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Research Article

Does Percutaneous Nephrolithotomy Cause a Local Decrease in Renal Parenchymal Thickness?

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Abstract

Introduction: This study aimed to investigate the effects of PCNL on the renal parenchymal thickness.

Materials and Methods: Adult (≥18 years) patients who underwent percutaneous nephrolithotomy (PNL) in Health Sciences University Diskapi Training and Research Hospital between May 2016 and May 2021 constituted the target population of this descriptive study. Patient data were retrospectively reviewed. All patients had preoperative and postoperative sixth-month abdominopelvic computerized tomography (CT) scan images and preoperative and postoperative day 1 blood workup results. Stone surface areas (SSA) and stone densities were measured using preoperative CT scans. The renal parenchymal thickness (RPT) was calculated on preoperative and postoperative CT images. Preoperative and postoperative RPT values were compared. **Results:** 358 patients (232 men and 126 women) were included. Thirty-two (8.9%) patients had 2 PNL surgeries. Median SSA and stone density were calculated as 566.5 (100-2237) mm^2 and 937.5 (304-1474) Hounsfield Units. The mean duration of hospital stay was 4.2±2.1 days. Our analysis revealed a significant reduction in RPT ($p<0.001$). While the median RPT reduction was 2.5 (0-8) mm in patients who underwent PNL once, it was five (1-12) mm in patients who underwent PNL twice ($p<0.05$). Correlation analysis revealed no correlation between RPT reduction and duration of hospital stay. **Conclusion:** A significant decrease in RPT was detected after PNL. No correlation was found between the decrease in renal parenchyma thickness and the length of hospital stay.

Keywords Computed tomography; Percutaneous nephrolithotomy; Renal parenchymal thickness; Renal stone

Introduction

The incidence of urinary tract stone disease depends on geographical, climatic, ethnic, dietary, and genetic factors (1). The prevalence of urinary tract stones ranges from 1% to 20%. Urinary tract stone disease is a common health problem with a recurrence rate of 51% within ten years, depending on its etiology (2).

The decision regarding the treatment method is given based on stone composition, localization, and burden (3). Treatment strategies include conservative methods, medical therapy, extracorporeal shock wave lithotripsy (ESWL), flexible or rigid ureterorenoscopy, percutaneous nephrolithotomy (PNL), and open/laparoscopic surgery.

The PNL procedure is the preferred treatment modality in cases with a high stone burden since it can lead to a stone-free rate of as high as 95% with relatively low retreatment rates and short hospitalization and convalescence periods (4,5). Also, it is recommended as the standard treatment method for all renal stones larger than two cm and lower pole stones larger than one cm by both the American Association of Urology (AUA) and European Association of Urology (EAU) guidelines (6). It was reported that bleeding requiring transfusion, urinary extravasation, septicemia, colon injury, and pleural injury are the most common complications of this procedure (7). Although there are sufficient clinical studies and data regarding PNL outcomes, little is known about the effects of the PNL procedure on the renal parenchyma.

Protection of the renal parenchyma is essential for saving the glomerular function and glomerular filtration rate (GFR). Since there is a risk of renal parenchymal loss with the PNL procedure, the clinicians need to know the factors related to this risk.

This study aimed to investigate the effects of PNL on renal parenchymal thickness (RPT) with the guidance of computed tomography (CT) scan. Pre-PCNL and post-PCNL renal parenchymal thicknesses of the kidneys were measured and compared for this analysis.

Materials and Methods

Adult (≥18 years) patients who underwent PNL in Health Sciences University Diskapi Training and Research Hospital Department of Urology between May 2016 and May 2021 constituted the target population of this study. It was approved by the Ethical Review Committee of the same institution (01.11.2021-123/09). Data of the patients were retrospectively reviewed. Patients who did not have a preoperative CT scan and a postoperative follow-up CT scan and those with incomplete data were excluded. Also, those with a solitary kidney, renal ectopia, or any other congenital renal abnormality were excluded.

In our routine practice, preoperative abdominopelvic CT scans are performed one month before PNL surgery, while postoperative CT scans are performed six months after the procedure. Therefore, all patients had preoperative and postoperative abdominopelvic CT scans.

All CT scans were performed using the same machine with GOM software (ZEISS Group Company, Braunschweig, Germany). An experienced radiologist reviewed the CT images, and coronal or sagittal reformatted CT images were also evaluated to supplement the axial images when found necessary by the radiologist. Attenuation value measurements were calculated as Hounsfield units using bone window settings with appropriate magnification. Stone densities were recorded in Hounsfield Units. The renal parenchymal thickness was measured preoperatively at the planned calyx of puncture and postoperatively at the puncture site indicated in the operative note using soft-tissue window settings in the axial CT images (Figure 1). These values were measured and recorded in milliliters. Stone surface areas were measured using an arithmetic calculation formula.

All PCNL surgeries were performed in a standard aseptic manner and the prone position under general anesthesia. Tract dilatation was performed with Amplatz dilators in all patients.

An 18F nephrostomy catheter was routinely left in place after completing the procedure. The nephrostomy catheter was removed on the second or third postoperative day unless there was a complication associated with drainage. *Success* was defined as stone-free status or the presence of residual fragments smaller than four millimeters.

All patients underwent preoperative routine laboratory workup at our institution. Complete blood counts of all patients were checked the day before and the day after surgery. All data, including the duration of hospital stay, were collected from electronic patient folders. In addition, the preoperative and postoperative RPT measurements were compared.

Categorical variables were expressed as counts and percentages. Kolmogorov Smirnov test was used to evaluate the normality of continuous variables. Variables with non-normal distribution were expressed as median (i.e., interquartile range) and analyzed using Wilcoxon and Spearman correlation tests. A p-value <0.05 was considered to be statistically significant. The Statistical Package for Social Sciences (SPSS) version 22.0 for Windows (SPSS Inc. Chicago, USA) software package was used to analyze the study data.

Results

After applying inclusion and exclusion criteria, 358 patients were included in this cohort. Among these patients, 232 (64.80%) were men, while 126 were women (35.19%) (Table 1). Thirty-two (8.9%) of these patients had two PNL surgeries. Median stone surface areas were calculated as 566.5 (100-2237) mm^2, and median stone densities (Hounsfield Unit-HU) were calculated as

937.5 (304-1474). The mean duration of post-surgical hospital stay was 4.2±2.1 days. While the median parenchyma reduction was 2.5 (0-8) mm in patients who underwent PNL once, it was found as five (1-12) mm in patients who underwent PNL twice.

Table 1. Demographic data and descriptive characteristics of the patients

Male / Female, n (%)	232 (64%) / 126 (36%)
Number of patients who underwent PNL once, n(%)	326 (91.1%)
Number of patients who underwent PNL twice, n(%)	32 (8.9%)
Stone size (mm^2), (min-max)	566.5 (100-2237)
Stone density (HU), (min-max)	937.5 (304-1474)
Postoperative hospital stay (Day), (mean±SD)	4.2±2.1
Renal parenchyma thickness reduction after the first PNL (mm), (min-max)	2.5 (0-8)
Renal parenchyma thickness reduction after the second PNL (mm), (min-max)	5 (1-12)

PNL: Percutaneous nephrolithotomy, HU: Hounsfield unit, SD: Standard deviation

While the median RPT of the patients in our study was 23.5 (10-36) mm before the PNL operation, the median RPT of the patients who had one PNL operation was 21 (8-30) mm. Some patients in our study (n=32) underwent two PNL operations from the same kidney and with the same calyx access. Before the second PNL procedure, the median RPT of the patients who underwent PNL operation for the second time was measured as 20 (7-29) mm. After the second PNL procedure, the median RPT of the patients who underwent PNL operation for the second time was measured as 18.5 (8-27) mm. Our comparative analysis revealed a significant reduction in RPT after PNL operations (p< 0.001) (Table 2).

Table 2. Parenchymal thicknesses before and after PNL surgeries

	n=358	Before PNL	After the PNL	p	n=32	Before the second PNL	After the second PNL	p
Parenchymal thickness of kidneys (mm), (min-max)		23.5 (10-36)	21 (8-30)	<0.001*		20 (7-29)	18.5 (8-27)	<0.001*

*Wilcoxon test, PNL: Percutaneous nephrolithotomy

There was no statistically significant relationship between RPT reduction, stone density, stone size, and postoperative hospital stay (p=0.211, 0.733, 0.814, and 0.659) (Table 3).

Table 3. Relationship between renal parenchymal thickness reduction and perioperative data

	Value	p
Stone density (HU), (min-max)	937.5 (304-1474)	0.733*
Stone size (mm^2), (min-max)	566.5 (100-2237)	0.814*
Postoperative hospital stay (Day), (mean±SD)	4.2±2.1	0.659*

*Spearman correlation test, SD: Standard deviation

Discussion

Ideal surgical treatment of urinary system stone disease aims to remove the stones with minor damage to the kidney (8). Among several surgical treatment modalities, PNL is especially preferred in patients with a relatively high stone burden. This procedure has advantages such as a relatively short hospital stay, low treatment cost, short convalescence period with favorable cosmetic results. Despite these advantages, there are insufficient data and only a few clinical studies on the effects of PNL on renal function. It is widely accepted that CT is an optimal imaging modality for assessing the renal parenchyma after PNL (8). In our study, the median preoperative RPT was significantly higher than the median postoperative RPT.

The complication rate of PNL is reported to be in the range of 3% to 18% in the literature (9). Bleeding requiring transfusion is one of the most severe surgical complications of this procedure. It was reported that the factors responsible for renal hemorrhage were the duration of the PNL procedure, stone size, stone location, and the RPT (9). Al-Nahas et al. stated that increased RPT and increased kidney size may increase the risk of bleeding due to the potential damage in the renal tissue and vascular structures during both percutaneous access and dilatation of the access tract (10).

Currently, imaging methods such as ultrasound (US) and CT are used for the morphological assessment of the renal parenchyma (11).

In the literature, there are studies regarding the effect of PNL on kidney functions and renal parenchyma (12,13). However, these studies have relatively small sample sizes. In one of these studies, Handa et al. showed that PNL damaged the kidney tissue and led to renal functional impairment (12). However, these studies have relatively small sample sizes. In one of these studies, Handa et al. showed that PNL damaged the kidney tissue and led to renal functional impairment (12).

On the other hand, Holman et al. reported that PNL did not damage the kidney even in the early postoperative period and improved kidney function (13). However, the effect of surgical trauma caused by PNL on the renal parenchyma should be considered. It was previously suggested that the number of PNL procedures performed on the kidney was correlated with the severity of renal parenchymal damage, and the decrease in RPT was more significant in these patients (12,13). In our study, the comparison of the preoperative and postoperative CT images revealed a statistically significant difference regarding RPT, both in patients who underwent PNL once or twice.

In the studies with large patient series from the normal patient population, a very high correlation was observed between CT and Tc-99m DMSA scintigraphy regarding kidney size and RPT measurements (14). Therefore, in our study, CT was used for these measurements.

Only a few studies in the literature evaluated the association between stone density and post-PNL reduction in RPT (15). Our study did not find a statistically significant correlation between stone density and reduction in the RPT after PNL. Therefore, we suggest that the decrease in RPT after PNL is due to renal parenchymal injury. Although it can be proposed that the amount of renal parenchyma loss could be directly correlated with intraoperative blood loss, we did not find a significant hemoglobin drop in our patients (data not shown).

In many studies, stone size was associated with renal parenchymal damage and PNL success (16). However, in our study, there was no statistically significant correlation between the stone size and post-PNL reduction in RPT.

There are only a few studies in the literature on the relationship between the decrease in RPT and the length of hospital stay (15). Karalar et al. found no statistically significant correlation between RPT and length of hospital stay. Also there was no correlation between the decrease in RPTand the length of hospital stay.

This study has some weaknesses which need to be considered while evaluating its findings. First, it is a retrospective study that can be affected by all weaknesses stemming from its retrospective design. Second, data such as the number of punctures and duration of surgery were not included. Third, estimated glomerular filtration rates of the patients were not analyzed since these data were incomplete in our database.

Conclusion

Despite these weaknesses, we conclude that PNL can lead to a significant decrease in RPT. However, no correlation was found between the decrease in RPT and the length of hospital stay. Our study should be supported by prospective clinical trials, which include data regarding the changes in ipsilateral renal function such as eGFR.

Conflicts of interest

The authors declare no conflicts of interest.

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This study is unfunded.

Ethical approval

This study has been approved by Ankara Diskapi Training and Research Hospital Ethical Review Committee (01.11.2021-123/09)

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