To the Editor: Percutaneous nephrolithotomy (PCNL) is first-line therapy for “staghorn” stones. A multi-access approach is the mainstay of treatment in many cases because the stone burden is high. Finding feasible parameters to predict the outcome of treatment for staghorn stones is important. The factors that can affect PCNL are controversial. Several parameters, such as the infundibular-pelvic angle (IPA), upper-lower calyx angle (ULCA), infundibular length (IL), and infundibular width (IW) were important to affect the result of the operation. Whether the objective parameters in computed tomography (CT) can predict success through a particular approach has not been evaluated. This study investigated if the anatomy of the collecting system could improve the outcome in selected patients according to pretreatment images.

The clinical data of 320 patients with staghorn stones (172 males and 148 females; mean age, 55.2 ± 12.6 years), who underwent PCNL between December 2014 and October 2016 in Beijing Tsinghua Changgung Hospital were retrospectively reviewed. There were 115 cases of “complete staghorn stones” and 205 cases of “partial staghorn stones”. CT was done routinely in these patients. For patients who could not tolerate CT, intravenous urography or retrograde urography was undertaken. Two patients had bilateral staghorn stones. The stone burden was the longest diameter of the staghorn stone in the CT image. Patients with a congenital abnormal collecting system (horseshoe/duplicated/malrotated/ectopic kidney) were excluded from the study.

Patients were divided into two groups according to the residual stones: no residual stones or residual stones ≤2 mm (Group 1) and residual stones >2 mm (Group 2). Access to the target was set preoperatively depending on the CT image. Parameters were recorded preoperatively by a surgeon who did not participate in the surgical procedure. The IPA of the lower calyces was measured as the inner angle formed at the intersection of the ureteropelvic and central axes of the lower-pole infundibulum, as defined by Elbahnasy et al. The IL of the access calyx was measured as the distance between the distal point of the calyx and the pelvic-infundibular junction. The IW of the access calyx was measured at the pelvic-infundibular junction point along the infundibular axis. The ULCA was the angle between the central axes of the upper and lower calyx infundibula [Figure 1]. All parameters were measured by two radiologists twice, and the mean value used as the final value.

All procedures were undertaken under general anesthesia or epidural anesthesia. Ultrasound was used to find the correct

![Figure 1: Anatomy of the collecting system. ① Infundibular-pelvic angle; ② Upper-lower calyx angle; ③ Infundibular length; ④ Infundibular width.](image-url)

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target calyx corresponding to the CT image. After puncture of the calyx, tract dilation was accomplished using plastic Amplatz dilators (UroVision, Bad Aibling, Germany) and metal Alken dilators up to 24 Fr in two steps, or the tract was dilated by a high-pressure balloon in one step.[3] The staghorn stone was fragmented and cleared by pneumatic lithotripsy and an ultrasonic system (EMS Electro Medical System; Nyon, Geneva, Switzerland). Residual staghorn stones were detected by ultrasound to ascertain if additional tracts were necessary. Finally, a 6-Fr double-J stent was inserted antegrade into the ureter, and a 14-Fr nephrostomy tube placed.

Patients underwent plain radiography of the kidney, ureter, and bladder or ultrasound (for nonradiopaque stones) during postoperative recovery in the hospital. The nephrostomy tube was removed if staged surgery was not indicated. The ureteral stent was removed 4-week later. Patients were recalled to the clinic for re-examination at 3 months. Statistical analyses were undertaken using SPSS version 16.0 (IBM, Armonk, NY, USA). The Chi-square test and two-sample independent t-test were used. A $P < 0.05$ was considered statistically significant.

All procedures were completed, and the relevant parameters recorded and calculations made. At 3-month follow-up, patients were evaluated for enrolment into the corresponding group. Group 1 and Group 2 were similar with respect to gender distribution, body mass index, and age. There were significant differences between the two groups with regard to the shape of staghorn stones ($P < 0.001$). The mean diameter of staghorn stones was 3.5 ± 1.1 cm in Group 1, and 4.5 ± 2.6 cm in Group 2 ($P < 0.001$). A remarkable difference was also noted in tract number during surgery: 1.5 ± 0.5 in Group 1 and 2.1 ± 1.6 in Group 2. The mean IPA was 48.6 ± 15.5° in Group 1 and 50.1 ± 11.3° in Group 2, respectively, and this difference was not statistically significant ($P = 0.780$). This phenomenon was also seen for the ULCA (125.2 ± 23.1° in Group 1 and 130.1 ± 25.6° in Group 2) and IL (16.2 ± 11.5 mm in Group 1 and 18.1 ± 12.1 mm in Group 2), but these differences in the ULCA and IL were not significantly different between the two groups. The only significant difference among the parameters of the collecting system was the IW: Group 2 (6.0 ± 1.7 mm) had a much narrower infundibulum than Group 1 (11.2 ± 1.4 mm, $P < 0.001$).

Parameters such as operation time (59.8 ± 25.2 min vs. 52.5 ± 21.0 min, $P = 0.180$), blood loss (1.4 ± 0.4 g/L vs. 1.2 ± 0.3 g/L, $P = 0.080$), and duration of postoperative hospital stay (5.8 ± 2.1 days vs. 5.2 ± 1.7 days, $P = 0.120$) were higher or longer in Group 2, compared with Group 1. We defined postoperative fever >38.5°C, injury to an adjacent organ, and necessity of blood transfusion as "major complications". The significant difference in this parameter was not found between two groups ($P = 0.180$).

Several classification methods for the collecting system have been reported, but none have been adopted universally. We attempted to find a quantifiable index to predict the success of PCNL. The S.T.O.N.E system for predicting the prevalence of no residual staghorn stones is reliable and user-friendly; five simple variables can be judged readily from preoperative noncontrast-enhanced CT images.[10] Other classification systems have been postulated to be acceptable for evaluation of the success of PCNL or flexible ureteroscopy. Nevertheless, controversy reigns because of nonuniform designs, and because most studies have been based on fluoroscopy guidance.

We compared two groups of patients after surgical removal of staghorn stones. Group 2 had staghorn stones of larger diameter, more access points, and more complete staghorn stones. In addition, the IW was significantly lower in Group 2, compared with Group 1. Other parameters of the anatomy of the collecting system, such as the IL, ULCA, and IPA, were not significantly different between two groups. In our opinion, a narrow infundibulum was the key parameter that affected movement of rigid equipment to reach other calyceal stones. Although a flexible nephroscope could be used for complete clearance of staghorn stones, it is ineffective in cases with a narrow infundibulum because the nephroscope is fixed in the outlet of the calyx.[4]

The study had three main limitations. First, the status of staghorn-stone clearance was not evaluated by CT simultaneously due to the retrospective nature of our study, so some radiopaque staghorn stones may have been missed during the follow-up period. Second, the density of staghorn stones was not measured, which may have affected the results. Third, although anatomic parameters were measured by CT urography, the exact values should be obtained with three-dimensional CT.

All of the main parameters measured, the IW of a punctured calyx was the only index that could ensure removal of staghorn stones after PCNL. The IL, IPA, and ULCA were not predictors for successful PCNL. For patients with residual staghorn stones, additional access was often required. Therefore, renal surgeons should keep in mind that patients with a narrow infundibulum and larger diameter of staghorn stone probably need more tracts.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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