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Original Research

Outcomes in a Large Series of Minipercs: Analysis of Consecutive 318 Patients

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Abstract

Background and Purpose: The purpose of this study is to evaluate the outcomes of miniperc at our center.
Patients and Methods: This is a retrospective review of consecutive 318 minipercs done in a single tertiary urological center. The Miniperc system used was either Wolf (Richard Wolf) 14F with 20F Amplaz sheath or Storz (Karl Storz) nephroscope 12F with 15/18F sheath or 16.5/19.5F sheath. Data about the demography of patients, comorbidities, stone size, number and size of the tract, size of nephroscope, energy source used, total operative time, exit strategy, hospital stay, clearance of stones, total analgesic requirement, visual analogue pain score at 6 and 24 hours, hemoglobin drop and complications were analyzed by the chi-square test and analysis of variance test.
Results: The average age of patients, stone size, operative time, hemoglobin drop and hospital stay were 41.9 ± 17.0 years, 15.26 ± 6.35 mm, 60 ± 19 minutes,1.0 ± 0.6 g/dL and 2.8 ± 1 day, respectively. Complete clearance rate was 98.7%. Fourteen (4.4%) patients had Clavien–Dindo level 1 complications and 1 (0.31%) patient had Clavien–Dindo level 2 complications. The size of the stone treated by miniperc did not affect the hemoglobin drop (p-value = 0.26) or hospital stay (p-value = 0.924). There is no significant increase in hemoglobin drop (p-value = 0.064) or hospital stay (p-value = 0.627) with increasing number of miniperc tracts. An increase in operative time is associated with the increase in hemoglobin drop (p-value = 0.041). Different energy sources did not significantly affect the operative time (p-value = 0.184). Placement of only ureteral catheter is associated with less analgesic requirement (p-value = 0.000).
Conclusions: Miniperc is a safe alternative to standard percutaneous nephrolithotomy. In carefully selected patients, the best exit strategy would be a tubeless procedure with ureteral catheter drainage.

Introduction

Percutaneous nephrolithotomy (PCNL) was introduced for treatment of renal stones in 1976.[1] Over the years PCNL has undergone many modifications and improvements. These were aimed at improving the clearance of the stone and toward achieving complete clearance and also at decreasing the complications associated with it. PCNL is the standard of care for renal stones with size >20 mm and a treatment option for stones <20 mm.[2] Although there is no exact consensus on what should be considered as miniperc, it is a term generally accepted for PCNL done with tract size less than or equal to 20F.[3] Miniperc has been shown to have equal stone-free rates and reduced morbidity compared to standard PCNL. As the tract size decreases, the blood loss and pain associated with PCNL decreases.[4–6] The purpose of this study is to analyze the outcome of miniperc at our center.

Patients and Methods

Study design

It is a retrospective review of 318 patients who underwent miniperc in a urological tertiary hospital from June 2009 to December 2013. The institutional review board and ethics committee approved the study.

Miniperc was defined as PCNL with tract size less than or equal to 20F. In our study, the largest dimension of stone or cumulative largest dimension of multiple stones is considered as size of stone.

Procedure

Informed consent was obtained from patients for undergoing the procedure. Exclusion criteria for the procedure were bleeding tendencies, patients on anticoagulants, and pregnancy. Four different surgeons, experts in performing

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PCNL, performed miniperc. Procedures were done under general anesthesia. Patients were initially placed in a lithotomy position. Cystoscopy was done with a rigid cystoscope, and a ureteral catheter was placed in the ureter on the affected side. The Foley catheter was placed perurethrally. Patient was turned prone and the proposed calix to be punctured was determined. Under ultrasound or fluoroscopy guidance, the proposed calix was punctured. The puncture confirmation was determined by efflux of water from the needle, by placing dye into pelvicaliceal system and turning the fluoroscope into a thirty degree position. Once perfect puncture was confirmed, then glidewire® (Terumo) was passed into the pelvicaliceal system. The Miniperc system used was either Wolf (Richard Wolf) 14F with 20F Amplaz sheath or Storz (Karl Storz) nephroscope 12F with 15/18F sheath or 16.5/19.5F sheath. The tract was dilated over glidewire with 14F Angiotech single step dilator (PBN Medicals). After that, the dilator and sheath of the respective miniperc system were placed. The energy source for stone fragmentation was either laser or pneumatic. Stone fragments were either flushed out from the kidney by irrigation through the ureteral catheter or stones were extracted by Nitinol basket or with triflange forceps. Placement of ureteral catheter or Double-J stent with or without nephrostomy tube was decided by surgeons as per the merits of the case. Check X-ray of kidney, ureter, and bladder and ultrasound kidney, ureter, and bladder were done on the first postoperative day for evaluation of clearance of stone. Perurethral catheter with ureteral catheter with or without nephrostomy tube was removed on the first postoperative day if the procedure was uneventful. The check X-ray kidney, ureter, and bladder and ultrasound kidney, ureter, and bladder were repeated at 1 month postoperatively for reconfirming the stone-free status.

Data analysis

The data about the demography of the patients, stone size and average Hounsfield unit, stone site, puncture guidance, operative technique, tract size, nephroscope used, energy source used, exit strategy, total operative time, analgesic requirement (in milligrams of tramadol), visual analogue pain score (VAS) at 6 and 48 hours, stone-free status assessed before discharge and at 1 month follow-up, hospital stay, hemoglobin drop, Clavien–Dindo complication score were analyzed. The outcome parameters of interest were operative time, analgesic requirement, VAS at 6 and 48 hours, hemoglobin drop, and hospital stay. We looked at the parameters such as number of tracts, tract size, stone size, stone Hounsfield units, energy source, operative time, and exit strategy that could affect the outcome parameters. Univariate analysis of these parameters was done with respect to evaluating the outcome parameters.

Results

The demographic parameters in the study are as depicted in Table 1.

Table 1. Demographic Parameters

Parameter	*Number*
Total number of renal units treated	318
Age (mean ± SD), range (years)	41.91 ± 16.97 (1–87)
Male:Female ratio	223:95
Stone size (mm) (mean ± SD)	15.26 ± 6.35
Stone size	
< 1 cm	58
1–2 cm	228
> 2 cm	32
Tract size and miniperc system used	
20F Amplaz sheath with 14F Wolf nephroscope (Richard Wolf)	193
Storz 12F nephroscope with 15/18 sheath or 16.5/19.5 sheath (Karl Storz)	125
Energy source used	
None- Pick up stone	9
Ho:YAG Laser	148
Pneumatic	161
No. of tract used	
Single	305
Multiple	13
Exit strategy	
Tubeless with ureteral catheter	112
Tubeless with Double-J stent	112
Nephrostomy with or without Double-J stent or ureteral catheter	94
Operative time (mean ± SD) minutes	60 ± 19
Hemoglobin drop (mean ± SD) g/dL	1.04 ± 0.62
Hospital stay (mean ± SD) days	2.8 ± 1
Clavien–Dindo level of complication[7]	
Level 0	303
Level 1	14 (4.4%)
Level 2	1 (0.31%)
Stone-free status	314 patients (98.74%)

Complete clearance was achieved in 314 out of 318 (i.e., 98.74%) patients with miniperc.

Table 2 shows the findings of univariate analysis.

There is no significant increase in hemoglobin drop or hospital stay with increasing number of miniperc tracts.

The tract size of 20F Amplaz (with Wolf 14F nephroscope) or less than that (i.e., Storz 15/18 or 6.5/19.5 with 12F nephroscope) did not significantly affect analgesic requirement, VAS at 6 or 48 hours, hospital stay, or hemoglobin drop.

The use of laser or lithoclast did not significantly affect the total operative time or hospital stay in miniperc.

As the size of the stone increased, the analgesic requirement and VAS at 6 hours postoperatively significantly increased. However, the size of stone had no impact on VAS at 48 hours, hemoglobin drop, or hospital stay.

The Hounsfield units of stone did not affect operative time, hemoglobin drop postoperative VAS scores, analgesic requirement, or hospital stay.

As the total operative time increased, the hemoglobin drop increased. However, it did not affect analgesic requirement, VAS score at 6 or 48 hours, or hospital stay.

Patients with nephrostomy had more analgesic requirement than tubeless procedures. In the tubeless procedures, the analgesic requirement in the ureteral catheter drainage group was less than the Double-J stent drainage group.

The VAS at 6 hours is not influenced by exit strategy.

The VAS at 48 hours is minimum in patients with tubeless procedure with ureteral catheter drainage. It is intermediate

Table 2. Association of Various Factors with Miniperc Outcome Parameters

Parameters	*OR time*	*Analgesic requirement (grams of tramadol)*	*VAS score at 6 hours*	*VAS score at 24 hours*	Hemoglobin *drop (g/dL)*	*Hospital stay (days)*
Tracts						
Single tract ($n=305$)	—	—	—	—	0.9 ± 0.7	3.0 ± 0.8
Multiple tract ($n=13$)	—	—		—	1.2 ± 0.9	2.7 ± 0.6
p-Value	—	—	—	—	0.064	0.627
Tract size						
20F ($n=193$)	64.7 ± 19.6	62.4 ± 51.9	3.3 ± 1.0	1.7 ± 0.9	0.9 ± 0.7	2.0 ± 1.0
< 20F ($n=125$)	52.09 ± 15.303	64.1 ± 45.3	3.3 ± 1.0	1.8 ± 1.3	1.0 ± 0.7	2.9 ± 0.7
p-Value	0	0.76	0.99	0.41	0.295	0.689
Stone size						
< 1 cm ($n=58$)	—	52.6 ± 46.3	3.0 ± 1.0	1.7 ± 0.8	1.0 ± 0.7	2.9 ± 0.6
1–2 cm ($n=228$)	—	62.7 ± 48.7	3.3 ± 1.0	1.8 ± 1.2	0.9 ± 0.7	3.0 ± 0.8
> 2 cm ($n=32$)	—	84.4 ± 54.5	3.8 ± 1.0	1.9 ± 0.8	1.1 ± 0.8	3.0 ± 1.6
p-Value	—	0.013	0	0.594	0.26	0.924
Hounsfield unit						
< 1200	59.3 ± 19.1	62.0 ± 45.3	3.3 ± 1.1	1.8 ± 1.0	0.9 ± 0.6	2.9 ± 0.9
> 1200	59.98 ± 19.08	63.5 ± 51.0	3.3 ± 1.0	1.8 ± 1.1	0.9 ± 0.7	3.0 ± 0.8
p-Value	0.764	0.802	0.786	0.730	0.717	0.326
Energy source						
Laser ($n=148$)	59.8 ± 18.4	—	—	—	—	2.9 ± 0.8
Pneumatic ($n=160$)	59.1 ± 18.9	—	—	—	—	3.0 ± 1.0
Pick up ($n=9$)	71.1 ± 30.2	—	—	—	—	3.0 ± 0.9
p-Value	0.184	—	—	—	—	0.184
OR time						
<30 minutes ($n=27$)	—	72.2 ± 44.6	3.3 ± 1.1	1.6 ± 1.0	1.0 ± 0.7	2.9 ± 0.9
30–60 minutes ($n=105$)	—	65.3 ± 49.9	3.2 ± 1.1	1.8 ± 1.2	0.8 ± 0.7	3.0 ± 1.0
>60 minutes ($n=186$)	—	56.7 ± 49.5	3.3 ± 1.0	1.8 ± 0.8	1.0 ± 0.7	2.9 ± 0.7
p-Value	—	0.215	0.99	0.668	0.041	0.499
Exit strategy						
Ureteral catheter ($n=112$)	—	51.8 ± 47.9	3.1 ± 1.0	1.6 ± 1.1	0.9 ± 0.7	2.9 ± 0.8
Double-J stent ($n=112$)	—	57.6 ± 41.0	3.3 ± 1.1	2.0 ± 1.1	0.9 ± 0.6	2.9 ± 0.6
Nephrostomy ($n=94$)	—	83.0 ± 54.7	3.4 ± 0.9	1.7 ± 0.9	0.9 ± 0.8	3.0 ± 1.1
p-Value	—	0	0.215	0.016	0.799	0.66
Comorbidities						
Nil ($n=245$)	—	—	—	—	0.9 ± 0.7	3.0 ± 0.9
DM ($n=24$)	—	—	—	—	1.1 ± 0.6	3.0 ± 0.5
HT ($n=26$)	—	—	—	—	0.9 ± 0.7	2.8 ± 0.6
DM + HT ($n=16$)	—	—	—	—	0.9 ± 0.7	2.9 ± 0.3
Hypothyroid ($n=3$)	—	—	—	—	1.1 ± 0.9	3.7 ± 1.2
IHD ($n=4$)	—	—	—	—	0.6 ± 1.0	2.3 ± 0.5
p-Value					0.67	0.33

OR time = operative time; VAS = visual analogue pain score.

in patients with nephrostomy drainage, and it is maximum in patients with the Double-J stent drainage group.

Forty-three out of 112 patients who had Double-J stent as exit strategy had significant Double-J stent-related symptoms.

The exit strategy did not significantly affect hemoglobin drop or hospital stay.

The presence of comorbidities did not affect hemoglobin drop or hospital stay.

Discussion

Miniperc is associated with a similar clearance rate as the standard PCNL, but is associated with decreased hemoglobin drop, hospital stay, analgesic requirement, and complication rates.[3–6] However, these studies have compared miniperc with standard PCNL for < 2 cm size renal stones. In our study, we have also treated 32 patients with more than 2 cm size stones.

The stone-free status following PCNL in the solitary functioning kidney and bilaterally functioning kidney is 65.4% and 76.1%, respectively, as per the Clinical Research Office of the Endourological Society (CROES) data.[7] The overall stone-free status after PCNL was 75.7% as per the CROES data.[8] It was 82.5% overall in high volume in the PCNL center.[9] In our center, the stone-free rate of PCNL done for staghorn stone ranges from 81% to 93%.[10] It was 86% in complex caliceal and staghorn calculi in children less than 5 years in our center.[11] The stone size treated in this study was 15.26 ± 6.35 cm in size

and stones were less complex than in the above studies done at our center. The stone-free rate at our center after standard PCNL for stone size of 1.49 ± 0.6 mm is 100%.[6] Results of stone-free status of 98.74% in our study of miniperc are consistent with previously published literature from our center. Rest of the patients required second-stage conventional PCNL for complete clearance. This suggests that the stone-free status of miniperc is at least comparable to standard PCNL.

As per the CROES data, Clavien–Dindo complication[8,12] grades with PCNL were as follows: No complication (79.5%), I (11.1%), II (5.3%), IIIa (2.3%), IIIb (1.3%), IVa (0.3%), IVb (0.2%), and V (0.03%) patients. In our miniperc series, had no complications in 95.28% patients. Clavien–Dindo level 1 complications occurred in 4.4% patients and level 2 complications in 0.31% patients. This suggests that miniperc has lesser complication risk than standard PCNL.

Large renal calculi and staghorn stones often require the multiple tract approach for complete clearance of stone with rigid nephroscope or may require the use of flexible nephroscope. In standard PCNL, multiple tract or single tract with flexible nephroscopy for these complex renal stones did not have significantly different hemoglobin drop or hospital stay.[13,14] In our study, we used the multiple tract approach in 13 cases of miniperc. There was no significant difference in hemoglobin drop or hospital stay in patients who required single tract miniperc or multiple tract miniperc.

Coming to the issue of stone size, we treated 58 patients with size less than 1 cm, 228 patients with size 1 to 2 cm, and 32 patients with size more than 2 cm with miniperc. There was no significant increase in hemoglobin drop, VAS at 48 hours and hospital stay between minipercs for these increasing sizes of stones.

These findings suggest that larger size stones can be safely treated by miniperc and multiple miniperc tract approach may also be safe as and when necessary. The multiminiperc approach has been used and found suitable for management of staghorn stones, which require multiple tracts in children[11] as well as adults.[15]

The miniaturization of PCNL tract is associated with lesser complications and bleeding.[4–6] In our study of miniperc, the tract size of 15/18F, 16.5/19.5F, and 20F did not affect the hemoglobin drop, analgesic requirement, VAS score at 6 hours and 48 hours, and hospital stay. So, the different miniperc systems by different manufacturers analyzed in this study may not transform into clinically different outcomes. In other words, different miniperc systems by different manufacturers analyzed in this study are equally good.

Coming to the issue of hardness of stones and energy sources used, the Hounsfield units of the stone are predictors of the hardness of stone. The outcome of shock wave lithotripsy (SWL) is dependent on the Hounsfield units of the stone.[16] Lesser the Hounsfield units, the softer the stone and more amenable to the treatment by SWL. The Holmium laser and pneumatic lithotripters are capable of fragmenting the calculi of all densities efficiently.[17] In our study, the Hounsfield units of stone did not affect operative time, hemoglobin drop, postoperative VAS scores, analgesic requirement, or hospital stay of miniperc. The use of laser or lithoclast in our study did not significantly affect the total operative time or hospital stay in Miniperc.

In standard PCNL, as the operative time increased the hemoglobin drop also increased.[18] In miniperc also, as the operative time increased the hemoglobin drop significantly increased.[11] In our study, also prolonged operative time was associated with increased hemoglobin drop. The prolonged operative time is required for larger and complex staghorn stones. So, it is advisable to stage the procedure if prolonged operative time is necessary. Larger and staghorn stones also need multitract PCNL. As multiminiperc is a safe option, it does not lead to increase hemoglobin drop. So, timed staged multiminiperc is the approach suitable for treatment of larger stones. This finding is consistent with findings in an earlier publication advising timed staged multiminiperc for complex stones in children.[11]

To place nephrostomy or not, has always been the discussed and never settled issue. The absolute indications for keeping the nephrostomy tube after PCNL or miniperc are perforation, bleeding, and incomplete clearance, which would require secondary procedure, prolonged operative time, and severe infection.[12,19,20] Exit strategy as a tubeless procedure is more likely after miniperc[6] compared to standard PCNL. Generally, an impacted stone or perforation, bleeding, and prolonged operative time are indications of putting Double-J stent with nephrostomy and not ureteral catheter only.

In our study, only 92 (28.93%) patients had a nephrostomy tube placed as exit strategy. Patients with nephrostomy had more analgesic requirements than tubeless procedures. In the tubeless procedures, the analgesic requirement in the ureteral catheter drainage group was less than the Double-J stent drainage group. Overall, the placement of nephrostomy was the cause of pain and placement of Double-J caused more analgesic requirement compared to only the ureteral catheter. The ideal exit scenario would be one where there is no intraoperative need of placing nephrostomy and the PCNL is exited with tubeless and ureteral catheter only drainage. As miniperc leads to more chances for tubeless procedures compared to standard PCNL, it leads to less analgesic requirements compared to standard PCNL.

The VAS at 6 hours was not significantly different for different exit strategies.

The ureteral catheters and nephrostomy were removed on the morning after procedure; hence, at 48 hours after the procedure the nephrostomy and ureteral catheters were already removed, whereas the Double-J stent was removed 2 weeks after the procedure. Double-J stenting causes more VAS at 48 hours as it causes Double-J-related symptoms.

However, the exit strategy did not significantly affect hemoglobin drop related to surgery or hospital stay.

The miniperc is associated with lesser hospital stay compared to standard PCNL.[5,6]The hospital stay in standard PCNL was 4.8 to 6.9 days.[5] The hospital stay of standard PCNL for 14.9 ± 0.6 size stone in our center was 4.8 ± 0.6 days.[6] In our study, the hospital stay in miniperc was only 2.8 ± 1 day for 15.26 ± 6.35 mm stones. The size of the stone does not affect the hospital stay in miniperc.

The presence of comorbidities did not affect hemoglobin drop or hospital stay, so the presence of comorbidities was not a confounding factor in these outcomes.

We acknowledge that the limitations of these results are based on retrospective data; there may be surgeon bias in selection of energy sources, miniperc system, or exit strategy. The stone-free status was accessed with ultrasound kidney, ureter, and bladder and X-ray kidney, ureter, and bladder

instead of nonenhanced CT kidney, ureter, and bladder. However, based on these results, further large, multicentric, prospective randomized miniperc trials against standard PCNL for larger stones can evaluate the present role of miniperc in comparison to standard PCNL.

Conclusions

Our results of this study suggest that miniperc quickens the recovery after PCNL with lesser hemoglobin drop, more probability of tubeless procedures, less analgesic requirement, and lesser hospital stay. Even larger stones, >2 cm size, can be safely treated with miniperc with outcomes similar to outcomes of standard PCNL in published literature. These results need to be further validated by a prospective randomized trial of miniperc against standard PCNL for larger renal stones. Hounsfield units of stone do not affect the miniperc outcome. Both laser and pneumatic lithoclast are equally effective energy sources in miniperc. Different miniperc systems by different manufacturers evaluated in this study are equally effective. Miniperc has ushered in a paradigm shift as regard the exit strategy after PCNL. Majority of cases can be tackled with a tubeless approach, which leads to less analgesic requirements. In carefully selected patients, the best exit strategy would be a tubeless procedure with ureteral catheter drainage.

Disclosure Statement

No competing financial interests exist.

References

1. Fernstrom I, Johanson B. Percutaneous pyelolithotomy: A new extraction technique. Scand J Urol Nephrol 1976;10:257.
2. Turk C, Knoll T, Petric A, et al. EAU guidelines on urolithiasis. Uroweb 2013. Available at www.uroweb.org/gls/pdf/21_Urolithiasis_LRV4.pdf. Accessed on 17 Dec 2013.
3. Sabnis RB, Ganesamoni R, Sarpal R. Miniperc: What is its current status? Curr Opin Urol 2012;22:129–133.
4. Yamaguchi A, SkolarikosA, Buchholz N-P, et al.; on behalf of the Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Study Group. Operating times and bleeding complications in percutaneous nephrolithotomy: a comparison of tract dilation methods in 5537 patients in the Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study. J Endourol 2011;25:933–939.
5. Knoll T, Wezel F, Michel MS, Honeck P, Wendt-Nordahl G. Do patients benefit from miniaturized tubeless percutaneous nephrolithotomy? A comparative prospective study. J Endourol 2010;24:1075–1079.
6. Mishra S, Sharma R, Garg C, Kurien A, Sabnis R, Desai M. Prospective comparative study of miniperc and standard PNL for treatment of 1 to 2 cm size renal stone. BJU Int 2011;108:896–899.
7. Bucuras V, Gopalakrishnan G, Wolf JS, Jr., Sun Y, Bianchi G, Erdogru T, de la Rosette J; on behalf of the CROES PCNL Study Group. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: Nephrolithotomy in 189 patients with solitary kidneys. J Endourol 2012;336–341.
8. de la Rosette J, Assimos D, Desai M, Gutierrez J, Lingeman J, Scarpa R, Tefekli A. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: Indications, complications, and outcomes in 5803 patients. J Endourol 2011;11–17.
9. Opondo D, Tefekli A, Esen T, Labate G, Sangam K, De Lisa A, Shah H, de la Rosette J; CROES PCNL study group. Impact of case volumes on the outcomes of percutaneous nephrolithotomy. Eur Urol 2012;62:1181–1187.
10. Desai M, Jain P, Ganpule A, Sabnis R, Patel S, Shrivastav P. Developments in technique and technology: The effect on the results of percutaneous nephrolithotomy for staghorn calculi. BJU Int 2009;104:542–548.
11. Manohar T, Ganpule AP, Shrivastav P, Desai M. Percutaneous nephrolithotomy for complex calyceal calculi and staghorn stones in children less than 5 years of age. J Endourol 2006;20:547–551.
12. Shin TS, Cho HJ, Hong S-H, et al. Complications of percutaneous nephrolithotomy classified by the modified clavien grading system: A single center's experience over 16 years. Korean J Urol 2011;52:769–775.
13. Ganpule AP, Mishra S, Desai MR. Multiperc versus single perc with flexible instrumentation for staghorn calculi. J Endourol 2009;23:1675–1678.
14. Hegarty NJ, Desai MM. Percutaneous nephrolithotomy requiring multiple tracts: Comparison of morbidity with single-tract procedures. J Endourol 2006;20:753–760.
15. Li X, He Z, Wu K, et al. Chinese minimally invasive percutaneous nephrolithotomy: The Guangzhou experience. J Endourol 2009;23:1693–1697.
16. Tarawneh E, Awad Z, Hani A, Haroun AA, Hadidy A, Mahafza W, Samarah O. Factors affecting urinary calculi treatment by extracorporeal shock wave lithotripsy. Saudi J Kidney Dis Transpl 2010;21:660–665.
17. Ganesamoni R, Sabnis RB, Mishra S, Parekh N, Ganpule A, Vyas JB, Jagtap J, Desai M. Prospective randomized controlled trial comparing laser lithotripsy with pneumatic lithotripsy in miniperc for renal calculi. J Endourol 2013;27:1444–1449.
18. Kukreja R, Desai M, Patel S, Bapat S, Desai M. Factors affecting blood loss during percutaneous nephrolithotomy: Prospective study. J Endourol 2004;18:715–722.
19. Agarwal M, Agarwal M. Tubeless percutaneous nephrolithotomy, Indian J Urol 2010;26:16–24.
20. Aghamir SMK, Salavati A, Aloosh M, Farahmand H, Meysamie A, Pourmand G. Feasibility of totally tubeless percutaneous nephrolithotomy under the age of 14 years: A randomized clinical trial. J Endourol 2012;26:621–624.

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Abbreviations Used

CROES = Clinical Research Office of the Endourological Society
OR time = operative time
PCNL = percutaneous nephrolithotomy
VAS = visual analogue pain score