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INVITED REVIEW

“Microperc” micropercutaneous nephrolithotomy: a review of the literature

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Abstract

Recent years have seen innovations in working armamentarium of percutaneous nephrolithotomy (PCNL) leading to development of novel modifications such as miniperc, ultra miniperc, and microperc. Amongst these microperc appears to be least invasive and various authors, off late, have reported their experience with the technique. Literature on microperc was reviewed by a MEDLINE/PubMed search with articles in the English language since 2011 in published peer-reviewed journals. Articles comprised of case series, comparative, and noncomparative studies. Different facets encompassing the technique were analyzed including contemporary indications, technique and its modifications, outcomes, and comparison with other modalities. Technique is reported to be associated with high success rate (82–100%) and short hospital stay (1–2 days). Studies have reported minimal hemoglobin drop (0.1–1.4 gm%) and fewer complications of lower Clavien grades. Going small in PCNL has gone a long way to present day 4.85F puncture system. Utilization of this novel modification is on rise with larger case series and comparative analysis being reported in past 2 years. Technique boasts of high clearance rate, lower morbidity and short hospital stay. In the present era, this innovation in percutaneous stone management appears to be another milestone in quest for “knife to cannula to needle to nothing”.

Keywords Miniperc · Microperc · PCNL

Abbreviations

MeSH	Medical subject headings
PCNL	Percutaneous nephrolithotomy
SWL	Shockwave lithotripsy
Ho-YAG	Holmium-yttrium aluminum garnet
RIRS	Retrograde intrarenal surgery

Introduction

PCNL has come a long way to establish its current status of gold standard treatment modality for large burden renal calculi. With its minimally invasive nature, highest clearance rates, and infrequent requirement of ancillary procedures, it is superior to its counterparts such as SWL, Flexible Ureteroscopy, and Open approaches, so far as larger sized calculi are concerned. However, this may be associated with complications such as bleeding, visceral injury, fever, sepsis, and so forth. With passage of time and experience, evidence accumulated that these complications were associated primarily with access and tract size. This was followed by development of miniaturized sheaths, scopes, working instruments, and utilization of laser fibers as the energy source. This bundled armamentarium paved way for the development of novel modifications of standard PCNL (> 20 F) such as miniperc (12–20 F), ultraminiperc (11–13 F), and microperc (16 G). However, of the various modifications introduced so far, microperc is the one which appears to be the least invasive. Different authors off late have utilized these and have come up with their experience.

Methodology

Herein, we have reviewed the literature of microperc—a novel miniaturized version of the standard PCNL technique. The literature on microperc was reviewed by a MEDLINE/PubMed search with articles in the English language since 2011 in published peer-reviewed journals, with MeSH and keywords being—micropcnl, microperc, and micropercutaneous nephrolithotomy. Different facets encompassing

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the technique were analyzed including contemporary indications, technique and its modifications, outcomes (clearance, Clavien complications and conversions), comparison with other modalities, and, finally, the future considerations. The articles included comprised of case series, comparative (randomized/nonrandomized), and noncomparative studies.

Indications [1, 2]

Although microperc is in its burgeoning phase, its earlier application [3] to solitary < 1.5 cm and lower calyceal calculi seems to have extended to even moderate sized ≤ 3 cm [4], especially with the utilization of the 8F sheath if deemed necessary. Calculi in diverticula, those associated with infundibular stenosis, urinary diversions such as conduits, and even ectopic kidneys [5] are being increasingly dealt with successfully. Being one of the least traumatic modifications of PCNL, it also appears to be an attractive option for the management of pediatric urolithiasis [6–8].

The technique of microperc

Microperc is a recently introduced minimally invasive form of standard PCNL that provides safe and single-step percutaneous renal access, stone disintegration with Holmium: Yttrium-Aluminum-Garnet (YAG) laser, and clearance of stone debris with its own irrigation system [9, 10].

Though the technique is usually performed under general anesthesia, Karatag et al. [11] have reported successful outcomes under spinal anesthesia, as well. After induction as in standard PCNL, the patient is first placed in dorsal lithotomy followed by placement of 5–7 F open end ureteric catheter. Following this, the patient is switched over to the prone position, although Caione et al. [12] have successfully performed the procedure in Valdivia-Modified Position. The puncture could be done either using the direct visual guidance of the "all-seeing needle" or under image guidance. In the latter instance, the assistant retrogradely distends the pelvicalyceal system with saline if ultrasound-guided puncture is to be done, or conversely with contrast, if resorting to a fluoroscopy-guided puncture. Regardless of the imaging modality utilized, access to the collecting system is made by a single-step puncture performed with the 16 G micro perc needle directly steering it into the stone containing calyx. However, in a situation where the stone happens to be in the pelvis, a mid-posterior or a lower calyceal puncture is viable pathways to reach the same. After confirmation of proper puncture, a three-way adapter is connected to the hub. The latter serves as the inlet for—the holmium: yttrium-aluminum-garnet laser fiber (200/272 μ), saline irrigation, and 0.9 mm flexible telescope. Ureteric catheter drainage, both passive and active (intermittent aspiration by the assistant), helps to keep the pelvicalyceal pressure low. The task of disintegration is accomplished using Ho-YAG laser, with the energy settings suited for dusting rather than fragmenting usually 0.8 J at 8 Hz (6.4 W). This circumvents the need for larger tract required for fragment retrieval. After successful stone lysis, the ureteric catheter is left in situ, tied to the per urethral Foleys catheter, and removed the next morning along with the latter.

Modifications

Mini microperc is a technical modification [3, 6], where an outer sheath of size 8 Fr/10 Fr is placed to allow for more stability during intrarenal manipulations. While the standard Microperc needle admits only the Laser fiber, the minimicroperc sheath can admit other miniaturized accessories such as 1.6 mm Ultrasonic Lithotripter (which helps with faster fragmentation and extracting of fragments) as well as fine forceps (size 3 Fr). Another modification was described by Penbegul et al. [13] whereby a 14 G (6.6 Fr) *Angiocath* could be used in a manner similar to an amplatz sheath in pre-school children.

Outcomes (Table 1)

Miniaturization of instruments, puncture needles, sheaths, and energy sources have led to decreased complication rates and morbidity associated with the procedure, while at the same time keeping up with the success rates involved. The concept has evolved over a period of time to miniperc, ultraminiperc and microperc; the driving force being tract size as one of the prime determinants of complications [25]. Although being a refinement of conventional PCNL, Microperc does not require any different facet of learning, as targeting and calyceal access techniques remain the same and whether the puncture is made fluoroscopically or under ultrasound guidance. So any urologist well versed with the conventional technique can readily become acquainted with microperc.

Clearance

The novel all-seeing needle which was introduced by Bader [9, 26] was later implemented in a pioneering study by Desai et al. [10]. In this initial study incorporating 10 patients with mean stone size of 14.3 mm, the authors reported 89% success rate. The feasibility and promising outcome revealed in the study soon paved way for others (Table 1) to utilize this innovative modification. In the existing literature as of now, there are only few studies, most of which, however, are case series or noncomparative studies. The largest of these are

Table 1 "Microperc" review of published literature

Study	Type	Patients/units	Mean age (years)	Stone size	Stone location	Hospital stay	Success rate	Hemoglobin drop (mg/dL)	Complications
Desai et al. [10]	Initial prospective case series	10	43.9 ± 19.0 (9–63)	14.3 ± 6.3 (6–25)	LC-4 P-5 Multiple-1	2.3 ± 1.2 days	88.9%	1.4 ± 1.0	Intraoperative bleeding leading to conversion to Mini PCNL-1
Armagan et al. [4]	Retrospective, noncomparative	30	41.5 ± 18.2 years (range 3–69 years)	17.9 ± 5.0 mm (10–30 mm)	P-4 LC-16 MC-2 UC-1 P + LC-7	35.5 ± 18.6 (14–96) hours	93%	1.1 ± 0.8 (0–2.8)	Overall-13.3% Clavien grade I complication- Renal colic managed with medical treatment 2 Clavien grade IIIa complication Steinstrasse necessitating Double-J placement 2 Clavien grade IIIb complication Extravasation managed by drain placement 1
Tepeler et al. [14]	Retrospective, noncomparative	21	37.3 ± 20.1 (7–69)	17.8 ± 5.9 (9–29) mm	Lower pole	37.5 ± 14.4 h	85.7%	0.8 ± 0.6 (0.1–2.3)	Complications (n, %) 2 (9.5%) Clavien grade II 1 Urinary tract infection Clavien grade IIIa 1 Renal colic necessitating Double-J stent insertion
Silay [7]	Multicenter prospective study in pediatric population	19	7.5 ± 4.4 years	14.8 ± 6.8 mm	P-7 UC = 1 LC = 7 P + LC = 4	1.8 ± 0.8 days	89.5%	0.1 ± 0.3	Post-operative renal colic = 2 Intravasation requiring drain placement = 1
Piskin [15]	Consecutive case series	9	20.8 (3–47) years	12.8 (7–18 mm)	P = 3 UC = 1 MC = 2 LC = 3	1–3 days	85%	NA	Post-operative renal colic-1
Hatipoglu [16]	Multi-center, retrospective, noncomparative study	140 renal units	28.7 ± 20.6 (1–69) years	15.1 ± 5.15 (6–32) mm	P- 23 UC-5 MC-16 LC-62 Multi-calIceal-34	1.76 ± 0.65 (1–4) days	82.14%	0.87 ± 0.84 (0–4.1)	Overall-20 (14.28%) *Clavien grade I* Renal colic-7 *Clavien grade II* Urinary tract infection-3 Blood transfusion-1 *Clavien grade III-a* Renal colic necessitating D-J stent insertion-1 Steinstrasse requiring D-J stent insertion-2 *Clavien grade III-b* Steinstrasse requiring D-J stent insertion (pediatric patients)-3 Extravasation requiring drain placement-3

Table 1 (continued)

Study	Type	Patients/units	Mean age (years)	Stone size	Stone location			Hospital stay	Success rate	Hemoglobin drop (mg/dL)	Complications
Sabnis [17]	Comparative, prospective, randomized study between RIRS and Microperc	Microperc = 35 RIRS = 35	Microperc = 38.6 ± 14.6 RIRS = 43.7 ± 12.1	MICROP-ERC = 1.10 ± 0.23 RIRS = 1.04 ± 0.25	SITE P UC MC LC	MP 14 3 3 15	RIRS 13 2 3 17	MP = 57 ± 22 RIRS = 49 ± 18	MP = 97.1% RIRS = 94.3%	MP = 0.96 ± 0.41 RIRS = 0.56 ± 0.31	CONVERSION TO MINIPERC = 1 each in MP and RIRS *Intraop complication* Clavien grade 2-pelvic perforation = 1 in MP *POST OP Complication* Clavien grade 1 Mild hematuria-5 in MP Fever 3 in MP 4 in RIRS
Fata [18]	Comparative, prospective, nonrandomized study between RIRS and microperc	Microperc = 8 RIRS = 12	MP-53.5 (45.7–58.2) RIRS-51 (41.7–67)	1-3cm	 P LC	MP 4 4	RIRS 5 7	RIRS = 1 day Microperc = 1.5 days	RIRS-91.7% MP-87.5%	N.A	RIRS Clavien I (fever) 1 MP Clavien I (colic) 1
Hatipoglu [19]	Comparative, retrospective, study between ESWL and microperc	Microperc = 37 ESWL = 108	1–15 years	11.32 ± 2.84 (5–20) mm in the SWL group 14.78 ± 5.39 (6–32) mm in the microperc group (P < 0.001)	Location P UC Mid lower	ESWL 50 9 20 29	MP 10 2 4 21	ESWL = 8.4 ± 2.3 (6–10) Micro perc 49.2 ± 12.3 (16–64) P < 0.001	ESWL = 88% Microperc = 89.2%	Microperc = 0.9–0.4 (0.1–2.5)	Overall Microperc = 21.6% ESWL = 16.7% Clavien grade I (renal colic) Eswl-7 Microperc-4 Clavien grade IIIb Steinstrasse necessitating stent insertion ESWL = 11 Microperc = 1 Extravasation necessitating drain placement Microperc-3
Armagan [20]	Comparative, retrospective, study between microperc and flexible ureterorenoscopy	F-URS (n = 59) and microperc (n = 68)	f-urs = 49.3 ± 15.3 Microperc = 43.6 ± 18.9	F-URS = 14.4 ± 3.1 Microperc= 13.7 ± 4.2	Lower calyx			F-URS = 23.0 ± 58.1 h Microperc = 33.8 ± 17.2 h	F-URS = 44/59 (74.5) Microperc = 60/68 (88.2)	F-URS = 0.68 ± 0.51 Microperc = 1.29 ± 0.88s	Intractable renal colic (Clavien grade IIIa) F-URS = 6 Microprc = 1 Acute pyelonephritis (Clavien grade I) F-URS = 2 Microperc = 1
Karatag [21]	Retrospective, noncomparative, single-center experience	68 patients (70 renal units)	41.4 ± 18.8	122 ± 83 mm^2	Pelvis 19 Lower calyx 27 Middle calyx 9 Upper calyx 4			27.5 ± 12.4 (15–60) hours	95.7% (67/70)	0.95 ± 0.7 (0.1–1.5)	Urinary tract infection (Clavien I)-1 Renal colic requiring D-J stent insertion (Clavien III)-3

Table 1 (continued)

Study	Type	Patients/units	Mean age (years)	Stone size	Stone location	Hospital stay	Success rate	Hemoglobin drop (mg/dL)	Complications
Ganpule [22]	Retrospective, noncomparative, single-center experience	139	38.99 ± 17	1095 ± 1035 mm^3	Upper ureter 7 Pelvic 47 Upper calyx 11 Middle calyx 9 Lower calyx 57 Multiple locations 8 Multiple stones 16	2.36 ± 0.85 days	91.53%	0.63 ± 0.84 (0–3.7)	*Overall* n = 15 (11.53%) Clavien grade I Renal colic-8 Clavien grade II Urinary tract infection-3 Clavien grade III-a Renal colic necessitating D-J stent insertion-4
Karatag [23]	Retrospective, comparative, multicenter experience (microperc v/s miniperc)	Total = 119 Microperc = 56 Miniperc = 63	Microperc = 7.63 ± 5.04 years Miniperc = 9.32 ± 4.98 years	Microperc = 13.4 ± 3.4 mm Miniperc = 14.8 ± 3.7 mm	(Micro / Mini) Lower 28 / 6 Middle 2 / 4 Upper + middle – / 1 Pelvic 17 / 15 Pelvic + middle 2 / 2 Pelvic + lower 7 / 35	Microperc 43.0 ± 15.4 Miniperc 68.5 ± 31.7 (hours)	Microperc 92.8% miniperc 93.6%	Microperc 1.10 ± 1.90 Miniperc 1.85 ± 1.39	Microperc Renal colic requiring D-J stent insertion (Clavien grade III)-2 Extravasation requiring drainage (Clavien grade III)-1 Miniperc Fever (Clavien grade I)-1 Urinary tract infection (Clavien grade II)-1 Hemorrhage (Clavien grade II)-5 Renal colic requiring D-J stent insertion (Clavien grade III)-1
Tok et al. [24]	Retrospective, comparative, multicenter experience (microperc v/s miniperc)	Total = 98 Microperc = 58 Miniperc = 40	Microperc = 45.90 ± 14.44 Miniperc = 43.08 ± 12.31	Microperc = 13.97 ± 3.62 Miniperc = 16.13 ± 6.97	Lower calyceal	Microperc = 1.55 ± 0.95 Miniperc = 2.63 ± 1.31	Microperc = 86.2% Miniperc = 82.5%	Microperc = 1.96 ± 1.73 Miniperc = 3.98 ± 2.44	(Micro / Mini) Urinary tract infection (Clavien II): 2 / 3 Renal colic requiring D-J stent insertion (Clavien IIIa): 1 / 0

PCNL percutaneous nephrolithotomy, *MP* Microperc, *RIRS* retrograde intrarenal surgery, *F-URS* flexible ureterorenoscopy, *P* pelvis, *LC* lower calyx, *MC* middle calyx, *UC* upper calyx, *SFR* stone-free rate the ones by Ganpule et al. [22] and by Hatipoglu et al. [16]. The technique boasts of a high success rate range from 82% in larger series to 100% in the smaller ones.

Hospital stay

Study by Akman et al. [27] has shown percutaneous procedures performed without a tube as an exit strategy as being associated with decreased hospital stay. As microperc utilizes the same principle of being "tubeless", it is not surprising to find the hospital stay in most of these studies as being 1–2 days (Table 1).

Complications

Tract dilatation being a *single-step* maneuver in this technique obviates the need of multiple "in and out", the latter being associated with increased incidence of complications such as bleeding, and fluoroscopy exposure. The small needle size 4.85 F is another facet contributing to the same. Indeed, the current literature shows minimal drop in hemoglobin values (0.1–1.4 gm%) and fewer complications of lower Clavien grades (Table 1), including renal colic, fever, urinary tract infection, and occasionally extravasation and the need for double-J stenting. Renal colic and steinstrasse though variably reported are more frequent accompaniments of larger stone burdens. As the procedure is based on lysing the stone with holmium laser and clearance of the small debris with irrigation, at the end, there may be small fragments that may pass and lead to colicky episodes or even steinstrasse. In majority, the colic responds to analgesics, but if not, stent placement is usually required. Hatipoglu et al. [16], in their series, have even routinely stented patients with > 2 cm in the preoperative period. It seems plausible that energy settings performing "dusting", that is high frequency and low energy might bring down the incidence of these complications.

Conversion

The size of the needle being 4.85 F mandates meticulous handling and, at the same time, difficulty in negotiating different calyces if stone fragments scatter. Likewise, the vision may become obscure if bleeding occurs as a result of the small irrigation channel. This can however be managed by converting to miniperc or minimicroperc [3]. The latter utilizes a 8 F metallic sheath to which can be attached the same three-way connector with accessories as in standard microperc. An added advantage in this scenario is the option of using a 1.6 mm ultrasonic lithotripter, for fragmenting and sucking out the fragments. Conversion to miniperc has been quoted in the studies by Armagan et al. [4], Desai et al. [10], Tepeler et al. [14], and Piskin et al. [15]. This was required either on account of difficulty in maneuvering from one calyx to another or because of impaired visibility as a result of bleeding. As to whether the presence of hydronephrosis affects the outcome, Karatag et al. [28] did not find the same to affect the success rate and operative time.

Comparison with other techniques

Although presently being utilized for small-to-moderate stone burden, the very indication that eclipses with SWL, it is worthy to note that microperc utilizes the principle of precise stone localization, direct visualization, and laser mediated lysis, all transforming into high success rates with decreased need of ancillary procedures. Hatipoglu et al. [19] performed a comparative, retrospective, study between SWL and microperc in pediatric population, and found lower retreatment rates for microperc.

Another modality with which microperc is nowadays being compared with is RIRS. In a comparative study by Sabnis et al. [17] for mean stone size 1.1 cm, the authors found similar clearance and complication rates, but the former to be associated with more hemoglobin drop and analgesic requirement and increased requirement for placement of stent in RIRS group. Another comparative prospective study by Fata et al. [13] showed comparable success rates with the two modalities, albeit with requirement of ancillary procedures in both treatment arms. Similarly, Armagan et al. [20] in a retrospective comparative clinical study of microperc vs flexible ureterorenoscopy in treatment of moderate-size (< 2 cm) lower pole stones. The authors found microperc to be safe and efficacious, which was associated with significantly higher stone-free rate.

Karatag et al. [21] reported a multi-institutional retrospective comparative study of microperc ($n = 56$) and miniperc ($n = 63$) in pediatric patients with stone size 10–20 mm. The authors reported similar stone-free rates in both the groups (92.8 vs 93.6%; $P = 0.0673$) at first-month follow-up. However, there was significant difference in mean hemoglobin drop (more in miniperc group) and a significant difference in average hospitalization times 43.0 ± 15.4 vs 68.5 ± 31.7 h ($P < 0.001$), in microperc and miniperc groups, respectively. However, the authors found no statistically significant difference with regard to the overall complication rates ($P = 0.159$). A total of three complications (5.3%) were observed in the microperc group, including saline extravasation ($n = 1$) requiring percutaneous abdominal drainage (Clavien grade IIIb) and persistent renal colic ($n = 2$) requiring stent insertion in the microperc group (Clavien grade IIIb). Overall complication rate reported was 12.6% in the miniperc group, with hemorrhage requiring blood transfusion in five patients and one patient each requiring ureterorenoscopy and double-J stenting (Clavien grade IIIb), medical therapy for pyrexia (Clavien grade I), and antibiotic for urinary tract infection postoperatively (Clavien grade II). The authors concluded that microperc may be preferred as an alternative to miniperc for the treatment of pediatric kidney stones of sizes 10–20 mm with comparable success and complication rates, as well as shorter hospitalization and fluoroscopy times.

In another comparative study between microperc ($n = 58$) and miniperc ($n = 40$) for the treatment of lower pole stones of 10–20 mm, Tok et al. [24] reported similar (86.2 vs 82.5%, $p = 0.66$) stone-free rates and overall complication rates. However, mean hematocrit drop was significantly higher in miniperc group compared to microperc (3.98 vs 1.96%; $p < 0.001$), as was the duration of hospitalization (2.63 vs 1.55 days; $p < 0.01$). On the contrary, a tubeless exit strategy was quoted as being significantly higher in the microperc group ($p < 0.001$). The authors concluded microperc to be preferable as it was associated with lower blood loss, reduced fluoroscopy and hospitalization time, and a higher tubeless rate.

Conclusions

Going small in PCNL has gone a long way to the present day 4.85 F puncture system. The utilization of this novel modification is on the rise, with larger case series and comparative analysis being reported in the past 2 years. Although the microperc appears to be a promising modification that can be utilized in varied scenarios associated with renal calculi, the importance of the basic principle of percutaneous nephrolithotomy—'a perfect puncture', cannot be overemphasized [29]. The technique boasts a high clearance rate and lower morbidity and a shorter hospital stay. The *future* would probably see further refinements in energy sources and means of fragment extraction with respect to the technique. In present era, however, this innovation in percutaneous stone management appears to be another milestone in the quest for "knife to cannula to needle to nothing" [30].

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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