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Diagnostic Yield and Complications of Tangential Versus Non-Tangential Ultrasound-Guided Percutaneous Kidney Biopsy in Children

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Abstract

Background:

Ultrasound-guided percutaneous kidney biopsy is an essential diagnostic procedure for children with suspected kidney disease. Limited evidence suggests that a tangential approach may improve tissue adequacy while reducing complications. This study compared the diagnostic yield and safety of tangential and non-tangential ultrasound-guided native kidney biopsy techniques in children.

Methods:

This comparative study included children undergoing native kidney biopsy at a tertiary pediatric nephrology center. The non-tangential group included 137 children who underwent ultrasound-guided kidney biopsy from March to August 2025 and were identified retrospectively. The tangential group included 137 children who underwent real-time ultrasound-guided tangential kidney biopsy from September 2025 to February 2026 and were enrolled prospectively. The primary outcomes were biopsy-related complications and tissue adequacy.

Results:

A total of 274 children were included, with 137 patients in each group. Baseline demographic characteristics were comparable between the groups. Overall, biopsy-related complications occurred in 48 patients (18%). Complications were more frequent in the tangential group than in the non-tangential group, occurring in 31 of 137 patients (23%) and 17 of 137 patients (12%), respectively ($p = 0.026$). Hematuria, which did not require intervention, was the most common complication occurring in 25 patients (18%) in the tangential group and 15 patients (11%) in the non-tangential group. Sample adequacy was similar in both groups.

Conclusion:

Both tangential and non-tangential ultrasound-guided native kidney biopsy techniques provided comparable sample adequacy and were associated with minor complications. However, the overall complication rate was higher with the tangential approach. No major complications occurred in either group.

Introduction:

Real-time ultrasound-guided percutaneous kidney biopsy is the most commonly used technique for obtaining renal tissue for the evaluation of several kidney disorders []. Establishing an accurate

clinicopathological diagnosis depends on obtaining an adequate tissue sample while minimizing procedure-related complication [].

There are no universally accepted recommendations regarding the optimal needle trajectory [,]. Traditionally, kidney biopsies are performed using a non-tangential approach. More recently, a tangential approach has been proposed as a potentially safer technique with improved tissue yield specially in adults and transplanted kidneys. [3–].

Studies in adults have suggested that the tangential approach may provide greater sample adequacy with fewer biopsy-related complications compared with the conventional non-tangential technique. However, evidence evaluating this approach in children remains limited [].

Major complications include bleeding requiring an intervention, such as blood transfusion, bladder irrigation, radiological intervention, or surgery, whereas minor complications are self-limiting and do not require therapeutic intervention [,]. In addition to procedural safety, tissue adequacy is an important determinant of biopsy quality. The number of glomeruli required for adequate interpretation varies according to the underlying renal pathology.[,].

Given the limited pediatric evidence comparing biopsy trajectories, this study aimed to compare the safety and diagnostic yield of tangential and non-tangential ultrasound-guided percutaneous renal biopsy approaches in children.

Materials and Methods

1. Study design and pre-biopsy assessment

This was a single-center comparative cohort study with a historical control group. The historical cohort (Group A) included 137 pediatric patients who underwent percutaneous renal biopsy using the conventional non-tangential approach from March 2025 to August 2025. Following introduction of the tangential technique, pediatric patients undergoing real-time ultrasound-guided kidney biopsy using the tangential approach were prospectively recruited from September 2025 to March 2026 and were included in Group B.

The study was approved by the institutional Ethics Review Committee. Written informed consent for the biopsy procedure was obtained from the parents or legal guardians after explaining the procedure and its potential complications.

Before biopsy, all patients underwent routine investigations and ultrasonography for assessment of kidney size was done. For all children with severe kidney failure, we performed two consecutive days of dialysis before biopsy. Anesthesia clearance was obtained where required. Patients with uncontrolled hypertension, coagulation abnormalities, or other correctable risk factors were stabilized before proceeding with the biopsy.

1. Kidney Biopsy Procedure

Kidney biopsies were performed by a fellow pediatric nephrologist under cover of sedation or general anesthesia, with patients in the prone position. Up to two cores were obtained from the lower pole of the left kidney under real-time ultrasound guidance provided by an experienced radiologist.

Ultrasound guidance was performed using a high-resolution Canon Xario scanner with a 3.5–5 MHz convex probe. An 18-gauge spring-loaded biopsy needle (Geotek MaxiCore-M) was used in all cases.

Following sedation, 2% lignocaine was infiltrated into the skin, subcutaneous tissue, and perinephric tissues, and a small stab incision was made to facilitate needle passage. In Group A, the conventional non-tangential approach was used, with the biopsy needle introduced perpendicular to the renal capsule at the lower pole of the kidney. In Group B, the needle was introduced tangentially at an angle of 45–60° to the renal capsule, with the needle tip directed away from the renal hilum toward the corticomedullary junction along Brödel's line, a relatively avascular plane between the anterior and posterior segmental branches of the renal artery (Figure: 1).

Each biopsy core was examined under a dissecting microscope by a histopathology technician to assess the presence and adequacy of glomeruli.

1. Post-biopsy monitoring

Following the procedure, patients were kept under observation in supine position for at least 2 hours. Vital signs were monitored, urine was examined for gross hematuria, and renal ultrasonography was performed after 4–6 hours. Patients with macroscopic hematuria remained admitted until resolution, while those with perirenal hematoma underwent repeat ultrasonography as required.

Sample Analysis

Biopsy samples were initially examined under a light microscope in the procedure room and were then sent to the histopathology department in formalin, normal saline and glutaraldehyde solutions. Specimens were processed and stained according to standard laboratory protocols and examined by light microscopy. Immunofluorescence microscopy was also performed. A biopsy sample was considered suboptimal if it was insufficient to establish a diagnosis.

Statistical Analysis

Statistical analysis was performed using SPSS version 26. Continuous variables with a normal distribution were expressed as mean ± standard deviation, while skewed variables were presented as median with interquartile range (IQR). Categorical variables were reported as frequencies and percentages.

Categorical variables, including complication rates, biopsy adequacy, and indications for biopsy, were compared between the two groups using the chi-square test or Fisher's exact test, as appropriate.

Continuous variables, including the number of cores and glomeruli obtained, were compared between the two biopsy groups using the independent- samples t-test.

Results

A total of 274 children were included in the study, with 137 patients in each group. Baseline demographic characteristics were comparable between the groups. In both the groups the median age and gender distribution was similar. Nephrotic syndrome was the most common indication for kidney biopsy, accounting for 62 (45%) of biopsies in the tangential group and 84 (61%) in the non-tangential group. The sample was adequate in almost all the patients in both groups (Table 1).

Overall, biopsy-related complications occurred in 48 (18%) patients. In the tangential group complications were more frequent occurring in 31 (23%) children versus 17 (12%) patients had complications in the non-tangential group. This difference was statistically significant with a p value of 0.026. Out of all the patients who had a complication in the tangential group (n = 31), 25 (81%) had gross hematuria and 6 (19%) had perinephric collection. Similarly in the non-tangential group with complications (n = 17), 15 (88%) had gross hematuria and 2 (12%) had perinephric collection. No other major complications were observed in either group (Table 2).

Analysis of patients who developed complications revealed that in the tangential group the median estimated glomerular filtration rate (eGFR) was lower (83 vs 140ml/min/1.73 m^2 with p value of 0.04) and greater number of children required dialysis 11 (35%) vs 4 (24%). (Table 2). There was no other identifiable risk factor for increased frequency of complication seen in either group

Table 1
Subject characteristics at the time of kidney biopsy

Total patients	**Non tangential approach**	**Tangential approach**	**Total**
	137	**137**	**274**
Gender			
Female	62 (45%)	59 (43%)	121 (44%)
Male	75 (55%)	78 (57%)	153 (56%)
Median age (years)	8 (4.5–11)	9 (5.5–12)	
BMI (kg/m2)	15.6 (13.9–16.9)	15.8 (14.3–17.6)	
Numbers of attempts			
1	38 (28%)	42 (31%)	80 (30%)
2	96 (70%)	89 (65%)	185 (68%)
> 2	3 (2%)	6 (4%)	9 (3%)
Number of glomeruli	16 (10–22)	15.5(12–20)	
Adequate Sample	136 (99%)	136(99%)	
Clinical diagnosis prior to biopsy			
Nephrotic syndrome			
SRNS	73(54%)	53(39%)	126(46%)
SDNS	11(8%)	9(7%)	20(7%)
Cyclophosphamide failure			
Renal failure			
RPGN	16(12%)	17(12%)	33(12%)
Unknown cause	16(12%)	19(14%)	35(13%)
Lupus Nephritis	7(5%)	10(7%)	17(6%)
Others	14(10%)	29(21%)	43(16%)

BMI body mass index, SDNS steroid dependent nephrotic syndrome, SRNS steroid resistant nephrotic syndrome, RPGN rapidly progressive glomerulonephritis

Table 2
A comparison of complications arising following biopsies using the non-tangential and tangential techniques

Complications	**Non-tangential**	**Tangential**	**p value**	**Total**
Yes	17 (12.4%)	31 (22.6%)	0.026	48 (17.5%)
No	120 (87.6%)	106 (77.4%)		226 (82.5%)
Total	137 (100%)	137 (100%)		274 (100%)
Specific complications (N = 48)				
Complications	**Non-tangential**	**Tangential**	**P value**	**Total**
Hematuria	15 (10.9%)	25 (18.2%)	0.087	32 (11.7%)
Perinephric collection	2 (1.5%)	6 (4.4%)	0.2	8 (2.9%)
Need of transfusion	0	0		0
No complications	120 (87.6%)	106 (77.4%)		226 (82.5%)
Total	137 (100%)	137 (100%)		274 (100%)
Patient characteristics with complications (N = 48)				
Character	**Non-tangential (n = 17)**	**Tangential (n = 31)**	**P value**	**Total**
Median age in years (IQR)	6(4–12)	9 (6–10)	0.8	48
Serum creatinine (mg/dl)	0.62	1.09	0.08	48
Estimated glomerular filtration rate	140	83	0.04	48
Dialysis requirement	4(23%)	11 (35%)	0.40	15
Comparison of tangential group with and without complication n = 137				

Complications	Non-tangential	Tangential	p value	Total

Character	Complications n= (31)	No Complications n = 106	P value
Median age in years (IQR)	9 (6–10)	10(5–13)	0.08
Serum creatinine (IQR)	1.09(0.34–4.2)	0.37(0.21–0.81)	0.04
Glomerular filtration rate (IQR)	83(16–177)	176(90–276)	0.002
Dialysis requirement	11(35%)	18(17%)	0.02

Discussion

Real-time ultrasound-guided percutaneous native kidney biopsy in children is an established diagnostic procedure with its inherent complications. [] Most of the literature regarding its techniques and complication rates does not consider the differences of a transplanted kidney versus a native kidney, the smaller size of the kidneys in different age groups of children as compared to adults and the altered homeostasis in kidney failure. [] Different needle trajectories have been described for percutaneous kidney biopsy with better results mostly in adult and transplanted kidneys. [5] Our study is unique because it was done only on native kidneys of children and the ultrasound guidance was given by the same radiology consultant. Most of the variables in both groups were almost same and the only difference was in the trajectory of the biopsy needle.

The overall rate of complication post biopsy with no major bleeding episode requiring intervention in either group was comparable to most other similar cohorts which can be attributed to thorough pre-operative preparations including general anesthesia to minimize the risk of moving during the procedure and availability of a histopathology technician to evaluate the sample in the operating room and thereby minimizing the number of passes made to obtain the sample.

We found a statistically significant risk of gross hematuria in our cohort where the tangential needle trajectory was used. This is in contrast with previous studies suggesting this approach may improve tissue adequacy and reduce the risk of complications. [,]. We hypothesize that the smaller kidney size of children increases the risk of injuring the minor calyx in the tangential approach; thereby; leading to higher frequency of gross hematuria. (Fig. 1) Moreover the edematous (echogenic) parenchyma of the kidney with altered platelet adhesion due to kidney failure may also contribute to this higher observed frequency in our cohort.

We also observed a relatively higher frequency of perinephric collection with tangential approach which is in contrast with the reported frequency by Pettit C et al from Australia who have reported 72/173 (42%) in non-tangential and 20/72 (28%) in tangential approach. [] This difference could be due to the timing of repeat ultrasound done in both cohorts. We performed post-biopsy ultrasound minimum 3 hours post procedure while in the Australian cohort it was done immediately after the procedure. It is likely that small perinephric collections seen immediately after the procedure had been resolved in our cohort by the time an ultrasound was performed.

A lower estimated eGFR and presence of kidney failure stood out as a risk factor for hematuria and perinephric collection in the tangential group in our study. This agrees with studies who have identified children at increased risk of complications along with younger age, anemia and systemic vasculitis. [-18]. Although significant hemostasis abnormalities are seen mostly with severe kidney failure (eGFR < 30) [], we have observed increased frequency of bleeding complications with eGFR up to 80ml/min/1.73 m2) especially in the tangential group. The sample size of this subgroup was too small to yield a conclusive result, however future studies to examine this aspect are recommended.

Needle gauge may also influence both tissue adequacy and procedural safety. In the present study, an 18-gauge biopsy needle was used consistently in both groups. The use of a single needle gauge in both study groups reduced procedural variability attributable to needle size. This differs from protocols in which 18-gauge needles are used in younger children and 16-gauge needles in older patients. [] This same gauge needle approach did not affect the adequacy of sample in our cohort.

This study has several limitations. First, its am bidirectional design, involving a historical control group and a prospectively recruited intervention group, may have introduced information bias and temporal confounding. Second, the allocation of patients to the two biopsy techniques was not randomized, and unmeasured differences between the groups may therefore have influenced the observed complication rates. Third, the study was conducted at a single center and included a relatively limited sample, particularly for assessing uncommon major complications. Larger, multicenter, randomized studies are needed to confirm these findings and identify patient- and procedure-related factors that may influence the relative safety of the two techniques.

Conclusion

The tangential and non-tangential real time ultrasound-guided percutaneous native kidney biopsy techniques in children demonstrated equivalent diagnostic yield in both groups. There was no major complication seen in either group requiring any transfusion or surgical intervention. A higher frequency of gross hematuria and perinephric collection was seen with the tangential approach in our cohort especially in children with lower eGFR and kidney failure requiring dialysis.

Nevertheless, interpretation should account for the study's non-randomized, am bidirectional, single-center design. Further prospective, multicenter studies with randomized allocation are required to

determine the preferred needle trajectory for ultrasound-guided percutaneous native kidney biopsy in children.

Author's contributions Conceptualization: HQ, AL and SA; Methodology: IA and SA; Investigations: AML and SA; Formal analysis: SA and HQ; Data curation: HQ, SA and IA, Writing (Original Draft): SA, HQ and MA, Writing (Review and Editing): AL, IA, MA; Supervision: AL. All authors approved the final manuscript

Declarations

Ethics approval

Ethical review committee of Sindh Institute of Urology and Transplantation approved the study with number SIUT-ERC-2025/A-580

Consent to participate

Consent from the study participants was undertaken

Assistance of artificial intelligence

Artificial intelligence tool Chat GPT-5 was used for language editing and grammar correction

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Data availability

Datasets analyzed in this study are not publicly available to protect the privacy of research participants and to comply with the regulations of the ethics approval. However, it would be available from the corresponding author upon reasonable request.

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Figures

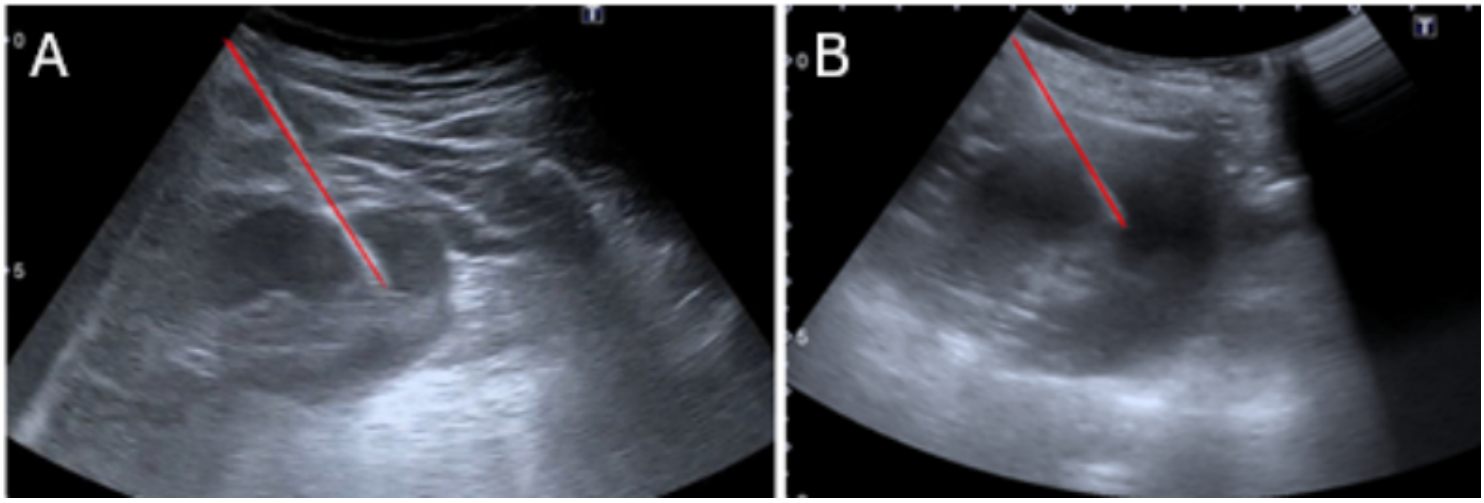

Figure 1

Kidney needle biopsy trajectory in tangential technique with needle (red line) at an angle of 60 degree to renal capsule. A. Longitudinal view B. Transverse view

Supplementary Files

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- STROBEchecklistBiopsy.docx