'Mini, ultra, micro' – nomenclature and cost of these new minimally invasive percutaneous nephrolithotomy (PCNL) techniques

Ther Adv Urol
2016, Vol. 8(2) 142–146
DOI: 10.1177/1756287215617674

Anna Wright, Nick Rukin, Daron Smith, Jean De la Rosette and Bhaskar K. Somani

***Abstract*:** New minimally invasive percutaneous nephrolithotomy (PCNL) techniques have changed the management of renal stones. We discuss the technological advances in PCNL and explain the meaning, requirements and set up costs for each of these 'newer' techniques.

Keywords: PCNL, micro, mini, ultramini, minimally invasive, cost, percutaneous, urolithiasis, calculi

Introduction

Percutaneous nephrolithotomy (PCNL) was first described by Fernström and Johansson in 1976 [Fernström and Johansson, 1976] and remains the first-line treatment option for large (>20 mm) renal calculi [Turk *et al.* 2014]. Since its inception, a number of technological developments have improved both the safety and efficacy of the procedure. Three-dimensional computed tomographical (CT) reconstructions have been used to improve planning for the surgical approach [Patel *et al.* 2009], a variety of energy sources are available for stone fragmentation [Lowe and Knudsen, 2009], and postoperatively there has been a trend away from the traditional practice of leaving a wide bore nephrostomy tube towards 'totally tubeless PCNL' [Istanbulluoglu *et al.* 2009]. Patient positioning has become increasingly topical, with emerging evidence to suggest supine PCNL may provide easier anaesthesia and improved patient safety [Valdivia *et al.* 2011].

Despite these advances, and its 'minimally invasive' status, PCNL remains a procedure with the potential for morbidity; consistently demonstrated in the complication rates reported by the British Association of Urological Surgeons (BAUS) PCNL data registry and the Clinical Research Office of the Endourological Society (CROES) worldwide PCNL data complications [Armitage *et al.* 2012; de la Rosette *et al.* 2011]. Complications include postoperative sepsis (2%), fever (10–16%), blood transfusion (3–6%) and significant bleeding (8%) [Valdivia *et al.* 2011; Armitage *et al.* 2012].

In recent years, further technological modifications have led to miniaturization of instruments, with much smaller access sheaths becoming available. Standard PCNL access tracts are 24–30F; with smaller access sheaths (<18Fr) initially developed for paediatric use. These are now becoming increasingly used in adult patients with the advent of 'mini-perc', 'ultra-mini perc' and 'micro-perc' procedures. The initial results are promising with good stone free rates (SFR), reduced risk of bleeding, decreased length of stay and improved analgesia requirements [Mishra *et al.* 2011].

The introduction of these miniaturized instruments has undoubtedly expanded the role of PCNL. The variation in techniques and equipment has made it somewhat challenging for urologists, theatre teams and patients to understand what is now meant by 'PCNL'. Indeed, it has recently been suggested that PCNL should be subclassified to take into account the positioning, sheath size, fragmentation method and postoperative drainage [Wright *et al.* 2014]. This would hopefully aid universal understanding of current practice and future PCNL technique.

Despite the expanding use of 'mini', 'ultra' and 'micro' PCNL in the literature, the terms remain poorly defined, with many studies using

Correspondence to:
Bhaskar K. Somani, FRCS (Urol)
Department of Urology, University Hospital Southampton NHS Trust, Tremona Road, Southampton, SO16 6YD, UK
bhaskarsomani@yahoo.com

Anna Wright, MRCS
Nick Rukin, FRCS (Urol)
Department of Urology, The Royal Wolverhampton Hospital NHS Trust, UK

Daron Smith, FRCS (Urol)
Department of Urology, University College London, UK

Jean De La Rosette, PhD
Department of Urology, AMC University Hospital, The Netherlands

Table 1. Summary of PCNL techniques available.

Terminology	Access sheath (Fr)	Manufacturer	Equipment		Cost* (£)	Cost* (€)	Cost* ($)
Mini	14–20	Cook Medical Stuart Wolf Karl Storz	Reusable	12Fr scope, dilator, amplatz sheath	£8000	€11,350	$12,500
Ultra-mini	11–13	LUT	Reusable	3Fr scope, dilator, amplatz sheath	£8800	€12,480	$13,750
Micro	4.85	PolyDiagnost	Reusable	Standard setup (modular fix-focus, optic modular PCNL, joint arm, steritray light cable)	£8679 plus £375 per case	€12,310 plus €530 per case	$13,550 plus $585 per case
			Disposables	Microperc set (parts for puncture, working shafts, with dilator)			

*Prices are estimates only based on nondiscount quotes from manufacturers.
PCNL, percutaneous nephrolithotomy.

overlapping terminology for the same size sheath. We aim to standardize the nomenclature as suggested in Table 1, which contains a brief description of each technique, necessary equipment and estimated costs. A comparison of the different techniques, including indications, is given in Table 2. Together we hope these two tables will provide a better understanding of the different techniques now available.

Current PCNL techniques available

Mini PCNL [Jackman et al. *1998a]*

The term 'mini-perc' appears throughout the literature, using access sheath sizes between 11 and 20Fr [Jackman *et al.* 1998a, 1998b; Moonga and Oglevie, 2000]. The first description of the technique was in children in 1998 using an 11Fr Vascular 'peel away' sheath [Jackman *et al.* 1998b]. Later that same year, the first mini PCNL series reported in adults used a 13Fr access, with good stone clearance, and identified the potential advantages of reduced bleeding, pain and length of hospital stay [Jackman *et al.* 1998a]. Another early report, published nearly 15 years ago, was performed with a 20Fr access sheath and reported a 56% decrease in the volume of renal parenchyma that had been dilated, with a concomitant reduction in perioperative bleeding [Moonga and Oglevie, 2000]. In light of the additional terms now being used we suggest 'mini' should be used more specifically in describing access sheaths of size 14–20Fr.

In this procedure, a nephroscope is used in combination with holmium laser or lithoclast for stone disintegration. Fragments are irrigated, suctioned or sequentially removed with grasping devices. More recently, SFR of 82% was achieved in a series of 1368 patients using a 16Fr tract [Hu *et al.* 2015]. Compared with the conventional PCNL (24–30F), bleeding complications were less common (1.4%) with these smaller tracts. Manufacturers of the equipment include Cook, Wolf and Karl Storz with an estimated set up cost of £8000 for the equipment, most of which is reusable.

Ultramini PCNL [Desai et al. *2013]*

Ultramini PCNL, or 'UMP' is a more recent addition to the options for PCNL, and generally refers to an access sheath size of 11–13Fr. A fluoroscopy guided puncture using an 18 gauge needle is initially performed. A guidewire is then inserted, the needle retracted and the 11Fr or 13Fr access sheath is advanced over the guidewire assembled with an obturator. A 6Fr mininephroscope is then used for vision. Given the size of the instruments, the only feasible energy source is a Holmium laser, which is used for stone fragmentation under direct vision. An endoscopic pulsed perfusion pump is used to maintain vision. Stone fragments are flushed out on rapid removal of the endoscope, due to a 'vortex' effect. This technique has been used in calculi <2 cm with reported complication rates of sepsis (6%), urinary extravasation (3%) and fever (8%) [Desai

Table 2. Comparison of standard, mini, ultra-mini and micro PCNL techniques.

PCNL technique	Indication	Stone free rate	Blood transfusion	Limitations	Fragmentation device
Standard PCNL (24–30F)	Large stones – any size (staghorn stones)	High SFR (depending on stone complexity)	3–6%	Increased risk with multiple tracts	Pneumatic or ultrasound or laser
Mini PCNL (14–20F)	Large stones	High SFR (depending on stone complexity)	1–2%	Longer operative time for larger stones (compared with standard PCNL)	Pneumatic or Ultrasound or Laser
Ultra-mini (UMP) PCNL (11–13F)	Stones up to 2 cm	85–92%	Transfusion – not reported	Able to remove small fragments only	Laser
Micro PCNL (4.8F)	Stones up to 1.5 cm	85–90%	Transfusion – not reported	Unable to remove fragments	Laser

PCNL, percutaneous nephrolithotomy; SFR, stone free rates.

et al. 2013]. Manufacturers include LUT (Leben and Technologie), with an estimated cost of £8800 for the equipment. Although the hardware is reusable, single-use laser fibre costs will add to the expense of an individual procedure. In centres where laser fibres are reused, the cost per case will be reduced accordingly, but these have a finite life depending on the energy and stone types that have been previously treated.

Micro PCNL [Desai et al. *2011]*

Micro PCNL was first reported in 2011 using a 4.85Fr 'all seeing needle' in which renal access and laser stone fragmentation are performed in a single step procedure. Under ultrasound or fluoroscopic guidance, selective calyceal puncture is made with the 4.85Fr (16 gauge) needle. The bevelled inner needle is removed and a three-way connector is attached to the proximal end of the sheath. The telescope is passed through the connector side port and the other port is used for irrigation. The connector central port is used to pass the 200 μm laser fibre. Stone clearance relies on adequate vaporization and pressurized irrigation as this technique does not allow any fragment retrieval at all. The smaller needle enabling omission of tract dilatation is proposed to reduce bleeding: in the initially reported feasibility study, the mean haemoglobin drop was 1.4 gm/dl, with no postoperative complications. One in 10 patients had micro PCNL converted to a mini PCNL due to bleeding obscuring the vision [Desai *et al.* 2011]. Mean calculus size was 14.3 mm, with ab SFR of 89%, suggesting this may be a feasible technique in smaller renal calculi (<15 mm). More recently, a larger study of 140 renal units reported similar outcomes, with no postoperative complications and a mean drop in haemoglobin of 0.87 mg/dl. One patient required transfusion, but 9% were converted to mini-perc and the need for residual stones requiring JJ stent insertion was 6% [Hatipoglu *et al.* 2014]. The current manufacturer of the 'all seeing needle' is PolyDiagnost (Pfaffenhofen, Germany). The standard initial investment costs are approximately £8600, with an additional estimated cost of £375 for disposables per case ('all seeing needle' set and working sheath).

Mini-micro PCNL [Sabnis et al. *2013b]*

Mini-microperc is a recent modification of micro PCNL [Sabnis *et al.* 2013b]. As the microperc is such narrow calibre, with a propensity to bend during manipulation and stone treatment, an 8Fr metallic sheath was introduced, which allows passage of an ultrasonic or lithoclast probe with suction. A ureteric catheter drains the pelvicalyceal system continuously. Intermittent manual suction through the ureteric catheter further reduces the intrarenal pressure. This modification theoretically allows easier manipulation of the pelvicalyceal system whilst allowing the insertion of a 1.6 mm lithotripter to aid stone clearance. The mini-microperc sheath allows attachment of the same three-way connector as described for the micro technique.

Discussion

The advent of miniaturized technology has without doubt enhanced and expanded the role of PCNL, with an expansion in reported studies in the recent literature. These techniques offer a particular advantage for difficult to access calculi, impacted lower pole calculi with an acute infundibular angle or stones in a calyceal diverticulum [Weizer *et al.* 2005; Kirac *et al.* 2013]. In the paediatric population, mini PCNL has been found to be a safe and effective alternative to standard techniques [Jackman *et al.* 1998a]. Length of stay is reduced with a faster recovery compared with standard techniques, primarily due to the totally tubeless technique and smaller incision [Akman *et al.* 2011; Hatipoglu *et al.* 2014].

In a randomized trial by Sabnis and colleagues, microperc was found to have comparable outcomes to retrograde intrarenal surgery (RIRS) in terms of length of stay, SFR and complication rates, with a lower requirement for JJ stenting in the microperc group [Sabnis *et al.* 2013a]. The requirement for a percutaneous nephrostomy tube is reduced, allowing a totally tubeless procedure with potential benefits of decreased postoperative pain and length of stay, rapid healing and minimal urine leakage [Akman *et al.* 2011; Wells *et al.* 2015].

The most important factor promoting the use of smaller tracts is reduced bleeding. Indeed, in a study of renal biopsy on anaesthetized pigs, the larger size needle was found to produce a significant increase in intraoperative bleeding [Gazelle *et al.* 1992]. Bleeding during PCNL compromises the operation through loss of vision [Desai *et al.* 2011]; the size of the nephroscope tract, number of tracts and methods of dilatation has been shown to be important factors in determining intraoperative bleeding [Desai *et al.* 2011]. Bleeding rates are consistently low when using smaller tracts, with no requirements for blood transfusion in several studies when using miniperc techniques [Kukreja *et al.* 2004].

With further advances in technology, alongside more universal use of the equipment amongst urologists, there may be an increasing role for these techniques in the future treatment of larger renal calculi. This review does not advocate that smaller PCNL techniques are superior to standard PCNL, or RIRS as the current evidence is limited, particularly for calculi >15 mm. Despite this, the initial results are promising; miniaturized PCNL technology has reliably provided a safe and effective alternative to standard techniques, potentially supporting its more widespread use in the future.

Conclusion

The modified minimally invasive PCNL techniques 'mini, ultra, micro' appear to be safe for treatment of small to medium size stones and offer a new dimension in the treatment of urolithiasis.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest statement

The authors declare no conflicts of interest in preparing this article.

References

Akman, T., Binbay, M., Yuruk, E., Sari, E., Seyrek, M., Kaba, M. *et al.* (2011) Tubeless procedure is most important factor in reducing length of hospitalization after percutaneous nephrolithotomy: results of univariable and multivariable models. *Urology* 77: 299–304.

Armitage, J., Irving, S., Burgess, N. and British Association of Urological Surgeons Section of Endourology (2012) Percutaneous nephrolithotomy in the United Kingdom: results of a prospective data registry. *Eur Urol* 61: 1188–1193.

De la Rosette, J., Assimos, D., Desai, M., Gutierrez, J., Lingeman, J., Scarpa, R. *et al.* (2011) The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: indications, complications, and outcomes in 5803 patients. *J Endourol* 25: 11–17.

Desai, J., Zeng, G., Zhao, Z., Zhong, W., Chen, W. and Wu, W. (2013) A novel technique of ultra-mini-percutaneous nephrolithotomy: introduction and an initial experience for treatment of upper urinary calculi less than 2 cm. *Biomed Res Int* 2013: 1–6.

Desai, M., Sharma, R., Mishra, S., Sabnis, R., Stief, C. and Bader, M. (2011) Single-step percutaneous nephrolithotomy (microperc): the initial clinical report. *J Urol* 186: 140–145.

Fernström, I. and Johansson, B. (1976) Percutaneous pyelolithotomy: a new extraction technique. *Scand J Urol Nephrol* 10: 257–259.

Gazelle, G., Haaga, J. and Rowland, D. (1992) Effect of needle gauge, level of anticoagulation, and target organ on bleeding associated with aspiration biopsy. Work in progress. *Radiology* 183: 509–513.

Hatipoglu, N., Tepeler, A., Buldu, I., Atis, G., Bodakci, M., Sancaktutar, A. *et al.* (2014) Initial experience of micro-percutaneous nephrolithotomy in the treatment of renal calculi in 140 renal units. *Urolithiasis* 42: 159–164.

Hu, G., Guo, Z., Liu, H., Luo, M., Liu, M., Lai, P. *et al.* (2015) A novel minimally invasive percutaneous nephrolithotomy technique: safety and efficacy report. *Scand J Urol* 49(2): 174–180.

Istanbulluoglu, M., Ozturk, B., Gonen, M., Cicek, T. and Ozkardes, H. (2009) Effectiveness of totally tubeless percutaneous nephrolithotomy in selected patients: a prospective randomized study. *Int Urol Nephrol* 41: 541–545.

Jackman, S., Docimo, S., Cadeddu, J., Bishoff, J., Kavoussi, L. and Jarrett, T. (1998a) The 'mini-perc' technique: a less invasive alternative to percutaneous nephrolithotomy. *World J Urol* 16: 371–374.

Jackman, S., Hedican, S., Peters, C. and Docimo, S. (1998b) Percutaneous nephrolithotomy in infants and preschool age children: experience with a new technique. *Urology* 52: 697–701.

Kirac, M., Bozkurt, Ö., Tunc, L., Guneri, C., Unsal, A. and Biri, H. (2013) Comparison of retrograde intrarenal surgery and mini-percutaneous nephrolithotomy in management of lower-pole renal stones with a diameter of smaller than 15 mm. *Urolithiasis* 41: 241–246.

Kukreja, R., Desai, M., Patel, S., Bapat, S. and Desai, M. (2004) Factors affecting blood loss during percutaneous nephrolithotomy: prospective study. *J Endourol* 18: 715–722.

Lowe, G. and Knudsen, B. (2009) Ultrasonic, pneumatic and combination intracorporeal lithotripsy for percutaneous nephrolithotomy. *J Endourol* 23: 1663–1668.

Mishra, S., Sharma, R., Garg, C., Kurien, A., Sabnis, R. and Desai, M. (2011) Prospective comparative study of miniperc and standard PNL for treatment of 1 to 2 cm size renal stone. *BJU Int* 108: 896–899.

Moonga, M. and Oglevie, S. (2000) Minipercutaneous nephrolithotomy. *J Endourol* 14: 419–421.

Patel, U., Walkden, R., Ghani, K. and Anson, K. (2009) Three-dimensional CT pyelography for planning of percutaneous nephrostolithotomy: accuracy of stone measurement, stone depiction and pelvicalyceal reconstruction. *Eur Radiol* 19: 1280–1288.

Sabnis, R., Ganesamoni, R., Doshi, A., Ganpule, A., Jagtap, J. and Desai, M. (2013a) Micropercutaneous nephrolithotomy (microperc) *versus* retrograde intrarenal surgery for the management of small renal calculi: a randomized controlled trial. *BJU Int* 112: 355–361.

Sabnis, R., Ganesamoni, R., Ganpule, A., Mishra, S., Vyas, J., Jagtap, J. *et al.* (2013b) Current role of microperc in the management of small renal calculi. *Indian J Urol* 29: 214–218.

Turk, C., Knoll, T., Petrik, A., Sarica, K., Skolarikos, A., Straub, M. *et al.* (2014) *Guidelines on urolithiasis*. Arnhem, The Netherlands: European Association of Urology.

Valdivia, J., Scarpa, R., Duvdevani, M., Gross, A., Nadler, R., Nutahara, K. *et al.* (2011) Supine *versus* prone position during percutaneous nephrolithotomy: a report from the clinical research office of the endourological society percutaneous nephrolithotomy global study. *J Endourol* 25: 1619–1625.

Weizer, A., Springhart, W., Ekeruo, W., Matlaga, B., Tan, Y., Assimos, D. *et al.* (2005) Ureteroscopic management of renal calculi in anomalous kidneys. *Urology* 65: 265–269.

Wells, H., Rukin, R., Wright, A. and Somani, B. (2015) Outcome based comparison of percutaneous procedures for urinary lithiasis with calibre of instrumentation less than 12Fr. *Curr Urol Rep* 16: 528–534.

Wright, A., Somani, B. and Rukin, N. (2014) Proposition for new terminologies in PCNL: what does 'Ultra-mini-micro' actually mean? *Urolithiasis* 42: 539–540.