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Impact of retrograde intrarenal surgery, miniaturized percutaneous nephrolithotomy, and standard percutaneous nephrolithotomy on renal damage biomarkers- A cross-sectional study.

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Abstract

Background
A frequent urological illness that has a significant socioeconomic burden and a high recurrence rate is nephrolithiasis. With endourological operations being the standard of care, choosing the right treatment is crucial. Patients with nephrolithiasis can find relief from these big stones by undergoing Percutaneous Nephrolithotomy (PCNL), a well-established, minimally invasive surgical treatment.
Objectives- The purpose of the study was to assess how biomarkers of renal injury were affected by standard PCNL, miniature PCNL, and retrograde intrarenal surgery.

Materials and methods
It was a cross-sectional study. The study was carried out in the Department of Urology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India. The study was conducted for one and a half years, that is, from October 2022 to April 2024. In all, 40 patients were enrolled. Participants have to be patients who had undergone PCNL for renal calculus at Mahatma Gandhi Medical College and Research Institute in Puducherry between 2022 and 2024.

Results
29 (72.5%) of participants were male, while the other 11 (27.5%) of the participants were female in the study. There were 22 stones on the left side (55%) compared to 18 on the right (45%). Thirty-three (82.5%) patients had sterile urine cultures, while seven (17.5%) had positive urine cultures. Serum Creatinine was found to be 1.14 ± 0.42 mg/dL. Renal parenchymal thickness of the operated kidney was found to be 16.07±1.04 mm, while that of the opposite kidney was 16.07±0.95 mm.

Conclusion
Urolithiasis is a complex illness that is impacted by several metabolic and clinical risk factors.

Recommendations
To validate these results, larger trials with longer follow-up are required. It is recommended to include more sensitive kidney biomarkers and standardize surgical factors.

Keywords: *Nephrolithiasis, Biomarkers, Renal function, Percutaneous nephrolithotomy, Retrograde intrarenal surgery*
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Introduction

A frequent urological illness that has a significant socioeconomic burden and a high recurrence rate is nephrolithiasis. With endourological operations being the standard of care, choosing the right treatment is crucial [1, 2]. Along with percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS), "miniaturization" techniques—the most common of which is the mini-PCNL—have been implemented as a result of ongoing technological advancements, including better and more advanced lithotripters and lasers [3].

Patients with nephrolithiasis can find relief from these big stones by undergoing PCNL, a well-established, minimally invasive surgical treatment [3]. Numerous studies conducted in the last few years have assessed the prognostic significance of acute kidney injury (AKI) and documented the relevance of novel biomarkers in its diagnosis in various demographics and settings, such as patients in the postoperative phase and those in intensive care units [4].

Serum and urine biomarkers of AKI that are frequently employed include N-acetyl-β-d-glucosaminidase (NAG), kidney injury molecule-1 (KIM-1), cystatin C, neutrophil gelatinase-associated lipocalin (NGAL), and interleukin-18 (IL-18). A notable rise in KIM-1 normalized for urinary Cr (KIM-1/Cr) levels and, consequently, NAG/Cr and NGAL/Cr ratios has been seen 24 hours after PCNL in patients who had the procedure for renal stones larger than 2 cm [5].

The combination of several biomarkers at various postoperative time points has been shown to increase diagnostic accuracy, even though there is currently no one ideal biomarker [6]. The perfusion to the renal artery is shown by the renal resistive index (RI). A healthy kidney's renal morphology is indicated by renal parenchymal thickness and renal parenchymal echogenicity. Sonography is used to assess the renal resistive index and renal parenchymal thickness. We can determine the condition of the renal unit with the aid of a straightforward, affordable, and non-invasive test. Increased vascular resistance and possible impairment in renal perfusion, which can result in renal impairment, are indicated by higher Resistive Index (RI) values in kidneys that have scarring [7].

The purpose of the study was to assess how biomarkers of renal injury were affected by standard PCNL, miniature PCNL, and retrograde intrarenal surgery.

Methodology

Study design

It was a cross-sectional study.

Study setting

The study took place at the Department of Urology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India. The study was conducted for one and a half years, that is, from October 2022 to April 2024.

Study population

In all, 40 patients were enrolled. Participants have to be patients who had undergone PCNL for renal calculus at Mahatma Gandhi Medical College and Research Institute in Puducherry between 2022 and 2024. Individuals who had received PCNL for a single kidney, lost follow-up, or had undergone any operation in the contralateral kidney were excluded.

Efforts to reduce bias

To minimize bias, the study used strict inclusion/exclusion criteria, standardized surgical protocols, and objective biomarkers. Outcome assessors were blinded to the type of surgery, and relevant clinical variables were documented to control for confounders. Ethical approval and informed consent further ensured transparency and reduced selection bias.

Data collection

Every patient got a routine physical examination and had a thorough medical history taken. Routine investigations, vascular Doppler, and ultrasound (USG) will be carried out. The patient's preferred language of written consent was used.

Sample size

Based on previous regional studies and available literature, the estimated prevalence of PCNL was assumed to be approximately 15%. With a 95% confidence level and an absolute precision (margin of error) of 5%, the minimum

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required sample size was calculated to be 40 participants using the formula:
$n=d2Z2\times p\times(1-p)$
Where:
n = required sample size
Z = 1.96 (standard normal deviate at 95% confidence level)
p = estimated prevalence (0.15)
d = margin of error (0.05)

Statistical analysis

Microsoft Excel and SPSS version 24.0 were used to assemble and analyze the study's data. Continuous variables were shown as mean standard deviation (SD), whereas categorical variables were shown as percentages or the number of participants (n).

Ethical clearance

Ethical approval has been obtained by the Institutional Ethics Committee (IEC), Mahatma Gandhi Medical College and Research Institute, Puducherry, India, under letter number MGMCRI/Res/01/2023/4/IHEC/10, dated 16 February 2023.

Informed consent

Written informed consent was obtained from all participants before their enrolment in the study.

Results

Out of 65 patients initially assessed, 5 were excluded due to incomplete records. Of the 60 screened, 8 were excluded for reasons such as single kidney, prior contralateral surgery, or refusal to participate. Forty-four patients were confirmed eligible and consented. Before analysis, 4 were excluded due to loss to follow-up, withdrawal of consent, or incomplete data. Thus, 40 patients were included in the final analysis.
29 (72.5%) of participants were male, while the other 11 (27.5%) of the participants were female in the study. There were 22 stones on the left side (55%) compared to 18 on the right (45%). Thirty-three (82.5%) patients had sterile urine cultures, while seven (17.5%) had positive urine cultures. The study participants' baseline demographics are shown in Table 1

Table 1. Baseline demographics of study participants

Parameters	Number of Participants	Percentages
Age (in years)		
< 30	06	15.0
31–45	16	40.0
46–60	13	32.5
> 60	05	12.5
Sex		
Male	29	72.5
Female	11	27.5
Laterality of Stone		
Left	22	55
Right	18	45
Urine Culture		
Sterile	33	82.5
Positive	07	17.5

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Table 2 depicts the postoperative renal functional and morphological outcomes following standard PCNL. Serum Creatinine was found to be 1.14 ± 0.42 mg/dL. Renal parenchymal thickness of the operated kidney was found to be 16.07±1.04 mm, while that of the opposite kidney was 16.07±0.95 mm.

Table 2. Postoperative renal functional and morphological outcomes following standard PCNL

Parameter	Mean ± SD
Serum Creatinine (mg/dL)	1.14±0.42
RI of Operated Kidney	0.625±0.042
RI of Opposite Kidney	0.613±0.039
Renal Parenchymal Thickness of the Operated Kidney	16.07±1.04 mm
Renal Parenchymal Thickness of Opposite Kidney	16.07±0.95 mm

Discussion

The majority of research that looked into how PCNL affected renal function concluded that it was a short-term, safe procedure with few immediate negative consequences on renal function. For example, no discernible long-term decline in renal function following PCNL was discovered by Kumar et al. in 2011 [8]. There is, however, little research on long-term impacts, particularly on renal morphology. Zhang et al.'s 2016 study, which evaluated long-term effects using color Doppler ultrasonography, found changes in renal shape but no appreciable changes in renal function [9]. According to these results, scarring and increased vascular resistance may develop over time, as evidenced by raised resistivity indices, even though renal function may stay stable.

In radiology and urology, the kidney's Resistive Index is a useful tool that helps diagnose and treat a variety of renal diseases by offering information on renal vascular resistance. Although there are many clinical advantages, interpreting it requires careful consideration of individual, physiological, and technical aspects. Healthcare practitioners can improve the precision of renal evaluations by combining RI measurements with thorough clinical evaluations.

The majority of instances (40%) in the current study occurred in the age range of 31–45 years, with 32.5% occurring in the 46–60 years range. There is no age-related variation in renal morphology or renal arterial resistive index following PCNL.

In line with the majority of urological literature, 72.5% of cases in the current study were male. According to a study, men are more likely than women to develop renal calculi, which could be caused by anatomical abnormalities, nutritional disparities, or lifestyle differences [8]. Research has repeatedly demonstrated that men are more likely than women to develop urological disorders such as nephrolithiasis, possibly as a result of consuming more protein and less water, both of which are factors in the development of stones. This discrepancy by sex also raises the possibility that renal calculus develops more frequently in men [10]. Urolithiasis has been associated with several clinical risk factors, including age over 60, male gender, diabetes, and insulin use. Higher body mass index, insulin resistance, and several additional specific dietary and urine components [11].

Generalizability

The study's generalizability is limited due to its single-center design, small sample size, and predominance of male participants. While it offers useful insights, the findings may not be broadly applicable to all settings or patient populations. Larger, multicenter studies are needed to confirm these results and improve external validity.

Conclusion

Urolithiasis is a more complex illness that is impacted by several metabolic and clinical risk factors. Men, especially those over 60, emphasize the significance systemic factors play in stone formation. Furthermore, lifestyle variables, including nutrition and obesity, increase the risk. For renal calculi to be effectively prevented, diagnosed early, and managed with precision, it is imperative to comprehend these relationships.

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Limitations

The study included many restrictions, like firstly, the results may not be as broadly applicable as they may be because of the limited sample size. Second, long-term changes in renal function could not be well captured by short-term postoperative biomarker tests. Long-term renal function follow-up and imaging-based functional outcomes were also not evaluated in this study.

Recommendations

To validate these results, larger trials with longer follow-up are required. It is recommended to include more sensitive kidney biomarkers and standardize surgical factors.

List of abbreviations

PCNL- Percutaneous nephrolithotomy
NGAL- Neutrophil gelatinase-associated lipocalin
KIM-1- Kidney injury molecule-1
IL-18- Interleukin-18
RIRS- Retrograde intrarenal surgery
NAG- *N*-acetyl-β-d-glucosaminidase
RI- Resistive Index
AKI- Acute Kidney Injury
USG- Ultrasonography
SD- Standard Deviation

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Conflict of interest

The authors declare no conflict of interest.

Author contributions

All authors contributed to the study design, data collection, analysis, and manuscript preparation.

Data availability

The data generated during this study are available from the corresponding author upon reasonable request.

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