Can Radiological Imaging Accurately Predict the Length of the Ureteral Defect/Stricture Following Ureteral Injury?

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Purpose: The incidence of ureteral injury is increasing due to the extensive application of endourological procedures. In the present study, we evaluated the accuracy of imaging studies in predicting the length of the defect in patients with ureteral injury.

Materials and Methods: We reviewed the data of all consecutive patients who underwent endourological management for ureteral injury in our institution from January 2020 to January 2023 to assess the accuracy of radiological evaluations in determining the length of the ureteral defect. We compared the radiological imaging results with intraoperative findings to determine their diagnostic accuracy.

Results: We report data on the accuracy of preoperative imaging and outcomes of endourological management in 5 patients who presented with apparently long ureteral defects in preoperative radiological evaluations following ureteral injury. The mean age was 35.4±6.8 years. Three of the five patients were male. The mean time from injury to ureteroscopic management was 12.5±7.5 days. The mean follow-up time was 7.3±2.2 months. Our experience showed that radiological evaluations have the potential to overestimate the length of the defect.

Conclusion: Radiological evaluations following ureteral injury have the potential to overestimate the length of the defect; therefore, endoscopic evaluations and intraoperative imaging studies are necessary to accurately determine the length of the defect and appropriate management. However, endourological management is safe and efficient in treating patients with short-segment ureteral defects/injuries.

Keywords: Endoscopic management, Iatrogenic ureteral injury, Radiologic evaluation, Ureteroscopy

INTRODUCTION

Ureteral injury accounts for 1-2.5% of genitourinary traumas, and the distal ureter is more vulnerable.[1] About 75% of ureteral injuries are secondary to surgical and particularly gynecological procedures; however, the incidence of ureteral injury following ureteroscopy is increasing due to the extensive application of endourological procedures.[1,2] The diagnosis of ureteral injury is challenging, and in most cases, there is a gap of 7-10 days between the trauma and diagnosis.[2] This injury can be managed by open, laparoscopic, or endoscopic approaches.[3] Various endourological techniques such as combined antegrade,[4] retrograde ureteral realignment,[5] laser cutting,[6] and metallic stent insertion[7] have been introduced. Several studies have compared the outcome of endoscopic management with open/laparoscopic approaches and showed the efficacy of endoscopic management, particularly in patients with injury to a short segment of the ureter.[8] Some studies reported that imaging studies are able to accurately determine the length of the defect; however, the literature is still scarce, and it is not clear if radiological evaluations can accurately estimate the length of the defect. In the present study, we evaluated the accuracy of imaging studies in predicting the length of the defect in patients with iatrogenic ureteral injury.

MATERIALS AND METHODS

We reviewed data of patients who presented with ureteral injury with apparently long ureteral defects in initial imaging studies from January 2020 to January 2023 in our referral center.

The ureteral defect length in preoperative ureterography is estimated by the length of the adjacent vertebral body. During the endoscopic management of the ureteral stricture/defect, the stricture/defect length is obvious as a white and fibrotic tissue in the ureteroscopic view and is distinguished easily from the inflamed mucosa. The length of the stricture is easily determined by moving the ureteroscope back and forth intra-operatively. All patients underwent endourologic management (antegrade/retrograde) and were followed for at least 3 months to assess the outcome.

The research received ethical approval from the Ethics Committee of Shahid Beheshti University of Medical

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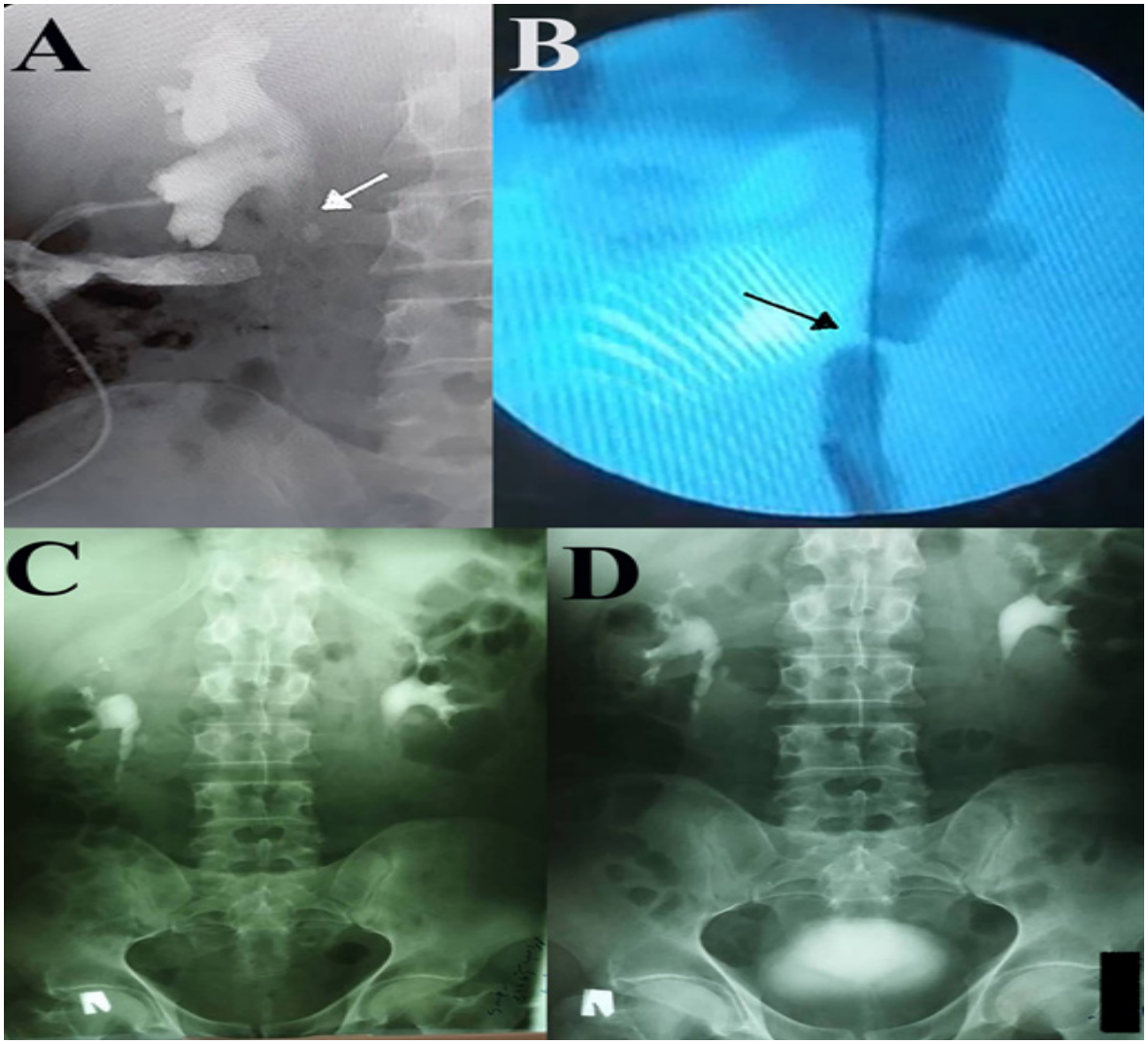

Figure 1. A: Antegrade urography showed the defect at the level of the ureteropelvic junction. **B:** During ureteroscopy and simultaneous antegrade and retrograde urography, the proximal ureter was patent 3 cm distal to the ureteropelvic junction, and the actual length of the defect was less than 1 cm. **C,D:** Intravenous urography 3 months following intervention revealed a patent ureter without stricture and hydronephrosis.

Sciences, Urology and Nephrology Research Center, and all participants provided informed consent to publish their data. The study was conducted in compliance with the ethical standards outlined in the 1964 Declaration of Helsinki, as revised in 2000.

RESULTS

The mean age was 35.4 ± 6.8 years. Three of the five patients were male. The mean time from injury to ureteroscopic management was 12.5 ± 7.5 days. The mean follow-up time was 7.3 ± 2.2 months.

Case 1: Patient number 1 was referred with a ureteral injury following ureteroscopy who was initially explored for urinoma and abscess formation. Antegrade urography revealed a relatively long defect starting at the level of the ureteropelvic junction (**Figure 1a**). The ureteroscopy was performed, and contrast agent was injected through both the ureteroscope and the nephrostomy tube. Applying this method, we found that the length of the defect was less than 1 cm, and in contrast to the initial imaging, the proximal ureter was patent for about 3 cm distal to the ureteropelvic junction (Figure 1b). Therefore, the stricture was managed using endoureterotomy with a Holmium laser. Three months following endoureterotomy, intravenous urography revealed a patent ureter with no evidence of hydronephrosis (**Figure 1c,d**).

Case 2: Patient number 2 was a 42-year-old man who presented with a ureteral injury following ureteroscopy. The patient had a nephrostomy tube and a retroperitoneal drain. Simultaneous antegrade and retrograde urography was performed. Injection of contrast through the nephrostomy showed the proximal end of the defect at the level of the ureteropelvic junction. Contrast was also injected through a ureteral catheter, and the distal end of the defect was at the level of the sacral promontory (**Figure 2a**). However, we found the true ureteral passage during ureteroscopy, and the route was patent up to the proximal ureter. The ureteroscope did not enter the pelvis. Contrast agent was injected through both the nephrostomy and the ureteroscope to determine the exact length of the injured ureter, and it turned out to be a ureteral angulation secondary to a periureteral urino-

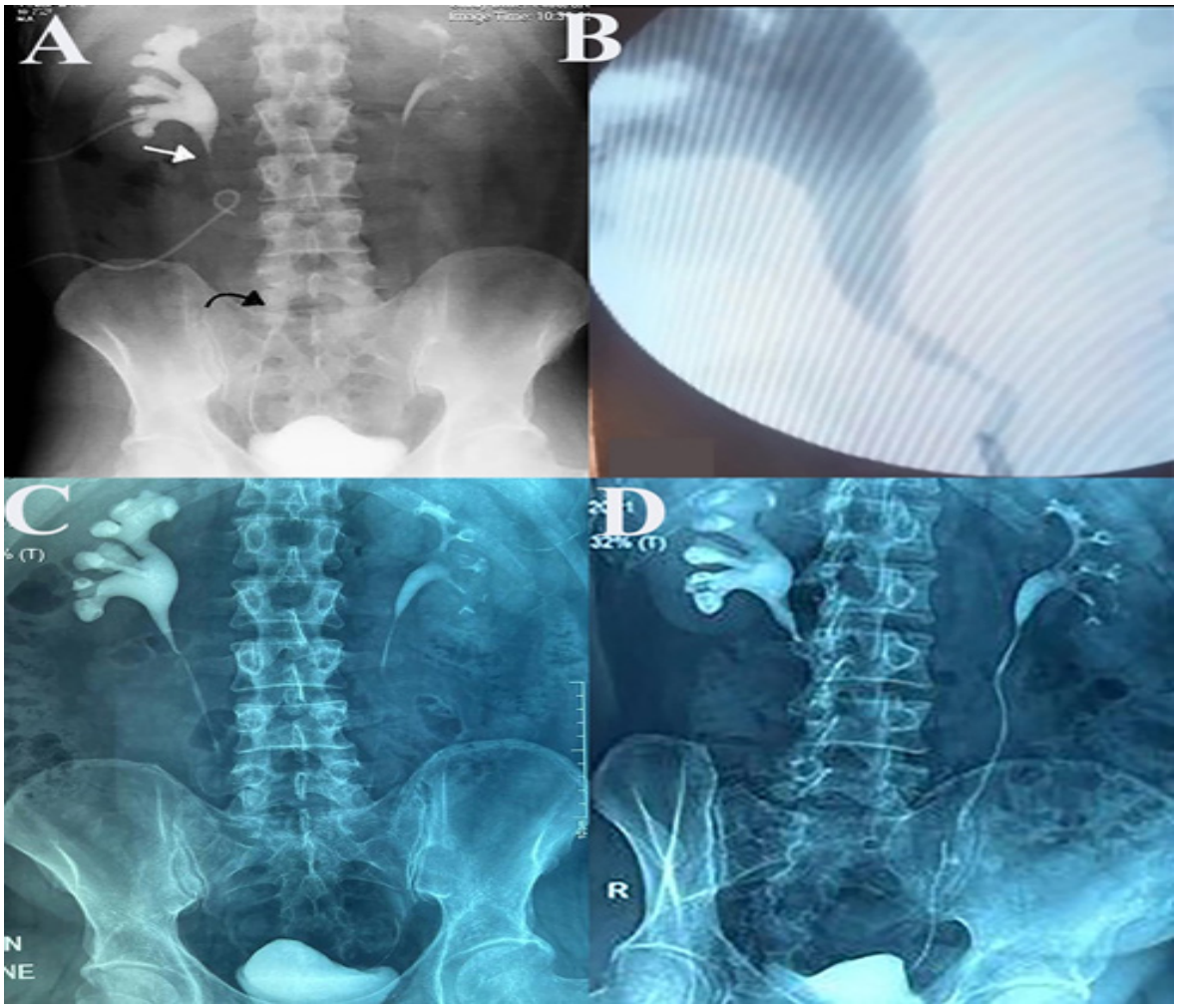

Figure 2. A: Antegrade urography through the nephrostomy tube revealed the proximal end of the defect at the level of the ureteropelvic junction (white arrow). Contrast injection through a ureteral stent revealed the distal end of the defect (curved arrow). **B:** During ureteroscopy, the true passage was found, and contrast injection showed ureteral angulation secondary to a periureteral urinoma without an actual defect/stricture. **C, D:** Intravenous urography 3 months following intervention revealed a patent urinary system.

ma (**Figure 2b**). We passed a floppy-tip guidewire into the renal pelvis and followed the guidewire with an 8 Fr ureteroscope. A DJ stent was inserted, and intravenous urography 3 months following DJ removal revealed a patent ureter without leakage (**Figure 2c,d**).

Case 3: Patient number 3 was a 40-year-old woman with a right ureteral injury following transureteral lithotripsy. A nephrostomy and DJ stent were inserted; however, the DJ was displaced into the contralateral retroperitoneal space through a false passage (**Figure 3a**). In antegrade urography, the length of the defect was apparently large, between the ureteropelvic junction and the L5 vertebral body. During ureteroscopy, we found the true passage next to the false route, and no defect/stricture was evident up to the renal pelvis (**Figure 3b**). A DJ stent was inserted through the true passage (Figure 3c), and intravenous urography prior to DJ removal confirmed healing of the ureter (**Figure 3d**). One year following the intervention, both intravenous urography and a renal scan revealed a patent pyelocaliceal system and ureter (**Figure 3e,f**).

Case 4: Patient number 4 was a 43-year-old woman with a proximal ureteral stone refractory to shock wave lithotripsy who underwent transurethral lithotripsy (TUL) (**Figure 4a**). Ureteroscopy resulted in ureteral injury, and intravenous urography showed ureteral perforation and urine leakage from the proximal ureter (**Figure 4b**). A nephrostomy was inserted, and after 1 week, simultaneous antegrade and retrograde urography revealed the proximal and distal ends of the defect to be at the ureteropelvic junction and sacroiliac joint level, respectively (**Figure 4c,d**). Ureteroscopy was performed, and the true passage was not found as the ureter seemed to be blind-ending. However, we could pass a guidewire by applying antegrade ureteroscopy. After antegrade insertion of the guidewire, we followed the guidewire during retrograde ureteroscopy into the pelvis and inserted a DJ stent (**Figure 4e,f**). Nine months following the procedure, a renal scan revealed a non-obstructive pyelocaliceal system (**Figure 4g,h**).

Case 5: Patient number 5 was a 21-year-old man with a history of a left ureteropelvic junction injury secondary to a car accident. The patient underwent open exploration, and due to extensive fibrosis in the ureteropelvic junction (**Figure 5a**), he underwent ureterocalicostomy. Following the operation, hydronephrosis remained, and a CT scan showed double-J stent migration from the site of anastomosis to the retroperitoneal space (**Figure**

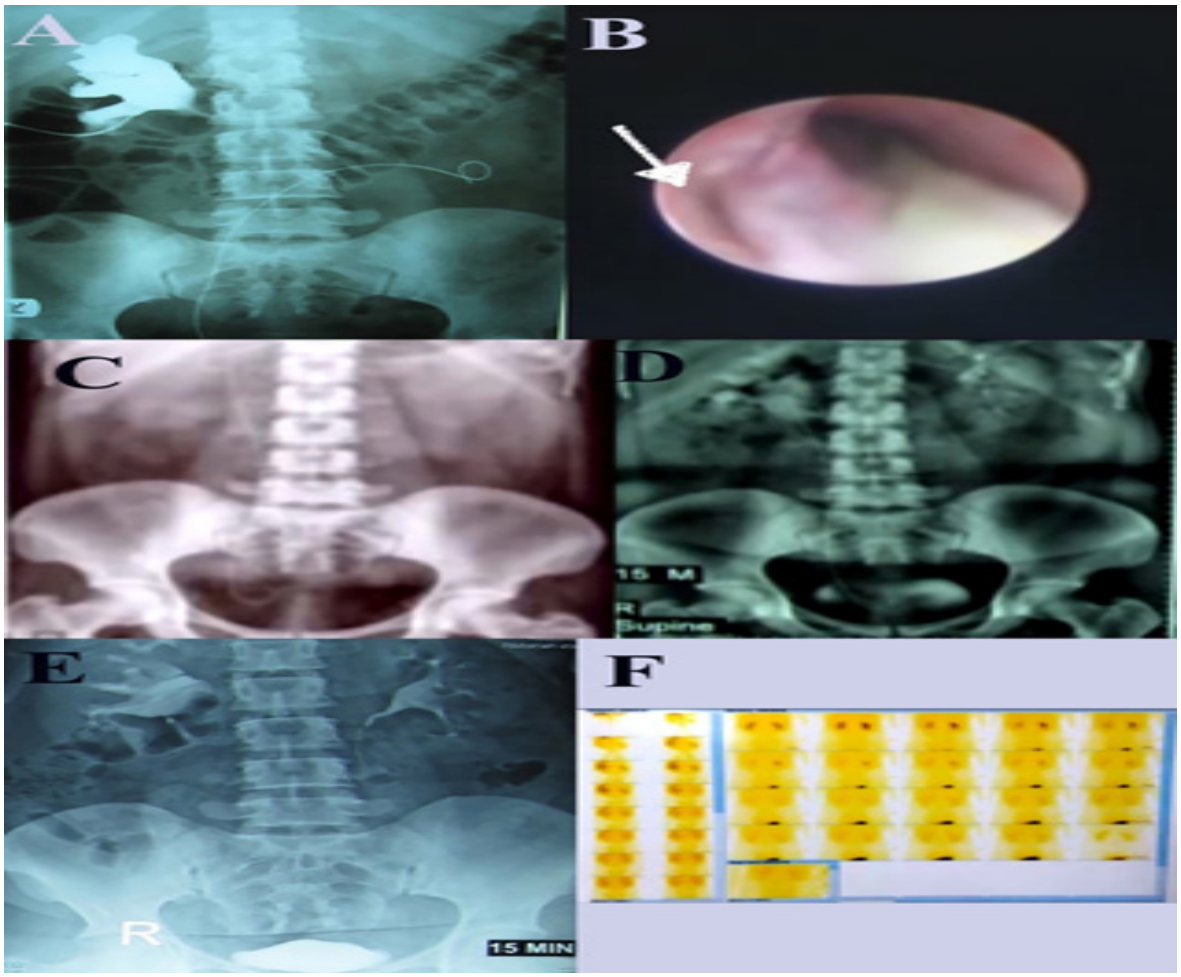

Figure 3. A: A DJ stent was placed through a false passage in the ureter into the contralateral retroperitoneal space, suggesting the distal end of the defect is at the level of the L5 vertebral body. The proximal ureter is not visualized, indicating the defect is at the level of the ureteropelvic junction with an approximate length of 15 cm. **B:** During ureteroscopy, the true passage was found next to the false route in the distal ureter (arrow). **C:** Placement of a DJ stent through the true passage. **D:** Intravenous urography prior to DJ removal confirmed healing of the ureter. E,F: Intravenous urography and diuretic renal scan 1 year following intervention revealed a patent pyelocaliceal system and ureter.

5b). After insertion of a nephrostomy, we identified the proximal and distal parts of the stricture by antegrade urography and contrast injection through the ureteroscope, respectively (**Figure 5**c). The length of the stricture was estimated to be 2 cm. Severe bullous edema was evident at the distal part of the stricture through the ureteroscopic view. After inserting a guidewire through the bullous edema and following the guidewire, the ureteroscope passed a ring-form stricture of about 1 to 2 mm and entered the calyceal system (**Figure 5d**), and a DJ stent was inserted. During follow-up, a DTPA scan revealed a non-obstructive pattern in the operated kidney (**Figure 5e**).

DISCUSSION

Ureteral stricture may lead to serious complications, including hydronephrosis, pyonephrosis, parenchymal loss, and potential loss of the unilateral renal unit. Early diagnosis and treatment would lessen the morbidities. Several modalities with acceptable sensitivities have been introduced to diagnose ureteral stricture preoperatively. CT urography in a non-urological setting and antegrade and retrograde pyelography in the urological setting are the gold standard methods to evaluate ureteral injuries and strictures.[9]

In this study, we reported on 5 patients whose preoperative imaging overestimated the length of the ureteral stricture compared to the intraoperative findings. In a pictorial review, Alabousi et al.[9] discussed the pros and cons of different imaging modalities for the diagnosis of ureteral injuries. They mentioned that the role of antegrade and retrograde urography is fading as CT urography is recognized to be more accurate, quicker, and providing much more information. This review mainly addressed the accuracy of different imaging modalities in the diagnosis of ureteral injury rather than determining the length of the defect. In a comparative study of different diagnostic imaging modalities in 25 patients with iatrogenic ureteral injury, Martov et al.[10] found that the results of MR urography were similar to CT urography but less informative than antegrade and retrograde ureteropyelography in patients with ureteral obliteration. This may be due to a lack of visualization of the ureter distal to the injury. They also found that the determination of ureteral stricture length was more accurate with MR urography in comparison to intravenous urography (IVU) or CT urography in 2 patients,

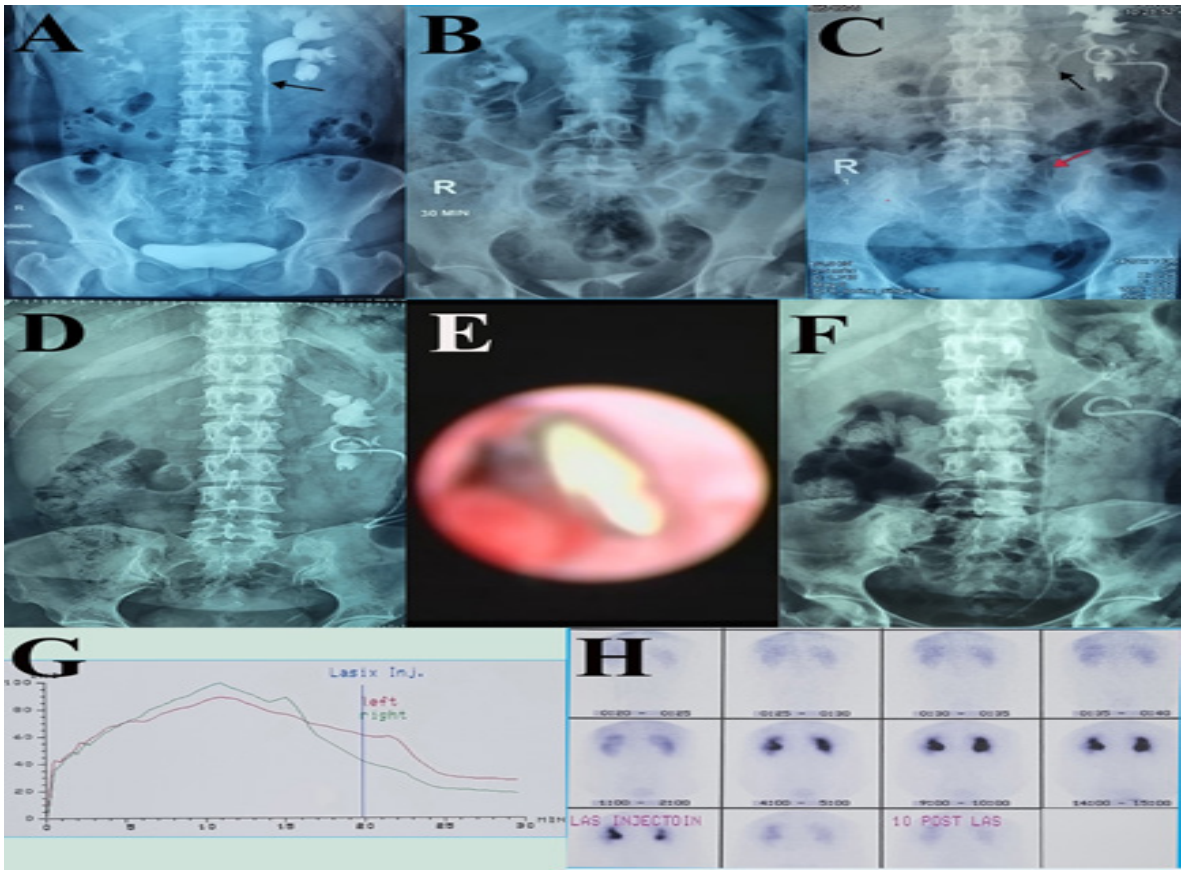

Figure 4. A: A left ureteral stone with hydronephrosis is evident in intravenous urography (arrow). **B:** Ureteroscopy resulted in ureteral injury, and intravenous urography revealed urine leakage from the proximal ureter. C: Simultaneous antegrade and retrograde ureterography revealed a long ureteral defect (the distance between red and black arrows). **D:** The proximal end of the defect is at the level of the ureteropelvic junction, and the proximal ureter is not visualized in nephrostography. **E:** The tip of the antegrade-inserted guidewire shows the true passage. **F:** Successful insertion of a DJ stent after finding the true passage by antegrade ureteroscopy and guidewire insertion. **G, H:** A diuretic renogram revealed no obstruction 3 months following the procedure.

but they did not compare the imaging results to intraoperative findings. Zielonko et al.[11] evaluated the role of MR urography in the diagnosis of obstructive uropathy. In their study, 23 of 60 patients presented with benign ureteral stenosis. MR urography (MRU) was per-

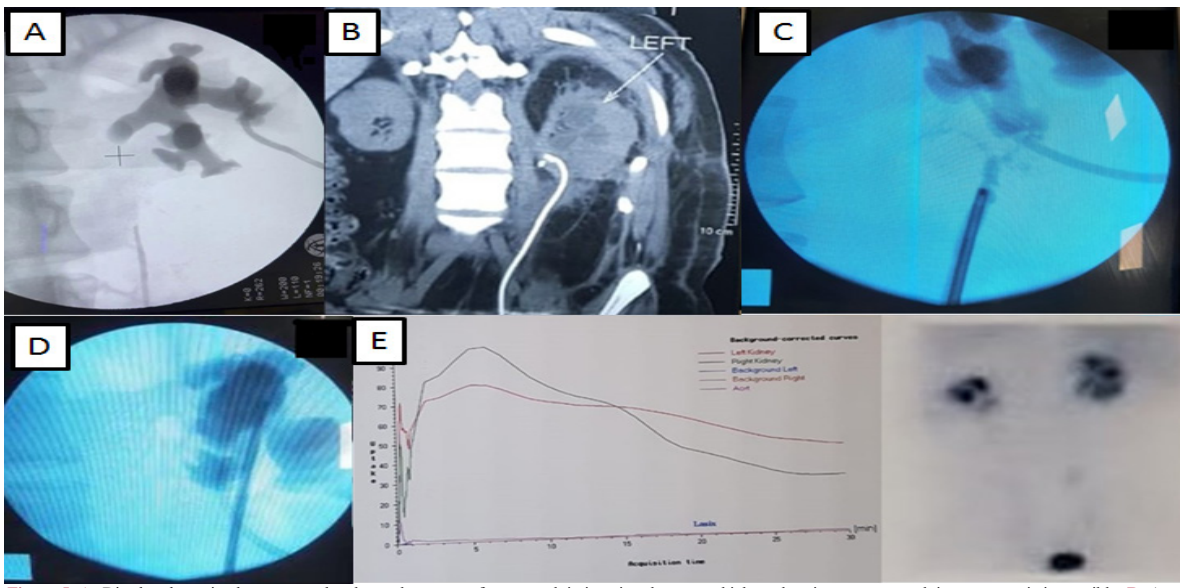

Figure 5. A: Distal and proximal ureterography shows the extent of ureteropelvic junction damage, which made primary ureteropelvic anastomosis impossible. **B:** An abdominopelvic CT scan following ureterocalicostomy shows double-J stent migration from the site of anastomosis to the retroperitoneal space. **C:** The proximal and distal parts of the stricture are identified by proximal urography and ureteroscopy, respectively. **D:** The calyceal system is visualized after injection of contrast agent through the ureteroscope. **E:** A DTPA scan reveals a non-obstructive pattern after a six-month follow-up in the operated kidney.

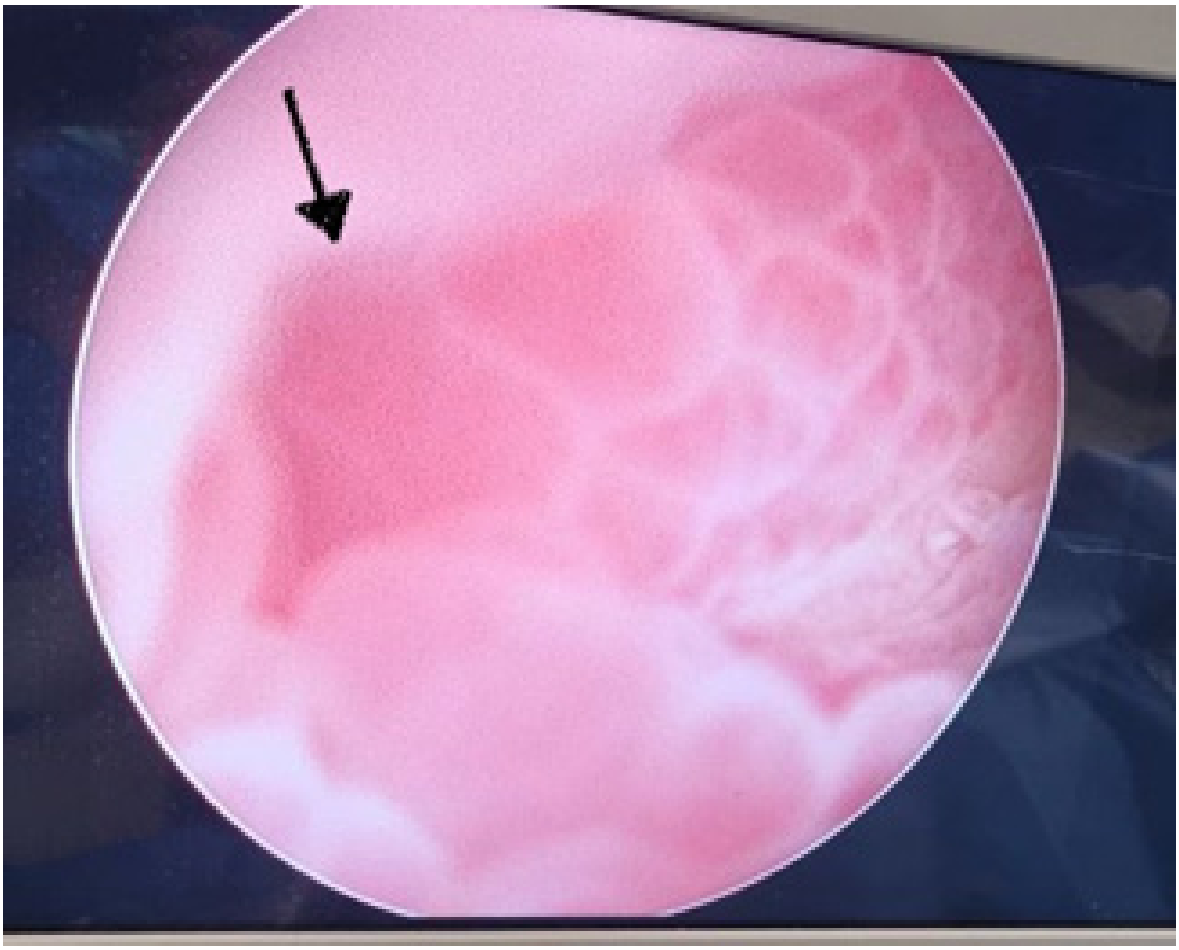

Figure 6. Inflammation in the renal pelvis adjacent to the ureteropelvic junction secondary to the presence of a nephrostomy tube. The arrow shows the ureteropelvic junction.

formed in all patients, and the results were compared to IVU, ultrasound, or CT urography findings. They determined the obstruction level in 100% of cases with non-calculous ureteral stricture and concluded that MR urography would be a complementary method in the diagnosis of urinary stricture and the best modality in altered anatomical conditions. Identification of the ureteral stricture extent is an important part of the patient's evaluation to choose the best type of treatment, including endoscopic management or reconstructive surgeries.[12] In these two recent studies, the authors evaluated and compared different preoperative modalities in the diagnosis of ureteral stricture, but they did not compare their results to intraoperative findings in terms of ureteral stricture length measurement.

In the present study, we showed that radiologic evaluations in patients with ureteral injury may significantly overestimate the length of the ureteral defect. This overestimation may be related to poor radiological technique and the interval between trauma and the imaging study. It seems that mucosal inflammation in the pyelocaliceal system and severe bullous edema, especially when a nephrostomy tube is in place, may impede the passage of urine through the ureteropelvic junction (**Figure 6**) or affect the ureter's nerve supply and consequent dynamic obstruction. This finding is similar to the overestimation of urethral defect/stricture in patients with urethral injury who undergo voiding cystourethrography and the posterior urethra is not evident. Another important issue to consider is that imaging under local anesthesia (particularly antegrade) may overestimate the injury. This is likely because of underfilling of the collecting system due to patient pain from induced hydronephrosis (or at least concern about such pain). General anesthesia at the time of intervention may lead to a better assessment of the true injury.

To our best knowledge, this is the first report on the limitations of radiographic evaluation in patients with ureteral injury, and further studies are necessary to assess this hypothesis. We recommend designing prospective studies with a larger sample size to evaluate the accuracy of ureteral defect length detection following iatrogenic ureteral injury by comparing preoperative imaging and intraoperative findings. In this study, we successfully managed 5 patients with a history of ureteral injury by retrograde and antegrade endoscopic techniques. Although iatrogenic ureteral injury is a rare complication of gynecological procedures, it is usually a severe complication with difficult management. Historically, endoscopic approaches have played a limited role in the treatment of these injuries.[10,12,13] However, with the advancement in endoscopic procedures and instruments, the endourological management of ureteral injuries has become more popular and widespread.[14]

CONCLUSIONS

Radiological evaluations following ureteral injury have the potential to overestimate the length of the defect; therefore, endoscopic evaluations and intraoperative imaging studies are necessary to accurately determine the length of the defect and appropriate management. However, endourological management is safe and efficient in treating patients with short-segment ureteral defects/injuries.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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