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# Lower Pole Stone Management

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## Introduction

The life-long incidence of stones in the population of the Western world is 5-15% [1]. They may be an incidental discovery or present with, sometimes severe, colicky abdominal/lumbar pain. The variation of clinical manifestations that is occasionally encountered in renal stone disease is related largely on stone location and pain radiation. For this reason, urolithiasis is included in the differential diagnostics of the acute abdomen.

However, clinicians, surgeons and urologists have become increasingly aware to the fact that not all stones produce clinical symptoms or do they hold the same potential for complications. Subsequently, the question arose on whether pursuing active treatment was ever cost-effective or merely "stone-driven". This is particularly true for renal stones in the lower pole calyces, mainly because of the dependent anatomic configuration, but also due to the increasing detection rates of these stones during abdominal imaging.

## The Lower Pole Calyceal Stone: Anatomical Considerations

It has often been questioned whether gravity was the only factor responsible for lower pole lithiasis. The frequency for stones in lower renal calyces has increased from 2% in mid eighties to 48% in the early nineties, which is roughly the same time with the widespread extracorporeal shock wave treatment (ESWL) use [2].

It seems that migration of smaller stone fragments occurs post ESWL. These become relocated in the lower calyces and act as a nucleus for new stone formation. The incidence of lower pole stones is calculated between 30-40% since 1990 [2]. These findings led to the more detailed study and understanding of calyceal anatomy, especially for the lower pole moiety. The first anatomic parameter evaluated was the infundibular length [3]. This was defined as the distance from the most distal point at the bottom of the infundibulum to the midpoint at the lower lip of the renal pelvis. Another parameter evaluated was the infundibular diameter termed as the diameter at the narrowest point along the infundibular axis [3]. The pelvicalyceal height termed as the distance between lower lip of renal pelvis and bottom of stone bearing calyx. Other anatomic parameters include the lower pole infundibulopelvic & infundibuloureteric angles [3]. Infundibulo pelvic angle a (IPA-a) is an angle between the central axis of lower pole infundibulum and a tangential line at the renal pelvis. IPA-b is an angle between the central axis of lower pole infundibulum and renal pelvic axis, which is the line connecting the central axis of upper ureter at lower pole level to the central axis of the UPJ. Infundibulo uretero pelvic angle a (IUPA-a) is an angle between the central infundibular axis and the perpendicular ureteral axis, whereas IUPA-b is an angle between the central infundibular axis and the ureteropelvic axis (line connecting central point of pelvis opposite superior and inferior renal sinus) [3].

The logic behind evaluation of anatomical factors is based on their importance in fragment clearance. It should be noted that the effectiveness of any stone treatment method is dependent on both stone fragmentation and subsequent fragment elimination. The pioneering study of Sampaio and Aragao [4] investigated the anatomy of the lower pole calyces by reproducing the collecting system in 3D with the use of polyester resin casts. The fact for the infundibular length is that the longer it is, the harder it is for the stones to be expulsed following ESWL and the worse the stone free rates (SFR's) are [5]. When the infundibular diameter was evaluated, a cut-off value of 5 mm was associated with significantly different SFR's. If the infundibular diameter was >5 mm SFR's were better and this is logical because the wider the infundibular neck, the easier it is to pass the stones [5]. The pelvicalyceal height of the lowest stone bearing calyx was compared to the renal pelvis (>15 mm) and it was concluded that it is harder it to expulse stone fragments [5]. This is explained by the fact that in this case the stone fragments have to move against gravity for a bigger distance. The general principle behind the various infundibulopelvic & infundibuloureteric angles is that the more an acute angle the lower pole calyx forms with the pelvis, the harder it is to have a stone free status. In particular, an angle greater than 90 degrees facilitates drainage of fragments following ESWL. Elbahnasy et al. [5] reported 100% SFRs following ESWL in patients with an infundibulopelvic angle >90 degrees. Measurements were based on intravenous urogram (IVU) studies. Evidently, in case an inferior pole is drained by a single infundibulum, stone fragments have a higher chance of elimination [5].

In the majority of studies it is clearly highlighted that the more favorable anatomic parameters a patient with a lower calyceal stone has, the more probable it is to obtain a stone free status after a ESWL session. In a retrospective analysis by Sabnis et al. [6] in 133 patients, the pelvicalyceal angle, diameter of the lower calyx infundibulum and lower-pole calyceal pattern were determined from IVU. They concluded that an angle < 90 degrees, a diameter of <4 mm and a simple calyceal pattern play a key role in predicting the clearance of stone and they should be assessed during IVU to facilitate the planning of treatment for lower calyceal stones. However, in a contradictory study by Sorenson and Chandhoke [7], patients were segregated into favourable or not anatomy groups, the former being those with infundibular angle >70 degrees, infundibular lenghth <30 mm and infundibular width >5 mm (Level of evidence: 3/B). No difference was noted for stone free rates between the two groups. Another retrospective study by Madbouly et al. [8] reported no significant impact on stone clearance of the aforementioned parameters. Other studies have also reported no correlation between anatomical parameters in their SWL success rates [3,7]. The reason of controversy lies in the diversity of methods used for the measurements by various authors due to lack of consensus of a standardized approach, as well as poorly defined cutoffs. Furthermore, Maltaga and Assimos [9] included stone composition and type of lithotripter used as factors that influence the contribution of anatomical

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factors. Results from recent randomized trials have provided higher level evidence, in an attempt to revalidate infundibular height, width and infundibulopelvic angle as significant for stone free rates [10-13]. All studies investigated single lower pole calyceal stone of <25 mm treated by ESWL. Parameters that seem to have a particular influence in stone clearance include IPA-a, pelvicalyceal height and infundibular length [12]. When three favorable anatomic parameters are present a stone free rate of up to 85% can be predicted. On the contrary if none of these parameters is present the stone free rate is expected to be only 6.7% [11-13]. The European Association of Urology Guidelines, indicate that a steep infundibulopelvic angle, a long calyx and a narrow infundibulum as factors that impair ESWL success, as well as stone composition (calcium oxalate monohydrate, cystine and brushite) .

## Management of the Lower Pole Calyceal Stone

Treatment options include ESWL, percutaneous nephrolitholapaxy (PCNL), retrograde flexible ureteronephroscopy (RIRS) and, on very rare occasions, lower pole partial nephrectomy. General indications for management are increasing stone size, pain, which maybe acute or chronic, obstruction and infection, and constitute the rule regardless of stone or fragment location.

### The asymptomatic stone

An area of debate exists with regards to the prophylactic treatment of the asymptomatic lower pole stone. As one might expect, the natural history of such calculi eventually leads to complications, mainly of the infectious type, an assumption supported with fact by Hubner and Porpaczy [14]. Other investigators showed that the possibility of a symptomatic episode requiring intervention following observation of asymptomatic stones was approximately 10% per year [15]. In a multi-center randomized trial comparing two treatment modalities for lower pole stone management, namely ESWL versus PCNL, one of the most interesting secondary findings was the fact that as stone size increased > 10mm, the likelihood of being stone free with ESWL decreased dramatically (Le:1) [16]. Mahoney et al. [17] come to supplement that, for stones >10 mm, the risk of developing a symptomatic episode within two years is 47% (Le: 2a/B). However, in a prospective randomised controlled trial with 2.2 years clinical follow-up, Keeley et al. [18] reported no significant difference between ESWL and observation when they compared asymptomatic caliceal stones <15 mm in terms of stone-free rate, symptoms, requirement for additional treatment, quality of life, renal function, or hospital admission rate.

Nevertheless, even asymptomatic stones carry a significant prospective morbidity that cannot be overlooked, and thus prophylactic treatment should be offered, especially for a diameter >10 mm. The choice of the treatment modality in such instances has been reviewed. In a recent study, PCNL had significantly higher stone free rates when compared to ESWL as initial treatment [13]. This finding was also supported by another group, which reported stone free rates of > 95% for sizes 0-20 mm following PCNL after one failed ESWL session for single lower pole calculi [19]. Another study compared efficacy of RIRS versus PCNL and concluded that no significant difference in clearance was found for stones up to 20 mm, albeit higher complication rate for PCNL [20]. Koo et al. [11] provided with evidence that support ESWL as both efficacious and cost effective when compared to RIRS. Therefore, it seems a reasonable option to suggest ESWL as primary treatment for asymptomatic lower pole stones up to 20 mm, especially in case of favorable anatomic parameters (Le: 3/B) exist [1,2,21,22]. Although the role of medical expulsion therapy has not been studied in this context, its addition could be an appealing prospect with future perspective, especially when considering inversion therapy in view of collecting system dynamics [23].

### The role of ESWL

ESWL is the preferred method of treatment for patients with symptomatic upper urinary tract stones [3]. The efficacy of ESW depends on the clearance of calculous debris following fragmentation. Many authors have investigated shock wave efficacy in lower pole lithiasis. Talic and El Faqih [24] reported a 56% complete clearance of all calculous material at a 3-month follow-up after SWL. Obek et al. [22] in a series of 455 patients with isolated lower pole calculi treated with a single ESWL reported a stone-free rate of 63%. For patients with stone size > 2 cm, the stone-free rate was 49%, irrespective of calyceal location [22]. Chen and Streem reported a series of 206 patients with isolated lower pole calculi [25]. The stone-free rate at 1 month following treatment was 48% and a longer-term stone-free rate after ESWL was 54.3%. In case of residual stones, only 9% required secondary intervention. In a study by Lingeman et al. [16] the limitations of ESWL for lower pole stones are highlighted. A total of 2927 patients that underwemt ESWL were reviewed and the result was a low overall stone free rate of 60%, versus 90% for PCNL. Furthermore, higher re-treatment rate was observed when comparing the lower calyx with other intrarenal locations (Le:1). Although recurrence rates appear similar in long term follow up, as reported by McDougal et al. [26] in a randomized study comparing PCNL and ESWL, PCNL is superior with regards to stone free rates, regardless of size and burden [3,16,26]. Moreover, ESWL is associated with lower morbidity, treatment on a day-case basis, faster recovery and return to daily activities [2,26,27].

The poor stone clearance following ESWL for lower pole stones has stimulated several investigators to examine techniques to facilitate fragment passage. To counteract the effect of dependency in the lower pole, various investigators have suggested that adjunctive treatment with manual percussion, diuresis and inversion (PDI) may improve fragments clearance rate [20,21]. Percussion diuresis and inversion therapy consists of asking the patient drink 500cc of water before the ESWL and after completion of the session placing the patient on a couch in a prone position of 45 degree angle. Thereafter, the patient is subjected for 10 minutes at continuous mechanical percussion of the flank. It is suggested that this technique increases urine production while in the same time mobilization will flush the residual fragments out of the calyx. Passage is facilitated by placing the patient in the prone position with simultaneous flank percussion. Brownlee et al. [28] reported the first formal evaluation of the safety and efficacy of controlled inversion therapy using intravenous hydration, inversion, and percussion. In a single-blind trial, Chiong et al. [29] randomized 108 patients with lower pole lithiasis <20 mm to ESWL and ESWL with PDI, to finally come up with a stone free rate of 35.4% and 62.5, respectively ($p < 0.006$) (Le:2a). Further studies evaluated the efficiency of PDI therapy. Pace et al. [30] reported a 50% clearance of residual fragments <4 mm versus observation alone, while Yu et al. [31] concluded that table inversion in this setting is a valuable adjunct in stone passage and can improve stone free rates.

Another technique that has been studied was retrograde irrigation by using a curved angiographic catheter. This was placed in the lower pole calyx and intermittent irrigation with saline was applied during ESWL. Nicely et al. [32] reported stone free rates of up to 71% in one series of 3 months follow-up, with the main drawbacks being the need for fluoroscopy and intravenous sedation for the procedure. On the other hand, Graham and Nelson [33] proceeded in an antegrade fashion with the use of a small nephrostomy tube in the lower pole to irrigate the fragments during ESWL.

The use of medical treatment has also been studied, in particular oral solution of potassium citrate, in order to decrease urinary saturation of calcium and inhibit aggregation of calcium oxalate crystals post ESWL. Soygur et al. [34] evaluated prospectively the recurrence rate in residual fragments and also following stone free status in an independently randomized group of patients (Le: 2a). They reported zero recurrence at 1 year versus 28.5% in the observation arm ($p < 0.05$) for initially stone free patients. Similarly, the residual fragment group had a significantly greater remission rate (44.5 versus 12.5%). It was suggested that such therapy may allow for spontaneous passage, thus increasing clearance rates. These results have been confirmed by other studies [35].

Other investigators have attempted to correlate spiral noncontrast CT findings with the likelihood of fragmentation and subsequent passage of residuals. Joseph et al. [36] prospectively evaluated the attenuation of calculi as a predictor of fragmentation (Le: 2/B). The success rate for stones with a value of >1000 HU was significantly lower than for stones of <1000 HU. They also reported a significant correlation between the mean attenuation and the number of shock waves required for lithotripsy. In a similar manner, Saw et al. [37] commented on Hounsfield unit attenuation and the probability of fragmentation, in that apparently half the attenuation value represented the number of lithotripter shocks required to be delivered for adequate results (Le: 3/B). Although further evidence is required, it seems that non-contrast CT provides a means of improving ESWL efficacy and may have a role in patient selection.

## The role of PCNL

PCNL has been studied extensively and can be considered the gold standard for lower pole stones of > 20 mm [1]. Albala et al. [3] reported SFRs of 95% compared to 37% for ESWL (3 months follow-up), in a prospective randomized multi-center study (Le:1a). A retrospective study by Havel et al. [38] reported rates of 95-97% (Le: 3). Although hospitalization is longer, the risk of complications was not shown to be significantly correlated. Aron et al. [39] suggested that stone size has little influence on success rates and that in cases with peculiar anatomy, upper pole access is a reasonable alternative. The general consensus favors PCNL against ESWL for lower pole stones of 1-2 cm, provided that negative predictors for clearance are present and given the disappointing results of ESWL consideration [1].

## The role of RIRS

The retrograde endoscopic approach to lower calyceal calculi represents the latest result of technological advancement in the field of endourology. Small caliber, flexible instruments with the use of holmium:YAG laser fibers and nitinol end baskets, as well as advanced access sheaths have improved access to the pelvicalyceal system and stone management. Reported stone free rates range from 532% to 87% in various studies [40-42]. RIRS is a reasonable approach for lower pole lithiasis, especially in obese individuals, patients on anticoagulation, concomitant ureteral calculi and bilateral occurrence [43,44]. Based on the available literature, flexible URS seems to have comparable efficacy as ESWL for stones <15 mm [5,6]. However, clinical experience with last generation ureterorenoscopes suggests an advantage of URS over ESWL, by paying the price of higher invasiveness. It is also reported that, in difficult cases, repositioning of the calculi to more accessible upper and/or middle calyces, especially for stones 1-2 cm, is safe and advisable [41,42] (Le:2a).

A recent study compared fURS with PCNL for stones 1.5-2 cm [45]. The authors reported similar stone free rates, both at initial treatment (89.3% versus.92.8%, URS versus PCNL) and also for additional intervention (94.6% versus 97.6%, respectively). Complications did not differ statistically, except for the need for transfusion in the PCNL group. It was concluded that URS has acceptable efficacy for medium sized lower pole stones (Le: 2a). To support these findings, Wendt et al. [46] in another recent study, investigated the role of new flexi scopes in the improvement of lower pole clearance rates. Novel digital scopes have improved deflexion, as well as a stiffer sheath, which allows for quick and multiple passes and working at lower collecting system pressures. When compared to standard flexible uereterorenoscopes, lower calyx access was better, with double the stone free rate (31% versus 69%).

## The role of open surgery

The indications for open surgery in the lower calyx have become quite rare nowadays, mostly due to development of minimally invasive procedures. Nevertheless, in special circumstances of a much dilated calyx, in a scarred and distorted lower pole, with a long, thin and tortuous infundibulum, a strong case can be made for an open approach to perform a lower pole partial nephrectomy.

## Conclusions

Lower pole calyceal lithiasis represents a significant clinical entity. It requires to be addressed individually with respect to the current evidence based medicine, in order to achieve optimal results by utilizing the most efficient method available with the lowest morbidity. Advances in lithotripter technology, minimal invasive techniques, but also percutaneous access techniques enable urologists to conduct safer and more effective operations and anticipate high stone free rates. Further research is required in order to ameliorate extracorporeal lithotripsy clearance rates, in an effort to reduce the need for invasive procedures.

### References

1. Turk C, Knoll T, Petrik A, Sarika K, Straub M, et al. (2011) Guidelines on Urolithiasis. EAU Guidelines.
2. Cass AS, Grine WB, Jenkins JM, Jordan WR, Mobley TB, et al. (1998) The incidence of lower-pole nephrolithiasis--increasing or not? Br J Urol 82: 12-15.
3. Albala DM, Assimos DG, Clayman RV, Denstedt JD, Grasso M, et al. (2001) Lower pole I: A prospective, randomized trial of ESWL and PCNL for lower pole nepphrolithiasis-initial results. J Urol 166: 2072-2080.
4. Sampaio FJ, Aragao AH (1994) Limitations of ESWL for lower caliceal stones;anatomic insight. J Endourol 8: 241-247.
5. Elbahnasy AM, Shalhav AL, Hoenig DM, Elashry OM, Smith DS, et al. (1998) Lower pole calyceal stone clearance after shockwave lithotripsy or ureteroscopy: the impact of lower pole radiographic anatomy. J Urol 159: 676-682.
6. Sabnis RB, Naik K, Patel SH, Desai MR, Bapat SD (1997) Extracorporeal shock wave lithotripsy for lower calyceal stones: can clearance be predicted? Br J Urol 80: 853-857.
7. Sorensen CM, Chandhoke PS (2002) Is lower pole caliceal anatomy predictive of extracorporeal shock wave lithotripsy success for primary lower pole kidney stones? J Urol 168: 2377-2382.
8. Madbouly K, Sheir KZ, Elsobky E (2001) Impact of lower pole renal anatomy on stone clearance after shock wave lithotripsy: fact or fiction? J Urol 165: 1415-1418.
9. Maltaga BR, Assimos DG (2002) The treatment of lower pole renal calculi in 2003. Rev Urol 4: 178-184.
10. Knoll T, Tasca A, Bucholz NP (2011) Treatment of small lower pole renal calculi: ESWL vs. URS vs. PNL? Arch Ital Urol Androl 83: 6-9.
11. Koo V, Young M, Thompson T, Duggan B (2011) Cost effectiveness and efficiency of shockwave lithotripsy vs. flexible ureteroscopic holmium: yttrium-aluminium garnet laser lithotripsy in the treatment of lower pole renal calculi. BJU Int 108: 1913-1916.

12. Zomorrodi A, Buhluli A, Fathi S (2010) Anatomy of the collecting system of lower pole of the kidney in patients with a single renal stone: a comparative study with individuals with normal kidneys. Saudi J Kidney Dis Transpl 21: 666-672.
13. Yuruk E, Binbay M, Sari E, Akman T, Altinyay E, et al. (2010) A prospective, randomized trial of management for asymptomatic lower pole calculi. J Urol 183: 1424-1428.
14. Hubner W, Porpaczy P (1990) Treatment of calyceal calculi. Br J Urol 66: 9-11.
15. Glowacki LS, Beecroft ML, Cook RJ, Pahl D, Churchill DN (1992) The national history of asymptomatic urolithiasis. J Urol 147: 319-321.
16. Lingeman JE, Siegel YI, ;Steele B, Nyhuis AW, Woods JR (1994) Management of lower pole nephrolithiasis: a critical analysis. J Urol 151: 663-667.
17. Mahoney JE, Jewett MAS, Honey RJD, Bombardier C (1996) Long-term outcome of asymptomatic renal calculi: A randomized clinical trial. J Endourol 276.
18. Keely FX, Tilling K, Elves A, Menezes P, Wills M, et al. (2001) Preliminary results of a randomized controlled trial of prophylactic shock wave lithotripsy for small asymptomatic renal calyceal stones. BJU Int 87: 1-8.
19. Pardalidis NP, Arndriopoulos NA, Sountoulidis P, Kosmaoglou EV (2010) Should percutaneous nephrolithotripsy be considered the primary therapy for lower pole stones? J Endourol 24: 219-222.
20. Bozkurt OF, Resorlu B, Yildiz Y, Can CE, Unsal A (2011) Retrograde intrarenal surgery versus percutaneous nephrolithotomy in the management of lower-pole renal stones with a diameter of 15 to 20 mm. J Endourol 25: 1131-115.
21. Deliveliotis C, Skolarikos A, Louras G, Kostakopoulos A, Karagiotis E, et al. (1999) Extracorporeal shock wave lithotripsy for lower pole calculi: Our experience. Int J Urol 6: 337-340.
22. Obek C, Onal B, Kantay K, Kalkan M, Yalçin V, et al. (2001) The efficacy of extracorporeal shock wave lithotripsy for isolated lower pole calculi compared with isolated middle and upper caliceal calculi. J Urol 166: 2081-2084.
23. Mudraia IS, Kirpatovskiĭ VI, Martov AG, Dzeranov NK, Moskalenko SA, et al. (1998) Functional state of the upper urinary tract during and after extracorporeal lithotripsy. Urol Nefrol (Mosk) 6-10.
24. Talic RF, El Faqih SR (1998) Extracorporeal shock wave lithotripsy for lower pole nephrolithiasis: efficacy and variables that influence treatment outcome. Urology 51: 544-547.
25. Chen RN, Streem SB (1996) Extracorporeal shock wave lithotripsy for lower pole calculi: long-term radiographic and clinical outcome. J Urol 156: 1572-1575.
26. McDougal EM, Denstedt JD, Brown RD, Clayman RV, Preminger GM, et al. (1989) Comparison of extracorporeal shock wave lithotripsy and percutaneous nephrolithotomy for the treatment of calculi in lower pole calices. J Endourol 3: 265-271.
27. Staios D, Andrews HO, Shaik T, Buchholz NN (2007) Quality of life after percutaneous nephrolithotomy for caliceal diverticulum and secluded lower-pole renal stones. J Endourol 21: 515-519.
28. Brownlee N, Foster M, Griffith DP, Carlton CE (1990) Controlled inversion therapy: an adjunct to the gravity-dependent fragments following extracorporeal shock wave lithotripsy. J Urol 143: 1096-1098.
29. Chiong E, Hwee ST, Kay LM, Liang S, Kamaraj R, et al. (2005) Randomized controlled study of mechanical percussion, diuresis, and inversion therapy to assist passage of lower pole renal calculi after shock wave lithotripsy. Urology 65: 1070-1074.
30. Pace KT, Tariq N, Dyer SJ, Weir MJ, D'A Honey RJ (2001) Mechanical percussion inversion and dieresis for residual lower pole fragments after hock wave lithotripsy: a prospective, single blind, randomized controlled trial. J Urol 166: 2065-2071.
31. Yu X, Chen ZQ, Yang WM, Liu JH, Zhou XC, et al. (2009) Application of inversion table in the treatment of lower pole renal stones. Zhonghua Wai Ke Za Zhi 47: 255-257.
32. Nicely ER, Maggio MI, Kuhn EJ (1992) The use of a cystoscopically placed cobra catheter for directed irrigation of lower pole caliceal stones during extracorporeal shock wave lithotripsy. J Urol 148: 1036-1039.
33. Graham JB, Nelson JB (1994) Percutaneous caliceal irrigation during extracorporeal shock wave lithotripsy for lower pole renal calculi. J Urol 152: 2227.
34. Soygur T, Akbay A, Kupeli S (2002) Effect of potassium citrate therapy on stone recurrence and residual fragments after shockwave lithotripsy in lower caliceal calcium oxalate urolithiasis: a randomized controlled trial. J Endourol 16: 149-152.
35. Fine JK, Pak CY, Preminger GM (1995) Effect of medical management and residual fragments on recurrent stone formation following shock wave lithotripsy. J Urol 153: 27-32.
36. Joseph P, Mandal AK, Singh SK, Mandal P, Sankhwar SN, et al. (2002) Computerized tomography attenuation value of renal calculus: can it predict successful fragmentation of the calculus by extracorporeal shock wave lithotripsy? A preliminary study. J Urol 167: 1968-1971.
37. Saw KC, McAteer JA, Fineberg NS, Monga AG, Chua GT, et al. (2000) Calcium stone fragility is predicted by helical CT attenuation values. J Endourol 14: 471-473.
38. Havel D, Saussine C, Fath C, Lang H, Faure F, et al. (1998) Single stones of the lower pole of the kidney. Comparative results of extracorporeal shock wave lithotripsy and percutaneous nephrolithotomy. Eur Urol 33: 396-400.
39. Aron M, Goel R, Kesarwani PK, Seth A, Gupta NP (2004) Upper pole access for complex lower pole renal calculi. BJU Int 94: 849-852.
40. Grasso M, Ficazzola M (1999) Retrograde ureteropyeloscopy for lower pole caliceal calculi. J Urol 162: 1904-1908.
41. Kourambas J, Munver R, Preminger GM (2000) Ureteroscopic management of recurrent renal cystine calculi. J Endourol 14: 489-492.
42. Schuster TG, Hollenbeck BK, Faerber GJ, Wolf JS (2002) Ureteroscopic treatment of lower pole calculi: comparison of lithotripsy in situ and after displacement. J Urol 168: 43-45.
43. Shah HN (2008) Retrograde intrarenal surgery for lower pole renal calculi smaller than one centimeter. Indian J Urol 24: 544-550.
44. Skolarikos AA, Papatsoris AG, Mitsogiannis IC, Chatzidarellis L, Liakouras C, et al. (2009) Current status of ureteroscopic treatment for urolithiasis. Int J Urol 16: 713-717.
45. Bozkurt OF, Resorlu B, Yildiz Y, Can CE, Unsal A (2011) Retrograde Intrarenal Surgery versus Percutaneous Nephrolithotomy in the management of lower pole renal stones with a diameter of 15-20 mm. J Endourol 25: 1131-1135.
46. Wendt-Nordahl G, Mut T, Krombach P, Michell MS, Knoll T (2001) Do new generation flexible ureterorenoscopes offer a higher treatment success than their predecessors? Urol Res 39: 185-188.

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