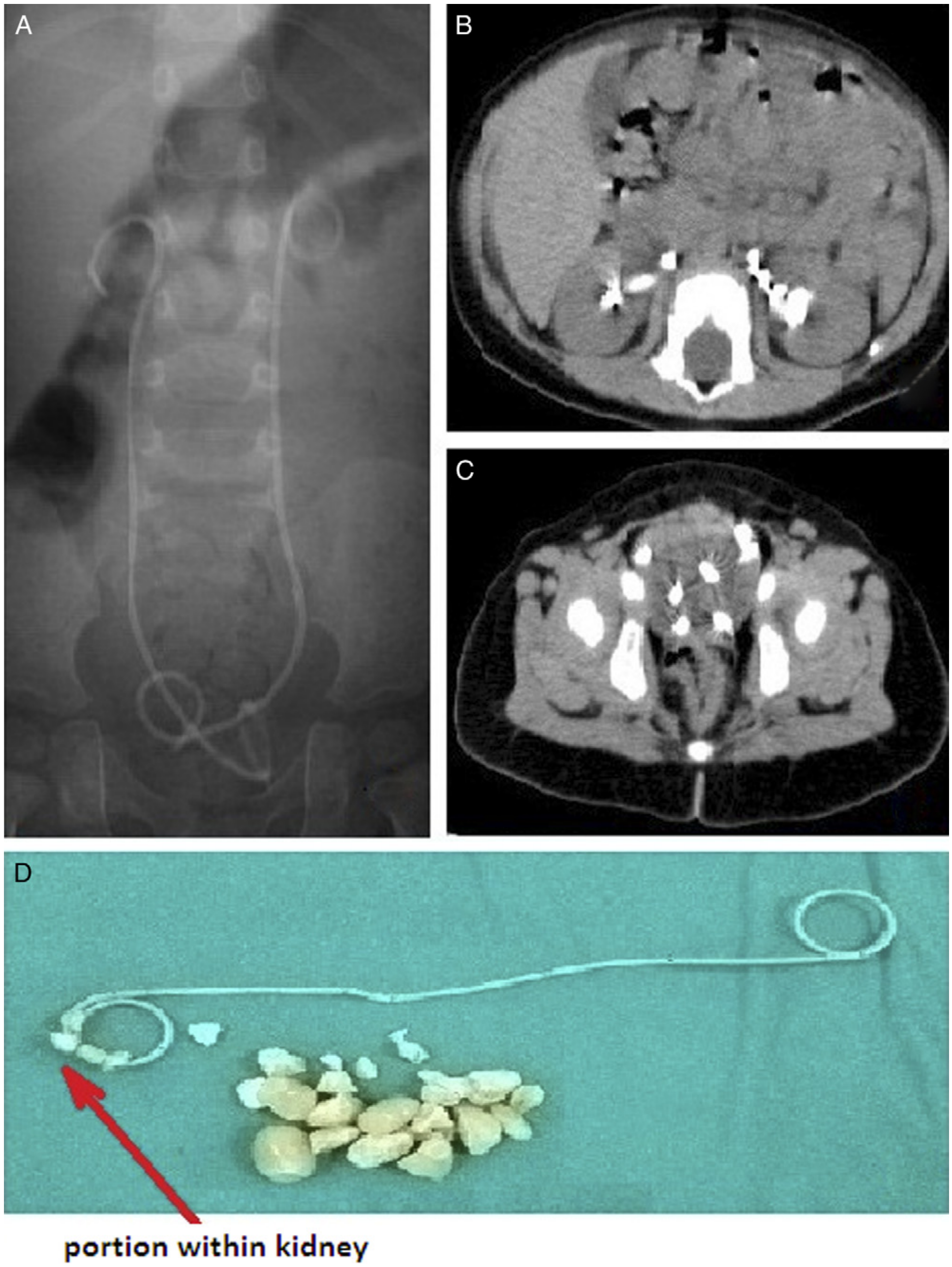

Figure 2. Image of forgotten bilateral DJS in 2-year-old boy with cystinuria for 6 months. *A*, there is no encrustation on KUB bilaterally. *B*, there is high volume of stone burden bilaterally, especially in left kidney. *C*, there is also encrustation on DJS in bladder. *D*, DJS and all stones in left kidney were removed by PCNL in first session.

The thickness of encrustation on DJS is closely related to the prolonged indwelling time of the stent. The earliest encrustations on DJSs begin to appear at 6 months after the implantation. Most of these encrustations begin to appear 12 months postoperatively.[12] Perhaps surprisingly, in our study stents in 2 patients with cystinuria had become severely encrusted within 6 months. This finding poses special problems with management because the encrustation is usually radiolucent and thus can be diagnosed only at surgery. The stone is usually quite compact and difficult to break, and the patients are at risk for early recurrent encrustation(s). Based on these results, in the pediatric age group stents implanted especially with a metabolic indication of cystinuria should be removed as early as possible.

Preoperative evaluation of patients with FUS is an important issue. Weedin et al reported that actual stone burden of the encrusted proximal stent is more accurately predicted by noncontrast CT than KUB.[13] Their study revealed the superior accuracy of CT compared to KUB to evaluate stone burden

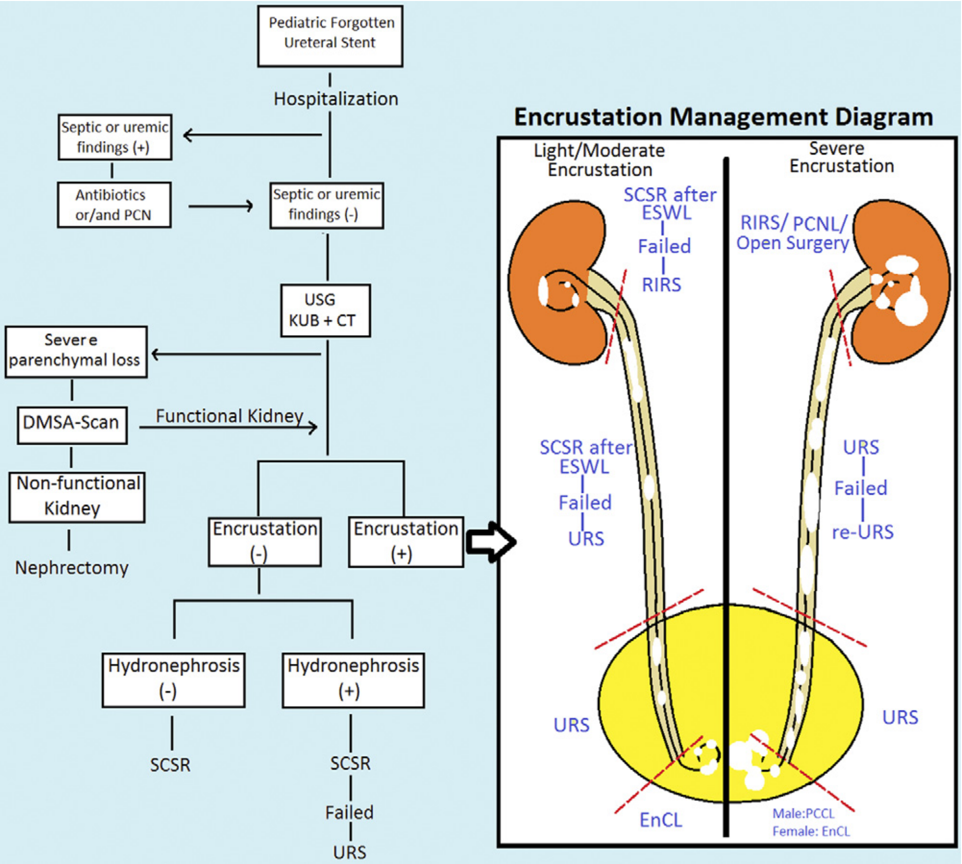

Figure 3. Algorithm for management of pediatric FUS. *DMSA*, dimercapto-succinic acid. *ESWL*, extracorporeal shock wave lithotripsy. *USG*, ultrasonography.

associated with encrusted ureteral stents. Since noncontrast CT has become the preferred modality to diagnose urinary calculi and stents that can become encrusted with radiolucent uric acid calcifications,[14] they hypothesized that CT precisely detects and localizes stent encrustation. However, as reported in the literature, some clinicians still attempt cystoscopic stent retrieval in adults when encrustation cannot be detected on KUB.[15]

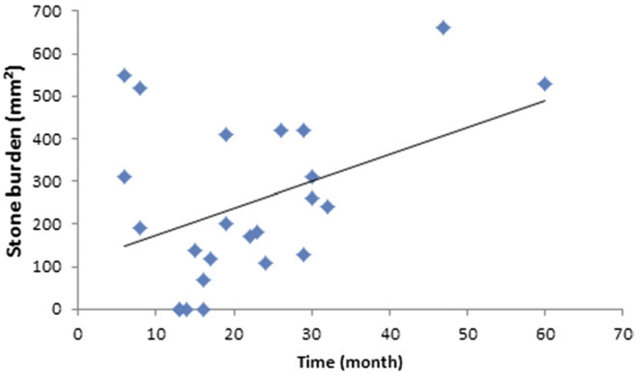

Figure 4. Stone burden was increased in parallel with duration of stent retention.

At our clinics we apply the same procedure for our adult patients.[16] However, in children this phenomenon may be totally different because in this age group metabolic stone disease (ie nonopaque cystine and uric acid stones) is more frequently seen. Besides, since bowel cleansing is hard to achieve in the pediatric age group, intensive intra-abdominal gas on KUB can mask visualization of actual stone burden. Therefore, if used alone, plain x-ray can underestimate proximal encrustation and lead to inadequate operative preparation, the development of complications and the need for unanticipated additional surgery.

In our study mean stone burden was 247 mm^2 on CT and 184 mm^2 on KUB. In 2 cases CT could detect severe stone burden due to encrustations not demonstrated on KUB. Therefore, in the pediatric age group routine CT before retrieval of FUS is appropriate to avoid surprises during the operation. CT appears to predict the location and grade of stent encrustation more accurately than KUB.

EnCL is widely used in adults and older children.[17] However, this treatment is problematic in younger infants, especially in males, due to the narrow caliber of the urethra. EnCL increases operating time and poses a considerable risk of urethral trauma, which will subsequently result in stricture. We believe that PCCL, which is popular in the management of primary bladder stones, can be used for retrieval of encrusted DJSs. With this approach the calcified intravesical segment of the DJS is fragmented and removed percutaneously using a pneumatic lithotripter without recurrent transurethral intervention.[18] We also used PCCL in 2 males with DJSs encrusted at the lower ends. We recommend PCCL especially in boys with FUS with moderately or severely encrusted intravesical segments.

Few reports in the literature have described the use of RIRS in the endourological management of FUS.[19] In our study we performed RIRS in 2 cases with broken stents at a center with ample experience in flexible endoscopic instrumentation.

This study has some limitations, including the retrospective design and relatively small patient cohort. In addition, in the urolithiasis group the composition of all stones was unknown. Ideally a larger study would be conducted to confirm and extend our findings.

CONCLUSIONS

At experienced centers combined endourological techniques can achieve successful and safe management of forgotten stents even in the pediatric age group, although treatment should be tailored to the severity of encrustation and associated stone burden. Imaging and assessment of the degree of stone burden are important before making any attempt to remove these stents. We advocate routine preoperative CT in children with FUS.

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