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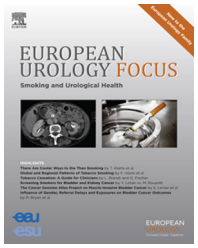

Review – Stone Disease

A Critical Review of Miniaturised Percutaneous Nephrolithotomy: Is Smaller Better?

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Abstract

Context: In an effort to reduce morbidity related to percutaneous nephrolithotomy (PCNL), some investigators have progressively introduced miniaturised approaches. The development of miniaturised nephroscopes facilitated widespread dissemination of these techniques and a significant expansion of the role of PCNL in endourology.
Objective: To discuss the different techniques comprising modern PCNL and identify the pros and cons of each of them.
Evidence acquisition: Data for this review were identified through a search of PubMed, including studies published in the last 20 yr in core clinical journals in English. The search terms included "urolithiasis", "nephrolithiasis", or "urinary stones" in combination with "miniaturised PCNL", "mini-PCNL", "micro-PCNL", "minimally invasive PCNL", and "ultra-mini PCNL". Publications relevant to the subject were retrieved and critically appraised.
Evidence synthesis: The indications for miniaturised PCNL have not been standardised yet. Even though data in the literature reveal limitations and conflicting results, these techniques seem promising in terms of effectiveness and safety for the treatment of renal stones. The development of miniaturised scopes facilitated knowledge of the physics behind the vacuum cleaner effect generated during procedures, and greater efficacy of holmium laser generators and surgeon skill have led to progressive expansion of the indications for miniaturised techniques. Well-designed, randomised, multi-institutional studies are needed to better understand the indications for these miniaturised techniques before considering them a standard procedure for potential replacement of conventional PCNL.
Conclusions: Miniaturised PCNL represents a valuable new tool in the armamentarium of modern endourologists, capable of offering good outcomes with lower complications rates compared to the standard technique and higher cost effectiveness compared to flexible ureteroscopy.
Patient summary: Miniaturised percutaneous nephrolithotomy represents a safe and effective alternative to standard techniques for the treatment of renal stones. Each patient needs to be considered individually and tailored surgical treatment has to be offered.

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1. Introduction

After decades in which open surgery was the only solution for treating renal stones, Fernstrom and Johansson [1] achieved a breakthrough in 1976, when the carried out percutaneous nephrolithotomy (PCNL) in the prone position for the first time in three patients with renal stones who were unfit for open surgery.

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Since then, relentless advances in the endourology armamentarium, downsizing of instrumentation, refinement of different lithotripters, progress in imaging techniques, and increasing requests for minimally invasive procedures have made PCNL one of the mainstays of modern endourology, even after the advent of other competitive and less invasive treatment modalities such has shock wave lithotripsy and, more recently, flexible ureteroscopy (fURS). This was possible because PCNL underwent relentless evolution over the years, aimed at reducing its invasiveness and complication rates and improving outcomes [2–7].

Despite these advances, PCNL remains a challenging procedure with associated morbidity. Postoperative sepsis (2%), fever (10–16%), blood transfusion (3–6%), significant bleeding (8%), and perforation of adjacent organs (0.4%) are still important complications after PCNL [8,9]. In an effort to reduce this morbidity, paralleling what happened in paediatric endourology [4], some investigators have progressively introduced miniaturised instruments. After initial scepticism regarding its potential [10], the development of dedicated miniaturised nephroscopes facilitated widespread dissemination of the technique and significant expansion of the role of PCNL in endourology. But the question then arises as to whether smaller is better.

The aim of this review is to discuss the different techniques comprising modern PCNL and identify the pros and cons of each of them.

2. Evidence acquisition

Data for this nonsystematic review were identified through a search of PubMed, including studies published in the last 20 yr in core clinical journals in English. The search terms included “urolithiasis”, “nephrolithiasis”, or “urinary stones” in combination with the terms “miniaturised PCNL”, “mini-PCNL”, “micro-PCNL”, “minimally invasive PCNL”, and “ultra-mini PCNL”.

Study selection was based on an independent review process by two authors (S.P., G.G.) after the structured data search. The list of articles was augmented with significant manuscripts not previously found in this search or outside the time period of the initial search and identified via extensive cross-checking of the reference lists from the selected articles and from previous reviews. Publications relevant to the subject were retrieved and critically appraised.

3. Evidence synthesis

The indications for miniaturised PCNL have not been standardised yet. Even though data in the literature show limitations and conflicting results, these techniques seem promising in terms of both effectiveness and safety for the treatment of renal stones.

The development of dedicated miniaturised scopes facilitated knowledge of the physics behind the vacuum cleaner effect generated during procedures, and the greater efficacy of holmium laser generators and surgeon skill have led to progressive expansion of the indications for miniaturised techniques. Well-designed, randomised, multi-institutional studies are needed to better understand the indications for these miniaturised techniques before considering them a standardised procedure with potential to replace conventional PCNL.

3.1. *Terminology in PCNL and miniaturised PCNL*

Despite the growing role of miniaturised PCNL, terminology in this field is not yet standardised, and the semantics of different acronyms can be confounding for endourologists. Terminologies recommended by different groups over the years are shown in Table 1 [11–17].

3.2. *Indications for miniaturised PCNL*

The indications for miniaturised PCNL have not been standardised yet. First used in a paediatric population, mini-PCNL has progressively become the procedure of choice in this subset of patients as a safe and effective alternative to standard PCNL [4]. The potential of miniaturised PCNL in adults was then recognised and the approach gained in popularity as an appealing middle ground between standard PCNL and fURS.

Traditionally, medium-sized (1.5–3 cm) and hard stones (>1000 Hounsfield units [HU]) is the ideal indication for mini-PCNL [11,12,18].

It is noteworthy that the development of dedicated miniaturised scopes facilitate knowledge of the physics behind the vacuum cleaner effect generated during procedures [19], and increased efficacy of modern holmium laser generators and surgeon skill led to progressive expansion of the indications for miniaturised techniques. As a consequence, some Chinese authors reported that miniaturised PCNL is comparable to standard PCNL in treating staghorn stones and proximal ureteral stones, yielding similar

Table 1 – Terminologies for PCNL and miniaturised PCNL.

Procedure	Sheath outer diameter (F)	Study
Conventional categorisation		
Standard PCNL	>22	Knoll et al [11]
Mini-PCNL	≤22	Jackman et al [4]
Minimally invasive PCNL (MIP)	9.5–26	Nagele et al [12]
Ultra-mini PCNL (UMP)	11–13	Desai et al [13]
Super-mini PCNL (SMP)	10–14	Zeng et al [14]
Mini-micro PCNL	8	Desai et al [15]
Micro-PCNL	<5	Desai et al [15]
Schilling [16] categorisation		
XL	≥25	
L	20 to <25	
M	15 to <20	
S	10 to <15	
XS	5 to <10	
XXS	<5	
Tepeler [17] categorisation		
Named according to tract size	PCNL $^{+size}$	

PCNL = percutaneous nephrolithotomy.