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Association Between Sampaio Pelvicalyceal System Anatomy and Surgical Outcomes in Retrograde Intrarenal Surgery

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Abstract

Renal pelvicalyceal system anatomy may influence stone accessibility and surgical outcomes during retrograde intrarenal surgery. This study evaluated the association between Sampaio pelvicalyceal system classification and surgical outcomes in patients undergoing retrograde intrarenal surgery for renal stones. Consecutive adult patients who underwent unilateral retrograde intrarenal surgery for renal stones between January 1, 2020 and September 30, 2025 were retrospectively reviewed. After applying the exclusion criteria, 128 patients were classified according to Sampaio subtype as A1 (n = 36), A2 (n = 31), B1 (n = 39), or B2 (n = 22). Demographic, radiological, operative, and postoperative outcomes were compared between groups. The primary outcome was postoperative stone-free status, defined as no residual fragment or clinically insignificant residual fragments smaller than 4 mm. Univariable and multivariable logistic regression analyses were performed. Baseline demographic and stone-related characteristics were comparable among the groups. Infundibular width was the only radiological parameter that differed significantly between subtypes (p = 0.031). Stone-free rates were highest in subtype B2 and lowest in subtype A1 (86.4% vs. 55.6%), although the overall group comparison was not statistically significant (p = 0.109). In multivariable analysis, subtype B2 was independently associated with stone-free status compared with subtype A1 (odds ratio 5.52, 95% confidence interval 1.36–22.34; p = 0.017). These findings suggest that Sampaio pelvicalyceal system anatomy may be associated with stone-free outcomes after retrograde intrarenal surgery. In particular, the B2 subtype showed more favorable postoperative stone-free results in this cohort.

Introduction

Urolithiasis is a common urological disease associated with high prevalence, recurrence risk, and frequent need for surgical intervention [1]. With advances in endourology, retrograde intrarenal surgery (RIRS) has become a widely used minimally invasive treatment for renal stones. Current European Association of Urology guidelines recommend percutaneous nephrolithotomy (PCNL) as the first-line treatment for stones > 2 cm, while RIRS remains an important option, particularly for lower-pole stones > 1 cm, when the efficacy of shock wave lithotripsy (SWL) is limited [2]. Despite technological advances, stone-free (SF) status after RIRS is still influenced by patient-, stone-, and anatomy-related factors [1–3].

The pelvicalyceal system is highly variable, and its configuration may affect both endoscopic access to the target calyx and clearance of residual fragments [1, 3]. Lower-pole anatomy has received particular attention because an acute infundibulopelvic angle, long infundibular length, narrow infundibular width, and complex calyceal orientation may impair fragment passage and reduce SF rates [3–5]. Inoue et al. reported that an infundibulopelvic angle < 45.8° and an infundibular width < 7.8 mm were negative predictors of lower-pole calyceal accessibility during RIRS [5].

The Sampaio classification, originally described for endourological procedures, categorizes the pelvicalyceal system into four subtypes (A1, A2, B1, and B2) based on mid-renal-zone drainage patterns [1, 6]. Experimental and clinical studies suggest that these anatomical variants may affect flexible

ureteroscopic access, technical difficulty, and stone-free outcomes [4, 7–9]. However, pelvicalyceal anatomy remains underreported in RIRS studies. A recent EAU Endourology Section methodological review found that most randomized RIRS studies did not systematically evaluate pelvicalyceal anatomy, and assessments were generally limited to lower-pole parameters such as the infundibulopelvic angle, infundibular length, and infundibular width [10]. Moreover, these measurements may be affected by interobserver variability and limited reproducibility due to the lack of standardized definitions [11].

Therefore, a computed tomography urography-based anatomical classification may provide a practical approach for preoperative risk stratification. However, the role of the Sampaio classification in predicting RIRS outcomes remains unclear. This study aimed to evaluate whether preoperative Sampaio classification is associated with postoperative SF status, residual fragments, and operative time in patients undergoing RIRS for renal stones.

Materials and Methods

Ethical standards

The study was conducted after obtaining approval from the Clinical Research Ethics Committee of Aydın Adnan Menderes University Faculty of Medicine (Decision No: 2025/305). The study was carried out in accordance with the principles of the Declaration of Helsinki. Owing to the retrospective design of the study and the use of anonymized data, the requirement for informed consent was waived by the ethicscommittee.

Study design and patient population

This single-center retrospective observational cohort study was conducted at the Department of Urology, Aydın Adnan Menderes University Faculty of Medicine, and was reported in accordance with the STROBE guidelines for observational studies [12]. Consecutive adult patients (≥18 years) who underwent unilateral RIRS for renal stones between January 1, 2020 and September 30, 2025, were retrospectively included in the study. Electronic medical records, operative reports, and the institutional Picture Archiving and Communication System (PACS) were reviewed. Patients with multiple renal stones; stone size >3 cm; urinary system anomalies including bifid renal pelvis, horseshoe kidney, extrarenal pelvis, duplex collecting system, atrophic kidney, and malrotated kidney; preoperative double-J stenting; absence of preoperative computed tomography urography (CTU); or lack of postoperative imaging and/or operative reports were excluded from the study. The patients were classified into four groups according to the Sampaio pelvicalyceal system (PCS) classification: Type A1, Type A2, Type B1, and Type B2. The patient selection process and final distribution according to Sampaio PCS subtypes are shown in Fig. 1.

Basic demographic data, stone characteristics, operative data, success, and complications were evaluated comparatively between the groups. The primary outcome was postoperative SF status. Postoperative imaging evaluation was performed 30 days after surgery. Residual stone fragments

measuring <4 mm were defined as clinically insignificant residual fragments (CIRFs), and patients with no residual fragments or only CIRFs were considered SF. Complications were classified according to the modified Clavien-Dindo grading system [13].

Imaging evaluation and stone characteristics

All patients underwent preoperative CTU, including nephrographic and excretory phase imaging. Multiplanar reconstruction (MPR) and maximum intensity projection (MIP) images were evaluated when available. All preoperative CTU images were reviewed by two radiologists experienced in genitourinary imaging, one associate professor and one professor. Final radiological assessments, including Sampaio classification and anatomical measurements, were recorded by consensus; therefore, formal interobserver agreement analysis was not performed. The recorded radiological parameters included maximal stone diameter (mm), stone volume, stone density measured in Hounsfield units (HU), and stone localization within the upper pole, middle pole, lower pole, or renal pelvis. Stone density was determined as the mean HU value obtained from three separate regions of interest (ROIs) placed within the stone on non-contrast CT images. Stone volume was calculated using the ellipsoid formula [14].

Sampaio classification and anatomical assessment

The Sampaio classification delineates pelvicalyceal anatomy into Types A1, A2, B1, and B2 based on renal calyceal drainage patterns, as illustrated in Fig. 2 [6]. In addition to the Sampaio classification, infundibulopelvic angle (IPA), infundibular length, and infundibular width were evaluated in patients with lower pole stones. Sampaio classification and anatomical measurements were assessed on CTU images by two radiologists experienced in genitourinary imaging, one associate professor and one professor. Final classifications and measurements were recorded by consensus.

Surgical technique

All procedures were performed under general anesthesia in the lithotomy position by experienced senior surgeons. After cystoscopic insertion of a 0.035-inch polytetrafluoroethylene-coated guidewire into the renal collecting system, a suction ureteral access sheath (ClearPetra®, Well Lead Medical, Guangzhou, China) was advanced under fluoroscopic guidance whenever feasible. When sheath placement was not possible because of ureterovesical junction narrowing or resistance, flexible ureteroscopy was performed by advancing the ureteroscope directly over the guidewire. Digital flexible ureteroscopes available during the study period included HugeMed (Shenzhen HugeMed Medical Technical Development Co., Ltd., Shenzhen, China), SeeGen (Shanghai SeeGen Photoelectric Technology Co., Ltd., Shanghai, China), and RedPine single-use flexible ureterorenoscopes (Guangzhou Red Pine Medical Instrument Co., Ltd., Guangzhou, China). Stone disintegration was performed using a 35-W pulsed Ho:YAG laser platform (HyPHo, Hyper Photonics, Italy) with 272-μm and 365-μm laser fibers. Laser settings were adjusted intraoperatively according to stone characteristics and surgeon preference. Fragmentation and/or dusting techniques were used as appropriate. At the end of the procedure, a 4.8/6 Fr double-J stent was routinely placed and removed after 2–3 weeks.

Statistical Analysis

All statistical analyses were performed using Python version 3.10 (Python Software Foundation, Wilmington, DE, USA). A two-sided p value <0.05 was considered statistically significant for all analyses. Normality of continuous variables was assessed using the Shapiro–Wilk test together with histograms, coefficient of variation tables, skewness and kurtosis values and Q–Q plot evaluations. Continuous variables were expressed as mean ± standard deviation or median (interquartile range [IQR]) according to data distribution, while categorical variables were presented as frequencies and percentages.

Comparisons between groups were performed using one-way analysis of variance (ANOVA) for normally distributed continuous variables and the Kruskal–Wallis test for non-normally distributed variables. When significant differences were detected, post-hoc pairwise comparisons were conducted using Dunn's test with Bonferroni correction for multiple testing. Categorical variables were compared using the chi-square or Fisher's exact test, as appropriate.

Univariable logistic regression analyses were initially performed to identify factors associated with postoperative SF status. Variables considered clinically relevant or statistically significant in univariable analyses were subsequently included in multivariable logistic regression models. The primary multivariable model included Sampaio classification, stone size, HU, and lower pole stone location. Lower pole anatomical parameters, including IPA, infundibular length, and infundibular width, were separately evaluated in secondary subgroup analyses restricted to patients with lower pole stones. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported for logistic regression analyses.

Results

A total of 128 patients were included and classified according to the Sampaio pelvicalyceal system subtype as A1 (n=36), A2 (n=31), B1 (n=39), and B2 (n=22). Baseline demographic and preoperative characteristics were comparable among the four groups. No significant differences were observed in age, sex distribution, comorbidities, or history of previous stone procedures (Table 1).

Table 1 Comparison of baseline demographic and preoperative characteristics according to Sampaio classification

Variables	Type A1 (n=36)	Type A2 (n=31)	Type B1 (n=39)	Type B2 (n=22)	p value
Age (years), median [IQR]	52.0 [40.3–65.0]	56.0 [44.5–65.0]	56.0 [46.5–62.0]	55.5 [51.0–60.5]	0.993
Sex, n (%)					
male	19 (52.8%)	19 (61.3%)	23 (59.0%)	12 (54.5%)	0.894
female	17 (47.2%)	12 (38.7%)	16 (41.0%)	10 (45.5%)	
Comorbidity, n (%)					
DM	12 (33.3%)	6 (19.4%)	8 (20.5%)	4 (18.2%)	0.427
Hypertension	12 (33.3%)	4 (12.9%)	9 (23.1%)	4 (18.2%)	0.233
Other	5 (13.9%)	6 (19.4%)	12 (30.8%)	5 (22.7%)	0.351
Previous stone procedure, n (%)					0.481
No Procedure	19 (52.8%)	19 (61.3%)	26 (66.7%)	14 (63.6%)	
Pnl	2 (5.6%)	5 (16.1%)	5 (12.8%)	3 (13.6%)	
Urs	6 (16.6%)	3 (9.7%)	6 (15.4%)	2 (9%)	
Eswl	9 (25.0%)	4 (12.9%)	2 (5.1%)	3 (13.6%)	

IQR: interquartile range, **DM:** diabetes mellitus, **PNL:** percutaneous nephrolithotomy, **URS:** ureteroscopy, **ESWL:** extracorporeal shock wave lithotripsy.

As age was not normally distributed, data are presented as median [IQR] and were compared using the Kruskal–Wallis test. Categorical variables were compared using Pearson's chi-square test.

Stone-related and radiological parameters were also largely similar across Sampaio subtypes. Stone side, stone size, stone area, stone volume, stone density, stone location, lower pole stone rate, infundibulopelvic angle, and infundibular length did not differ significantly between groups (Table 2). Infundibular width was the only parameter showing a significant overall difference among subtypes (p=0.031); however, post-hoc pairwise comparisons with Bonferroni correction did not reveal any statistically significant difference between individual groups (Table 3).

Table 2 Stone and radiological characteristics according to Sampaio classification

Variables	Type A1 (n=36)	Type A2 (n=31)	Type B1 (n=39)	Type B2 (n=22)	p value
Stone side, n (%)	18 (50.0)	10 (32.3)	14 (35.9)	11 (50.0)	0.344
right	18 (50.0)	21 (67.7)	25 (64.1)	11 (50.0)	
left					
Stone size (mm), median [IQR]	14.0 [10.0–17.0]	16.0 [11.0–20.0]	15.0 [10.5–19.0]	14.5 [12.2–18.0]	0.727
Stone area (mm^2), median [IQR]	95.0 [63.8–151.2]	140.0 [55.0–177.5]	110.0 [59.0–177.5]	102.5 [70.5–127.5]	0.946
Stone volume (mm^3), median [IQR]	657.4 [328.7–1249.7]	1142.2 [347.8–2017.0]	917.9 [376.6–1535.5]	729.6 [464.2–1438.0]	0.606
Stone density (HU), median [IQR]	1000 [522.5–1205]	920 [800–1140]	1050 [900–1250]	925 [722.5–1175]	0.239
Stone location, n (%)					0.589
upper pole	4 (11.1)	3 (9.7)	7 (17.9)	3 (13.6)	
middle pole	9 (25.0)	3 (9.7)	6 (15.4)	3 (13.6)	
lower pole	7 (19.4)	12 (38.7)	14 (35.9)	6 (27.3)	
renal pelvis	16 (44.4)	13 (41.9)	12 (30.8)	10 (45.5)	
Lower pole stone, n (%)	7 (19.4)	12 (38.7)	14 (35.9)	6 (27.3)	0.295
Infundibulopelvic angle (°),mean ± sd	68.9 ± 19.0	71.5 ± 21.6	69.4 ± 19.5	71.7 ± 17.1	0.918
Infundibular length (mm), median [IQR]	25 [21–28.2]	25 [23–28.5]	27 [22.5–29.5]	24.5 [22–28]	0.693
Infundibular width (mm), median [IQR]	5 [4–7]	6 [4–8.5]	6 [5–11.5]	6 [5–7]	***0.031***

HU: Hounsfield unit; **IQR:** interquartile range, **sd:** standard deviation

Variables that were not normally distributed (stone size, stone area, stone volume, stone density, infundibular length, and infundibular width) were presented as median [IQR] and were compared using the Kruskal–Wallis test. The IPA, which showed a normal distribution, was presented as mean ± sd and was compared using ANOVA.

Table 3 Post-hoc pairwise comparisons of infundibular width according to Sampaio classification

Comparison	Unadjusted p value	Bonferroni-adjusted p value
A1 vs A2	0.539	1.000
A1 vs B1	0.009	0.053
A1 vs B2	0.046	0.276
A2 vs B1	0.044	0.263
A2 vs B2	0.373	1.000
B1 vs B2	0.453	1.000

Data were analyzed using pairwise Mann–Whitney U tests following a significant overall Kruskal–Wallis test for infundibular width (p=0.031). Bonferroni correction was applied to account for multiple comparisons.

Operative and postoperative outcomes are summarized in Table 4. Access sheath use and operative time were comparable among the groups. Although the highest stone-free rate was observed in the B2 subtype (86.4%) and the lowest in the A1 subtype (55.6%), the overall difference in stone-free status did not reach statistical significance (p=0.109). Similarly, residual stone rates were numerically lower in the B2 subtype but did not differ significantly among groups. Only two postoperative adverse events were observed in the entire cohort: one case of postoperative pyelonephritis requiring antibiotic treatment in the A1 subtype and one postoperative death secondary to respiratory arrest in the B2 subtype. Because of the very low number of events, statistical comparison of complications was not performed.

Table 4 Operative and postoperative outcomes according to Sampaio classification

Variables	Type A1 (n=36)	Type A2 (n=31)	Type B1 (n=39)	Type B2 (n=22)	p value
Access sheath use, n (%)	30 (83.3)	28 (90.3)	34 (87.2)	19 (86.4)	0.869
Operative time (min), median [IQR]	60 [45–63.8]	60 [45–70]	60 [45–67.5]	47.5 [41.3–63.8]	0.798
SF status, n (%)	20 (55.6)	20 (64.5)	27 (69.2)	19 (86.4)	0.109
Residual stone, n (%)	16 (44.4)	11 (35.5)	12 (30.8)	3 (13.6)	0.109
Overall complications, n (%)	1 (2.8)	0 (0.0)	0 (0.0)	1 (4.5)	*N/A
Length of hospital stay (days), median [IQR]	1 [1–1]	1 [1–1]	1 [1–1]	1 [1–1]	†N/A

IQR: interquartile range.

As operative time was not normally distributed, data are presented as median [IQR] and were compared using the Kruskal–Wallis test. Categorical variables were compared using Pearson's chi-square test.

***** Statistical comparison of complications was not performed because only two events occurred in the entire cohort (one pyelonephritis and one death), resulting in insufficient statistical power.

† Length of hospital stay was not statistically compared because nearly all patients were discharged on postoperative day 1, resulting in minimal variability.

Although the overall comparison of SFRs among Sampaio subtypes was not statistically significant (p=0.109), exploratory pairwise analyses demonstrated a higher SFR in the B2 subtype compared with A1 (86.4% vs 55.6%; unadjusted p=0.021). However, this difference did not remain statistically significant after Bonferroni correction for multiple testing (adjusted p=0.126) (Table 5).

Table 5 Post-hoc pairwise comparisons of SF status

Comparison	Unadjusted p value	Bonferroni-adjusted p value	Significant
A1 vs A2	0.618	1.000	no
A1 vs B1	0.242	1.000	no
A1 vs B2	***0.021***	0.126	no
A2 vs B1	0.799	1.000	no
A2 vs B2	0.115	0.689	no
B1 vs B2	0.216	1.000	no

Pairwise comparisons were performed using Fisher's exact test. Bonferroni correction was applied for six pairwise comparisons.

In the logistic regression analysis, age, stone size, stone density, lower pole stone location, and Sampaio A2 or B1 subtypes were not significantly associated with stone-free status. In contrast, the Sampaio B2 subtype was associated with a higher likelihood of achieving stone-free status compared with A1 in both univariable analysis (OR: 5.07, 95% CI: 1.27–20.22; p=0.022) and multivariable analysis (OR: 5.52, 95% CI: 1.36–22.34; p=0.017). These findings suggest that B2 anatomy may be an independent predictor of postoperative stone-free status after RIRS (Table 6).

Table 6 Univariable and multivariable logistic regression analysis for independent predictors of SF status

Variable	Univariable OR (95% CI)	p value	Multivariable OR (95% CI)	p value
Age	1.01 (0.98–1.04)	0.458	—	—
Stone size (mm)	0.98 (0.91–1.05)	0.503	0.97 (0.90–1.05)	0.457
Stone density (HU)	1.00 (1.00–1.00)	0.450	1.00 (1.00–1.00)	0.453
Lower pole stone	0.70 (0.32–1.53)	0.369	0.60 (0.26–1.38)	0.226
Sampaio A2 vs A1	1.45 (0.54–3.90)	0.457	1.69 (0.61–4.70)	0.313
Sampaio B1 vs A1	1.80 (0.70–4.63)	0.223	2.19 (0.81–5.90)	0.122
Sampaio B2 vs A1	5.07 (1.27–20.22)	***0.022***	5.52 (1.36–22.34)	***0.017***

OR: odds ratio; **CI:** confidence interval; **HU:** Hounsfield unit. SF status was used as the dependent variable. A1 was used as the reference category for Sampaio classification. Variables included in the multivariable model were stone size, stone density, lower pole stone location, and Sampaio classification.

Discussion

This retrospective cohort study evaluated the association between Sampaio pelvicalyceal system anatomy and outcomes after retrograde intrarenal surgery. The main finding was that the B2 subtype was independently associated with postoperative stone-free status in multivariable analysis, whereas conventional stone-related factors, including stone size, stone density, and lower-pole stone location, were not independently associated with treatment success. Although the overall comparison of stone-free rates across the four Sampaio subtypes did not reach statistical significance, patients with the B2 subtype had the highest stone-free rate and the lowest residual stone rate, whereas those with the A1 subtype had the lowest stone-free rate. These findings suggest that pelvicalyceal system anatomy may contribute to postoperative stone clearance after retrograde intrarenal surgery.

The numerical differences in stone-free outcomes between subtypes should be interpreted cautiously because pairwise comparisons did not remain statistically significant after correction for multiple testing. Nevertheless, the independent association observed in multivariable analysis suggests that the Sampaio classification may capture anatomical characteristics not fully reflected by conventional lower-pole measurements, such as the infundibulopelvic angle, infundibular length, and infundibular width. The favorable outcome observed in the B2 subtype may reflect a more direct drainage pattern toward the renal pelvis, potentially facilitating endoscopic access, fragment mobilization, and postoperative clearance. In contrast, the A1 subtype, in which the midzone calyces are associated with both the superior and inferior calyceal groups, may represent a more complex collecting system configuration that could impair complete stone clearance. However, these anatomical explanations remain hypothesis-generating and should be confirmed in larger prospective studies.

Most previous retrograde intrarenal surgery studies have focused primarily on stone burden, stone location, and lower-pole anatomical parameters, while detailed pelvicalyceal branching patterns have been less frequently evaluated. A recent EAU Endourology Section methodological review reported that pelvicalyceal system anatomy was not systematically assessed in most randomized studies, and when evaluated, assessment was generally limited to lower-pole parameters [10]. Inoue et al. showed that an infundibulopelvic angle <45.8° and an infundibular width <7.8 mm were negative predictors of lower-pole calyceal accessibility during retrograde intrarenal surgery with reusable flexible ureteroscopes [5]. These findings support the concept that intrarenal anatomy can affect technical accessibility and treatment success.

The limited literature specifically evaluating the Sampaio classification also supports the potential clinical relevance of this anatomical system. Marroig et al. reported differences in lower-pole accessibility by Sampaio anatomy during flexible ureteroscopy, with the lowest accessibility in the A2 subtype [15]. Kirecci et al. evaluated 118 cases of flexible ureteroscopy and found that pelvicalyceal anatomy was significantly associated with the postoperative stone-free rate, with the highest rate in the B2 subgroup and the lowest in the A2 subgroup [7]. Our findings are partly consistent with these studies, particularly the favorable outcomes observed in the B2 subtype. However, unlike previous reports, the A2 subtype was not independently associated with stone-free status in our cohort. This discrepancy may be explained by differences in patient selection, stone distribution, imaging methodology, surgical technique, outcome definition, and limited subgroup sizes.

This study has several limitations. First, its retrospective, single-center design may have introduced selection bias and limited generalizability. The requirement for preoperative computed tomography urography and the exclusion of patients with preoperative double-J stenting, multiple stones, stones >3 cm, and urinary tract anomalies may also have resulted in a selected study population. Second, although all procedures were performed by experienced surgeons, surgical heterogeneity, including different flexible ureteroscope platforms, variable use of a suction ureteral access sheath, and individualized laser strategies, may have influenced postoperative outcomes. Third, the relatively small sample size after stratification into four Sampaio subtypes, especially the limited number of patients in the B2 group, may have reduced statistical power and contributed to wide confidence intervals in the regression analysis. In addition, radiological assessments were finalized by consensus between two radiologists experienced in genitourinary imaging; however, interobserver agreement for Sampaio classification and anatomical measurements was not formally quantified, which may limit reproducibility assessment. Finally, because clinically insignificant residual fragments <4 mm were included in the definition of stone-free status, direct comparison with studies using stricter definitions may be limited.

Despite these limitations, the study has several strengths, including a well-defined cohort, strict exclusion criteria, systematic computed tomography urography-based anatomical assessment, consensus-based radiological evaluation, and adjustment for relevant stone-related variables in multivariable analysis. Overall, these findings provide preliminary evidence that Sampaio-based pelvicalyceal system anatomy may have independent predictive value for stone-free outcomes after

retrograde intrarenal surgery. Further prospective multicenter studies with standardized imaging, surgical technique, and postoperative outcome assessment are needed to validate these results.

Conclusion

The Sampaio pelvicalyceal system classification was independently associated with postoperative stone-free status following retrograde intrarenal surgery. In particular, the B2 subtype showed higher odds of achieving stone-free status compared with the A1 subtype. These findings suggest that pelvicalyceal system anatomy may influence surgical outcomes and may be useful for preoperative risk stratification and patient counseling. Further prospective studies with larger cohorts are needed to validate these findings.

Declarations

Funding: No funding was received for conducting this study.

Competing Interests: The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval: This study was approved by the Clinical Research Ethics Committee of Aydın Adnan Menderes University Faculty of Medicine (Decision No: 2025/305) and was conducted in accordance with the Declaration of Helsinki.

Consent to Participate: Owing to the retrospective design of the study and the use of anonymized data, the requirement for informed consent was waived by the ethics committee.

Data Availability: The datasets analyzed during the current study are not publicly available due to patient privacy and institutional restrictions. De-identified data may be made available from the corresponding author upon reasonable request and subject to institutional approval.

Author Contributions: T.B. conceived and designed the study, contributed to data interpretation and literature review, and supervised the project. **M.T., O.A., and B.G.** contributed to study design, performed data collection, and assisted in manuscript drafting. **U.A.** contributed to data acquisition, imaging review, and interpretation of radiological findings. **C.O.** contributed to data curation, verification of analytical methods, and preparation of tables and figures. **A.E**. contributed to study design, contributed to data interpretation and literature review, performed the statistical analysis, and supervised the analytical methodology. **A.U. and M.G.** contributed to methodology refinement, interpretation of radiological findings, and substantial editing of the final manuscript. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Figures

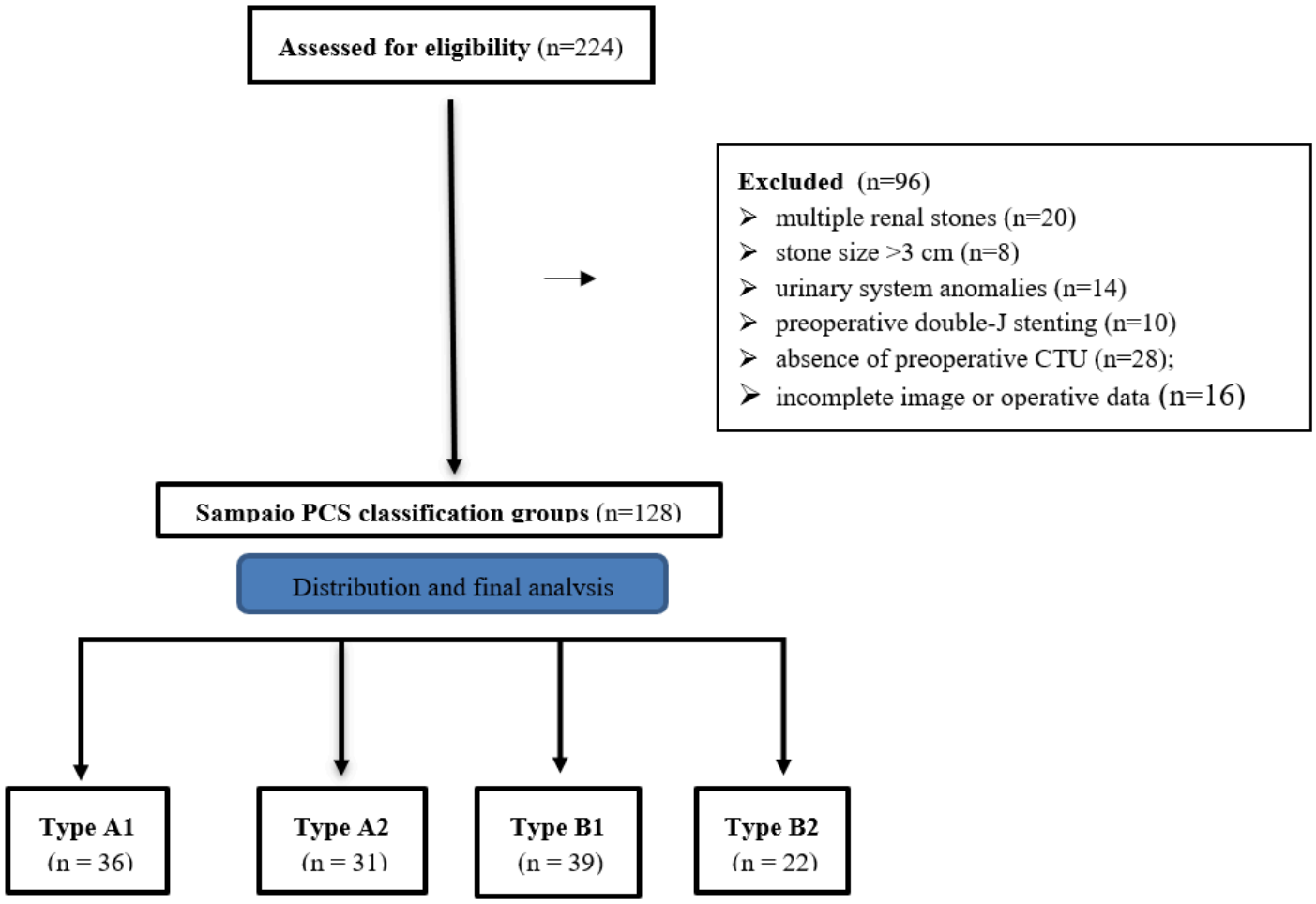


Figure 1

Flowchart of patient selection and final distribution according to the Sampaio pelvicalyceal system classification. Abbreviations: CTU, computed tomography urography; PCS, pelvicalyceal system

Outcome assessment

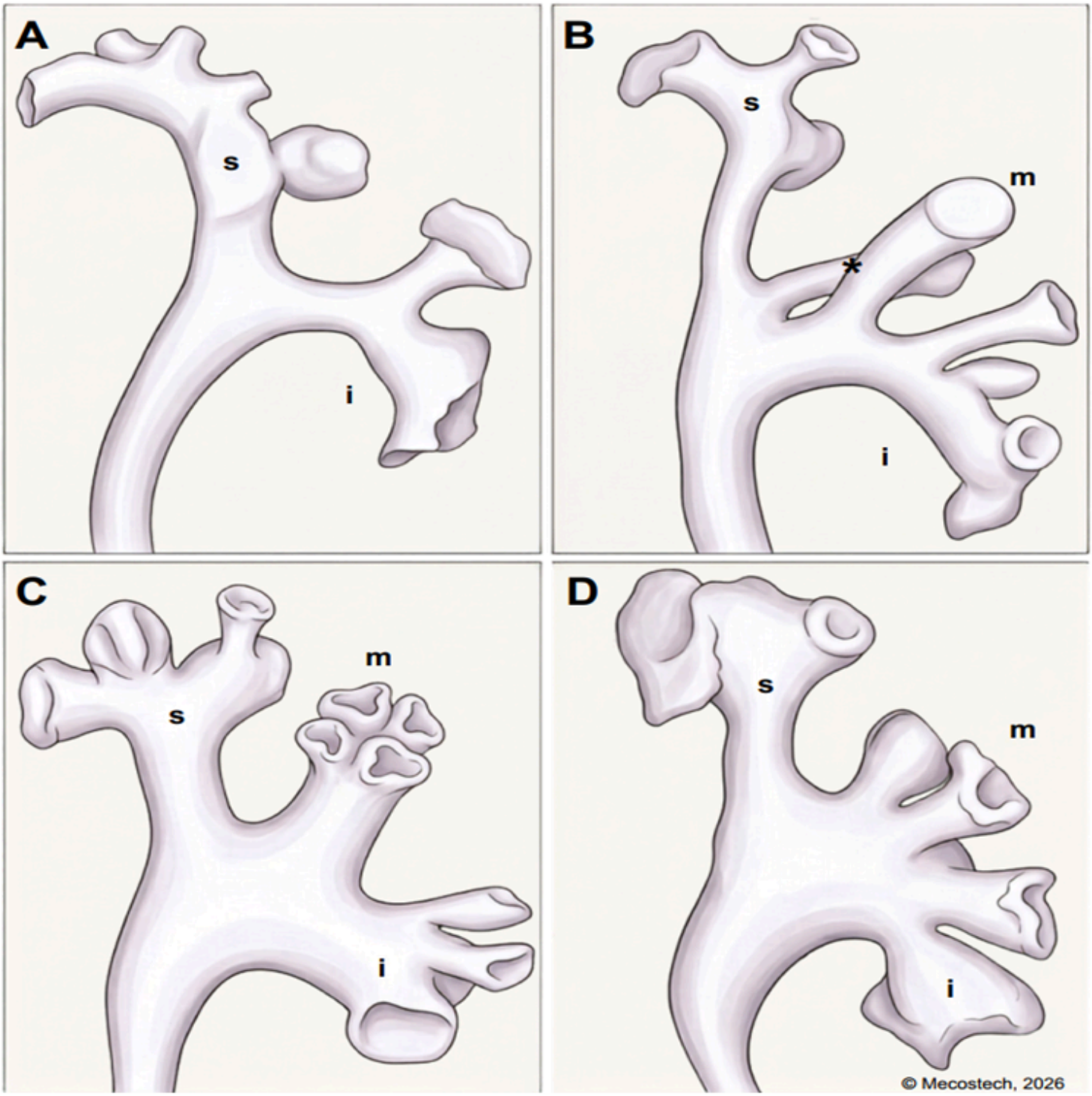


Figure 2

Schematic illustration of the Sampaio pelvicalyceal system classification, created by Mecostech Software Technologies Inc., Istanbul, Turkey, based on the original anatomical description by Sampaio et al. [6] (A) Group A1: midzone calyces are drained by minor calyces associated with both the superior and inferior calyceal groups. (B) Group A2: midzone calyces are drained by crossing calyces associated with the superior and inferior calyceal groups (*). (C) Group B1: midzone calyces are drained by an

independent hilar major calyx. (D) Group B2: midzone calyces drain directly into the renal pelvis via minor calyces. s, superior calyceal group; i, inferior calyceal group; m, midzone calyces.