

REVIEW ARTICLE

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## Place For Percutaneous Nephrolithotomy In Contemporary Era.

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### ABSTRACT

The basic surgical options for big (>20 mm) stag horn and diseased stones are often regarded as percutaneous nephrolithotomy (PCNL) and its miniaturised variations. Furthermore, in cases where lower pole stones are unreachable or there are anatomical anomalies, PCNL is a good substitute for retrograde intrarenal surgery (RIRS) for smaller stones (<20 mm). However, RIRS is extending its indications with the potential advantages of fewer problems and a shorter hospital stay, thanks to advancements in stone fragmentation devices and optical technology. Current research publications attest to the importance of this process and its possible use in the management of big and complicated stones. However, miniaturised PCNL has grown more competitive and is starting to take its place among the traditional signs of flexible ureteroscopy. Taking into account every advancement that has been made recently in the execution of this process, we can say that PCNL is unquestionably a tried-and-true method that will continue to be at the forefront of technology for some time to come.

**Keywords:** Percutaneous Nephrolithotomy ,Kidney Stones, Urological Surgery

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### INTRODUCTION

Percutaneous nephrolithotomy (PCNL) currently remains the gold-standard approach for challenging renal stones of the likes of large ,complex calculi, hard or lower pole calculi, stones associated with aberrant renal malformation and failure of other concomitant treatments and Complexities associated with patient's ages, comorbidities and body habitus. Safety and efficacy of PCNL reveal the unswerving improvements in technology and surgical skills abundantly explains

the superseding use of this procedure in the past five decades (1). Standardization of PCNL complications by means of the modified Clavien-Dindo classification (2) allows comparison of outcomes with in a hospital, between different centres, over period of time and depending upon the learning curve for different instruments used and operating techniques employed. A thorough review of the recent literature (3) identifies five major developing areas, inspiring prolific innovations in PCNL technique: A. Imaging before, during and after the procedure; B. Patient positioning (the traditional prone position being now challenged with the emerging supine positions); C. Endoscopy. D. Intracorporeal lithotripsy improved by new devices combining ultrasonic and pneumatic lithotripsy, trilogly or ultrasonic and high- power holmium: YAG laser lithotripsy); and 5 post-PCNL tube care, which includes completely tubeless and nephrostomy-free techniques. The surgical management of stones is heavily reliant on technology. This holds true for the advancement of current tools and technology. Furthermore, the fields of robotics and artificial intelligence (4) show great promise and are rapidly transforming medicine in general and endourology in particular. It's thrilling to imagine a day when a completely automated, robotically operated, artificially intelligent system would be able to treat patients; this day is not too far off.

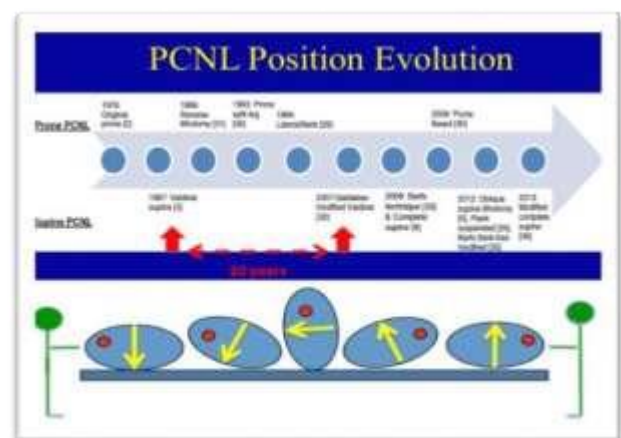
### Imaging

CT scan (5) has authoritatively inscribed on the epitaph of intravenous urogram “rest in peace” and now is on the move with diverse innovations like robotic-assisted fluoroscopic-guided and ultrasound-guided renal access in percutaneous nephrolithotomy. The potential benefit of virtual guidance revealed its usefulness both for surgical planning and for surgical

Using mixed reality and augmented reality navigation, the goal is to provide the surgeon with real-time assistance throughout the intervention. In PCNL, 3D is helpful not only for image reconstruction but also for 3D printing, which has a positive impact on pre- and intraoperative planning by enhancing anatomical spatial comprehension. When compared to normal puncture, An enhanced training experience that seems to translate into a shorter learning curve and a higher stone-free rate is made possible by 3D model printing, virtual and mixed reality, and faster access (6-7). In both supine and prone postures, robotic access increases the puncture accuracy for fluoroscopic and ultrasonography guided access. Robotics has the ability to minimise the necessity for needle punctures, radiation exposure during renal access, and the number of needle punctures by applying artificial intelligence. The integration of robots, virtual and mixed reality, and artificial intelligence has the potential to significantly improve PCNL surgery by optimising every facet of a successful intervention, from entrance to exit (8).

### Positions

It is reasonable to presume that while performing first percutaneous nephrostomy (Concept given in 1865 & done in 1955) the patient was placed in prone position primarily to avoid injury to colon, solid organs and great vessels (9-10).



## **A. Supine**

Complete Supine, Modified Supine, Oblique Prone, and Supine With the exception of a few urologists who sometimes did it in the supine position, it has been done in the same posture for the following forty years. The comparison of supine versus prone PCNL in published literature has not consistently shown a statistically significant advantage for either method in terms of complications or stone-free rates. On the other hand, the supine technique has consistently showed fewer problems and seems to shorten operating times. In conclusion, the surgical team's expertise is the most crucial consideration when deciding between a supine or prone technique. As a result, it can be concluded that no posture is completely better than any other (11–12). It's also crucial to remember that each position in the PCNL method has pros and cons of its own, whether supine or prone. Therefore, while doing PCNL, the posture should be chosen depending on the patient's clinical situation and the surgeon's expertise, since the prone position is the norm for PCNL by TRADITION rather than by EVIDENCE (14). The PCNL end-point is dependent on technical precision and is independent of the patient's location. Consequently, urologists need to be aware that PCNL in the supine position is the only option available to "difficult patients" (15). Additionally, the supine posture offers a singular chance to integrate all rigid and flexible endourological procedures.

## **B. Endoscopy**

Since the 1970s, urologists have been able to introduce ureteroscopy and percutaneous nephrolithotomy methods because to advancements in endoscopes and other devices. Subsequent developments included the creation of endoscopic tools that were more durable and effective. This process never ends since cutting-edge new medical gadgets and tools are always being developed. Significant advancements have been made in the development of digital camera systems based on complementary metal oxide (CMO) and charge-coupled devices (CCD), as well as the shrinking of equipment.-

Superconductor technology (CMOS) (16). These advancements allowed for the construction of flexible ureteroscopes and nephroscopes with larger working channels, improved picture clarity, and increased irrigation capacity, all of which facilitated instrument passage. Further developments in digital HD video technology combined with post-processing software such as NBI/SPIES will lead to improvements in optical field and resolution, enable the use of laser fibres to miniaturize endoscopes, and produce more efficient and intelligent irrigation and suction systems (17). Percutaneous nephrolithotomies are now classified into four categories: standard (24–30F), mini (20–22F), ultra/super-mini (12–14F), and micro (8–10F). In the near future, these gadgets will become more affordable and long-lasting.

## **C. intracorporeal lithotripsy**

The energy sources for intracorporeal lithotripsy are as follows: in 1967, electrohydraulic lithotripsy gained popularity; in 1977, ultrasound was used for the first time to destroy renal stones; in 1986, work on developing a laser to fragment ureteral calculi began; and in 1992, the first pneumatic stone fragmentation device was created (18). Renal and ureteral stones are increasingly being treated with laser lithotripsy thanks to advancements in laser fibres and power production devices (19). Numerous commercial brands of thulium fibre lasers and powerful modern Holmium lasers provide a multitude of parameters, including pulse width, frequency, and energy. Specific effects of dusting or fragmentation of stone may be achieved by varying the combinations of these factors in addition to the laser fibre size and the distance of the fibre tip from the stone (20). More than 15 years ago, the Holmium: Yttrium-Aluminum-Garnet (Ho: YAG) laser was introduced, completely changing the endoscopic treatment of stones (21). Variations of the Thulium Fibre Laser (TFL) are a more recent laser platform with

Advantageous physical characteristics in comparison to Ho: YAG (22). Compared to Ho:YAG, which works at a wavelength of 2100 nm, TFL operates at 1940 nm, which is extremely near to the water absorption peak (1950 nm).<sup>11</sup> Thanks to this characteristic, TFL may ablate stones up to four times lower than Ho:YAG while still allowing Ho:YAG-like disintegration of all stone kinds. TFL operates across a broader variety of configurations, producing pulse energy ranging from 0.025 to 6 J at frequencies as high as 2000 Hz, enabling extremely high peak power (~500 W). Compared to Ho: YAG's bottom limit of 200 µm, TFL's broad range of settings allows it to transfer high-power energy via smaller, more flexible fibres of 50 µm (23–24–25).

#### **D-Stone retrieval devices:**

In endoscopic stone therapy, it has become more important to remove all stone pieces after lithotripsy. Because of this, new designs and lower calibres of baskets and graspers are constantly being created. Simultaneously, tools have been developed to aid in the removal of calculi by hydrodynamic processes (vacuum-cleaner effect, purging, active/passive washout). To stop migration to other calyces and to make extraction easier, small pieces may be added to gels or glue-clots (26-27).

#### **Robotics:**

The use of robotics in the surgical treatment of prostate and renal cancer is becoming more and more effective. Today, the Da Vinci® surgical system is used all around the globe. With their greater affordability and accessibility, the equipment market has been inundated with newly designed surgical robot systems. In some unique and complicated stone situations, such as simultaneous pyeloplasty–pyelolithotomy, complex pyelolithotomy, and endourological operations, including ureteroscopy and percutaneous nephrolithotomy, these methods have helped to improve the results of minimally invasive treatments (28–29).

#### **Post-PCNL tube management.**

Without any major issues, Bellman et al. published the first study on tubeless PCNL in 1997. Limb et al. attempted to define discharge criteria in order to compare the duration of stay between tubeless and regular PCNL in an objective manner. They listed a variety of variables that may skew this variable, including the policies of the healthcare system, the coexisting medical conditions of the patient, and the subjectivity of pain perception (30). Aside from stone and patient characteristics, previous research on this subject has shown that these are the most important factors to take into account for any PCNL result. The tubeless PCNL group was shown to have a considerably reduced operational time and a mean hospital stay, as validated by meta-analysis. Nonetheless, there was no difference in the Stone Free Rate between patients with and without tubes, which was defined in most trials as residual pieces < 4 mm and/or no fragment observed on table examination or at initial imaging. In terms of analgesic needs and postoperative discomfort, tubeless PCNL had equal or superior results. Maheshwari et al. (31) suggested that patients may be released sooner, have better pain scores, fewer problems, and recover more quickly even with a Standard PCNL if a short pigtail is left in place as a nephrostomy tube. Interestingly, Eslahi et al. (32) also discovered that, in comparison to regular and tubeless PCNL, the amount of narcotics required and discomfort were much lower in entirely tubeless PCNL (no ureteral stent and no nephrostomy tube). Intraoperative tract infiltration for pain management is becoming a prevalent trend; nevertheless, its efficacy in providing immediate postoperative pain relief and reducing the need for analgesics is unknown. This is particularly true if the patient is being evaluated for same-day release (33). As shown by a recent 500-patient research by Chong et al., same-day discharge PCNL is now a reality. They found that 77% of cases had a typical tract dilatation (24–30 Fr), and 99% of cases utilised a ureteral stent as the sole source of drainage. While

Tubeless PCNL enabled for a quicker surgical procedure, a shorter hospital stay, and a decreased incidence of postoperative Reno cutaneous fistula, per extensive systematic reviews.

### Conclusion

Advances in the PCNL technique not only increase stone-free outcomes and reduce post-operative complications, but also significantly reduce peri-operative patient morbidity. What future holds for the benefits due to use of robotics and augmented reality combined with navigation and motion tracking systems, incorporation of artificial intelligence dedicated efforts for Future developments of radiation-free medical imaging equipment, variation of patients positioning ,extensive advancement in extracorporeal lithotripsy devices and tubeless percutaneous nephrolithotomy are exhilarating. Endourological stone surgery has enjoyed great progress due to technological advancement over the past two decades. The continued research and development of new instruments and new techniques has improved morbidity and efficiency of the various lithotripsy modalities. In the future, virtual training and diagnostics will further enhance our ability to treat patients more effectively. It is important for endourologists to keep up to date with the constant updates in methodology and treatment, as it is apparent that the progress and evolution of stone management procedures is an ongoing process far from over. "If doctors were to be found liable whenever they did not effect a cure or whenever something happened to go wrong it would be a great disservice not only to the profession itself but to society at large"

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