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ORIGINAL PAPER

A case of allograft ureteral stone successfully treated with antegrade ureteroscopic lithotripsy: use of a 3D-printed model to determine the ideal approach

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Abstract
We present the case of a 46-year-old man who underwent successful antegrade ureteroscopy for lithiasis in his allograft ureter. At a scheduled follow-up 15 years after transplantation, computed tomography (CT) detected a 12-mm renal stone in the renal pelvis of the transplanted kidney. During his follow-up, gross hematuria was seen; the stone moved to the ureter, causing hydronephrosis. Ultrasound and non-contrast CT revealed hydronephrosis and a 15-mm stone in the transplanted ureter. Considering the stone size, location, and the difficulty of the access to the anastomosed ureteral orifice, percutaneous ureteroscopic approach was planned. Due to the anatomical difficulty regarding his allograft kidney, we planned to prepare a 3D image and model for selecting the best percutaneous approach. The procedure was performed and a stone-free status was acquired without complication. Under precise simulation, we performed successful antegrade ureteroscopy for lithiasis in the allograft ureter supported by 3D imaging. Use of a 3D printed model may aid in a safe and effective procedure for lithiasis in the allograft kidney and ureter.

Keywords Urolithiasis · Allograft · Ureteroscopy · 3D printing

Introduction

Renal transplantation plays an important role in renal replacement therapy; graft survival and motility in recipients have improved dramatically in the past 2 decades, especially after improvements in immunosuppressive therapy [1]. On the other hand, lithiasis in allograft kidneys and ureters after renal transplantation is very rare, with an incidence of 0.17–1.8% [2, 3]. A few studies have previously reported on ureteroscopy (URS) for renal stones in allograft kidneys; most cases are treated with retrograde intra-renal surgery [3, 4]. We herein report a case of successful removal of a stone in an allograft ureter using the percutaneous antegrade ureteroscopic approach.

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Case presentation

A 46-year-old man underwent kidney transplantation from a living donor due to chronic renal failure when he was 32 years old. He has regularly been followed up in our out-patient clinic in the Department of urology and renal transplantation, Yokohama City University Medical Center, Yokohama, Japan.

However, 15 years after transplantation, a non-contrast computed tomography (CT) showed a 12-mm renal stone in his allograft kidney. After 1 year, the patient visited our hospital irregularly with the complaint of gross hematuria. A kidney, ureter, and bladder (KUB) radiograph and CT revealed hydronephrosis and ureteral stone in the transplanted ureter (Fig. 1). The stone was 15 mm in diameter; its maximum CT value was 1200 Hounsfield Units. The patient's serum creatinine level was 2.14 ng/mL and eGFR was 28.1, which is slightly higher than the baseline level. The patient reported no decrease in the volume of urine. Considering the stone size, location, and the difficulty of access via the anastomosed ureteral orifice, antegrade ureteroscopic lithotomy was planned.

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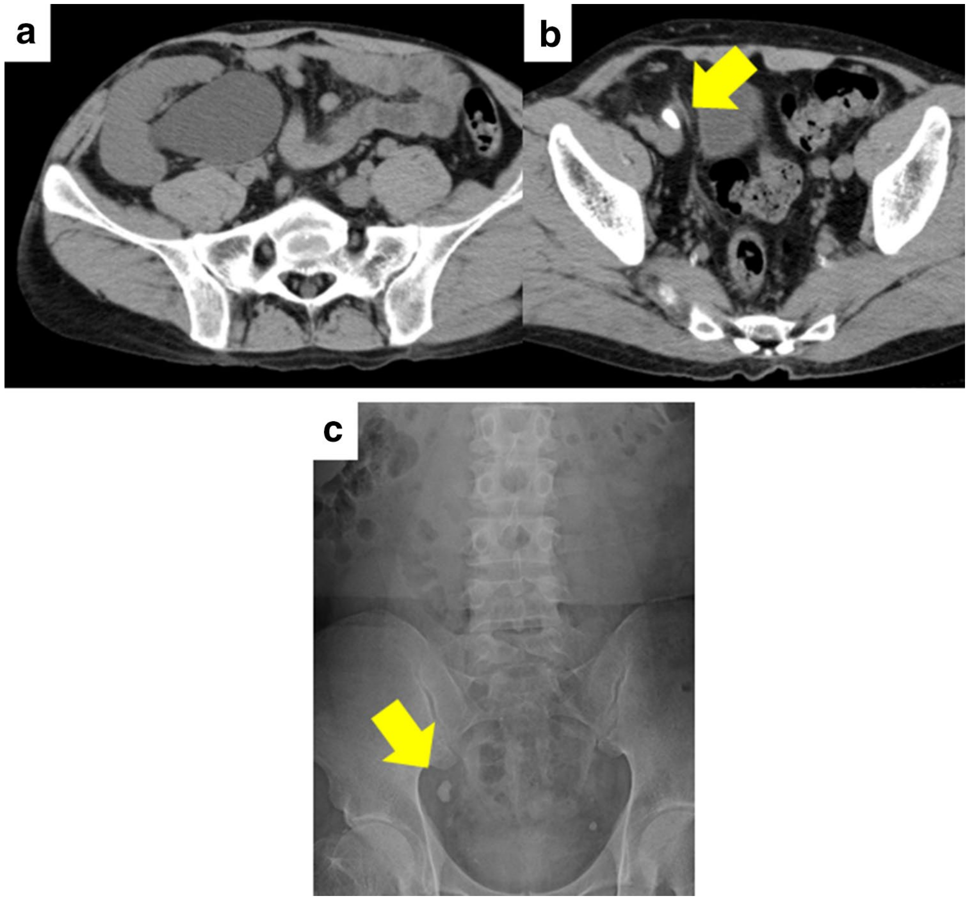

Fig. 1 Preoperative CT (**a**, **b**) and KUB (**c**) of the patient. A 15-mm stone (arrow) and hydronephrosis was confirmed in the allograft ureter

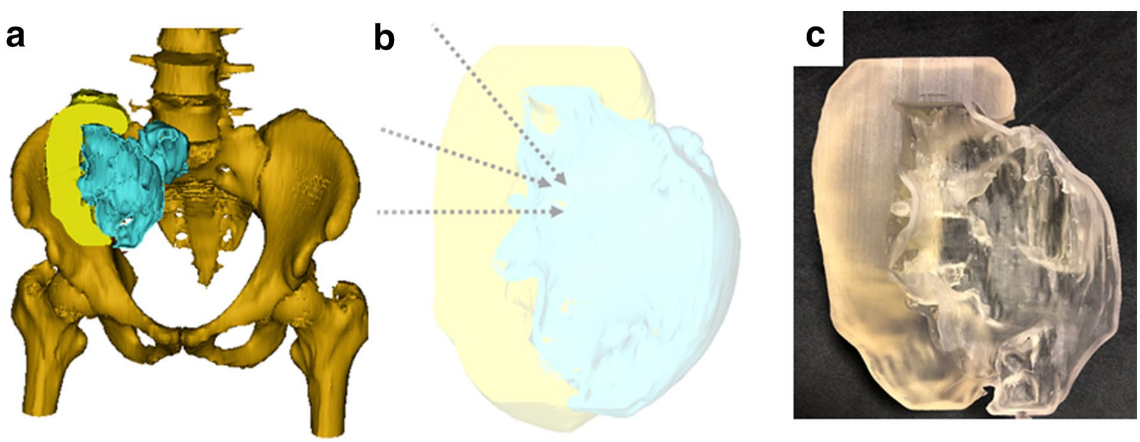

Fig. 2 The 3D images (**a**, **b**) and 3D model (**c**) of the patient's allograft kidney drawn and made using software Mimics inPrint Base® and a 3D printer. Based on this model, puncturing the upper renal calyx was considered to be the best approach

Creating a 3D-printed kidney model and preoperative simulation

The 3D kidney image was drawn using a 3D printer and software Mimics inPrint Base® (Materialise Japan, Kanagawa, Japan) and a 3D model was created using a 3D printer. Based on this model, we decided to puncture the upper renal calyx, as it was considered to be the best approach for accessing the target stone using ureteral access sheath (Fig. 2). Considering the diameter of the renal calyx, a 13/15-Fr ureteral access sheath (Navigator HD®; Boston Scientific Corp., Natick, MA, USA) was selected.

The procedure of antegrade ureteroscopy

With the patient under general anesthesia in the lithotomy position, we first punctured to reach the upper calyx under ultrasound and fluoroscopic imaging. For the operation, we used an 8.5-Fr flexible ureteroscope (URF-V2™, Olympus, Tokyo, Japan). A guidewire was passed through the renal pelvis and ureter smoothly to the bladder. A 22.5-Fr cystoscope was inserted, the guidewire was grasped and held outside the urethra as a "through and through wire". Using this guidewire, renal tract dilation was performed safely. Another guidewire was placed from the tract into the bladder as a safety guidewire. A 13/15-Fr access sheath was inserted close to the stone (Fig. 3a) and a 200-µm holmium:yttrium–aluminum–garnet (Ho:YAG) laser was used for stone fragmentation. The fragments were removed with a 1.9-Fr nitinol stone retrieval basket (ZeroTip™, Boston Scientific, Natick, MA). At the end of the operation, a 12-Fr nephrostomy catheter and 6-Fr double J stent was inserted for the tract and ureter, respectively (Fig. 3b).

The patient had no complications after the operation. A postoperative abdominal radiograph showed no residual fragments (Fig. 4). The nephrostomy catheter was removed 3 days after surgery and the patient was discharged 5 days after surgery. The double J stent was removed 2 months after surgery and a repeat CT showed no residual stone. Till date, no worsening of the renal function has been confirmed. The composition of the stone was determined to be > 98% calcium oxalate (Fig. 5).

Discussion

In kidney transplant recipients, ureteral stones do not cause severe pain as the allograft kidney is denervated [4–6]. This often causes a delay in diagnosing lithiasis, which may lead to renal failure and result in graft loss [5, 6]. In our case, asymptomatic hematuria enabled us to notice the hydronephrosis and ureteral stone.

Percutaneous nephrolithotomy (PCNL) is challenging for patients with a solitary kidney, especially if it is an allograft kidney, as there is a higher risk of complications such as severe bleeding and urinary tract infection compared to the other treatments [7]. However, at the same time, acquiring a completely stone-free status is also important in these

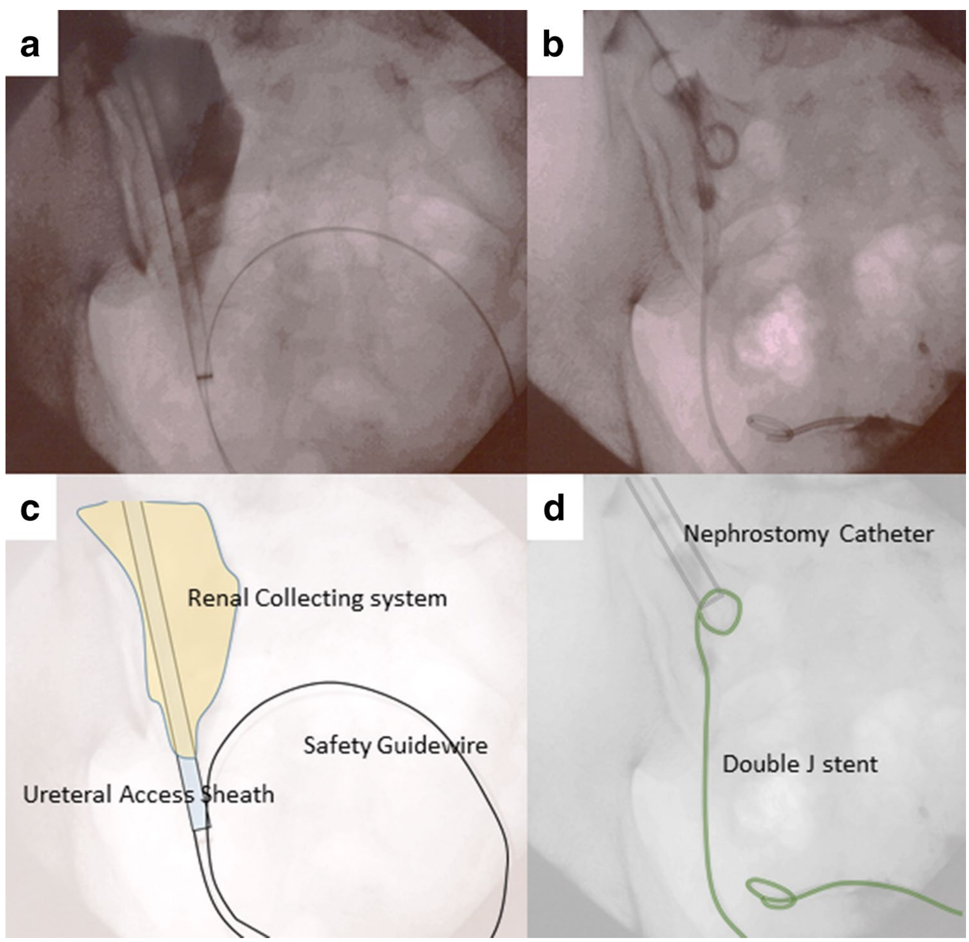

Fig. 3 Intraoperative images of the percutaneous approach. A 13/15-Fr ureteral access sheath and safety guidewire were placed to the allograft ureter (**a**). A 12-Fr nephrostomy catheter and 6-Fr double J stent was inserted for the tract and ureter, respectively, at the end of the operation (**b**)

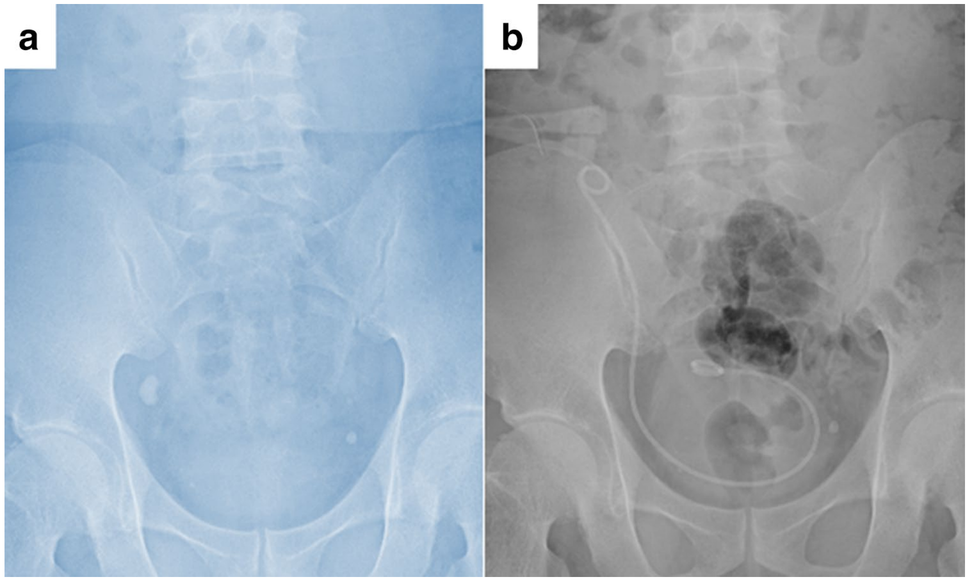

Fig. 4 The comparison of preoperative KUB (**a**) and postoperative KUB (**b**). There was no residual stone and a double J stent was placed in the postoperative KUB

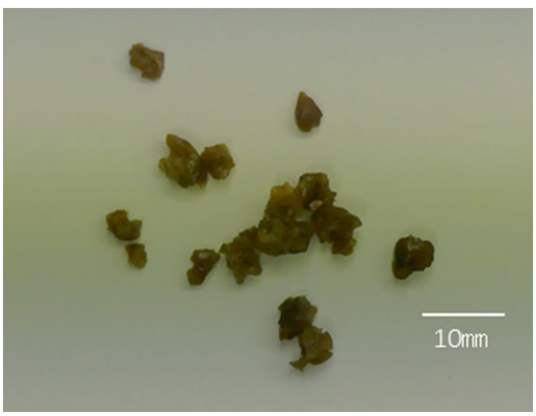

Fig. 5 Stone fragments retrieved in the operation. The composition of the stone was >98% calcium oxalate

patients, because even small residual fragments could cause renal failure, which might be a critical event for them.

As endourological devices and surgical techniques have improved, previous studies have reported increasingly safe procedures of URS and PCNL for urolithiasis in patients with a solitary kidney [8–10]. Some studies have reported successful URS for lithiasis in an allograft kidney [1, 2]. However, in our case, during kidney transplantation, ureterocystoneostomy was performed with creation of a submucosal tunnel to prevent vesicoureteral reflux. In addition to difficulty in accessing the ureteral orifice, retrograde URS may place a strain on the anastomosed orifice and submucosal ureter. There are only a few previous reports of percutaneous nephrolithotomy for lithiasis in an allograft kidney [11, 12]. To minimize the risks involved in the percutaneous approach, we used the 3D-printed model for the preoperative simulation. Visualizing the construction of the allograft kidney and preparing the proper devices enabled a safe and successful procedure. In the field of urological oncology, 3D-printed models are frequently used for preoperative simulation of partial nephrectomy for patients with renal cancer [13]. Recently, the efficacy of 3D simulation for training surgeons for performing PCNL has been reported [14]. Sait et al. used 3D segmentation software with CT images and reported that the ratio of the renal collecting system volume and analyzed stone volume and the number of tracts were independent risk factors for developing post-PCNL complications [15]. However, to the best of our knowledge, there is no previous study of 3D-printed model for urolithiasis in allograft kidney.

In conclusion, we performed a successful antegrade URS supported by 3D-printed model simulation. Under precise simulation of the operation, it may help perform a safe and effective procedure for lithiasis in the allograft kidney and ureter.

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Compliance with ethical standards

Conflict of interest There is no conflict of interest from any of authors.

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