Association Between Posterior Horn Dimensions of the Medial Meniscus and Posterior Horn Tears in Young Individuals: An MRI-Based Study

Shaafiya Ashraf[1], Arshed Hussain Parry[1]*, Sheetal Sharma[1], Arshad Bashir[2], Adnan Zahoor[3], Anil Sharma[1]

[1]Department of Radiodiagnosis and Imaging, Government Medical College, Srinagar, Jammu & Kashmir, India

[2]Department of Orthopaedics, Government Medical College, Srinagar, Jammu & Kashmir, India

[3]Department of Orthopaedics, Shifa Medical Center, Srinagar, Jammu & Kashmir, India

*Corresponding author: Arshed Hussain Parry

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Abstract

Objective: To evaluate the association between medial meniscus posterior horn dimensions and posterior horn tears on MRI in young individuals and to derive a candidate size threshold within the study cohort.

Material and Methods: This retrospective study included 554 patients aged 15–40 years, divided into tear and non-tear groups based on MRI findings. Meniscal size was assessed by measuring the anteroposterior (AP) diameter of the medial meniscus posterior horn on sagittal MRI images and the transverse diameter on coronal images. Measurements were compared between groups. Receiver operating characteristic (ROC) analysis was performed using the Youden Index to determine optimal cut-off values. Multivariable logistic regression analysis including posterior horn dimensions, age, sex, and body mass index (BMI) was performed to evaluate independent association with posterior horn tears. Interobserver reliability was assessed using intraclass correlation coefficient (ICC).

Results: The tear group demonstrated a significantly larger AP diameter of the medial meniscus posterior horn (18.77 ± 2.29 mm) compared with the non-tear group (14.36 ± 1.64 mm, $p < 0.001$). Similarly, the transverse diameter was significantly greater in the tear group (19.48 ± 2.75 mm) than in the non-tear group (14.45 ± 1.63 mm, $p < 0.001$). A cut-off value of ≥17 mm for AP diameter showed a sensitivity of 85.7%, specificity of 90.7%, and AUC of 0.943, while the same cut-off for transverse diameter demonstrated a sensitivity of 92.3%, specificity of 90.7%, and AUC of 0.955. Multivariable logistic regression confirmed that both AP and transverse diameters were independently associated with posterior horn tears after adjustment for age, sex, and BMI. Interobserver reliability showed excellent agreement for both AP (ICC = 0.91) and transverse (ICC = 0.92) measurements.

Conclusion: Larger medial meniscus posterior horn dimensions were associated with MRI-defined posterior horn tears in this retrospective cohort. A threshold of ≥17 mm was derived and evaluated in the same study cohort. It should be regarded as an exploratory morphometric marker rather than an independently validated clinical decision threshold. These findings do not establish that larger dimensions precede or cause tears.

Keywords: Medial meniscus; posterior horn tear; posterior horn dimensions; morphometric assessment; MRI

Introduction

The menisci are crescent-shaped fibrocartilaginous structures that deepen the tibial articular surfaces and play a critical role in load transmission, shock absorption, joint stability, and lubrication of the knee joint [1]. The medial meniscus transmits approximately 45–75% of axial load across the knee and covers nearly 50% of the articular cartilage contact area in the medial compartment [2,3,4]. Structurally, the meniscus is composed predominantly of type I collagen fibers arranged circumferentially with radial tie fibers, allowing conversion of compressive forces into tensile hoop stresses that are transmitted to the meniscal attachments and underlying bone [5].

Disruption of this structural organization due to meniscal tears leads to altered load distribution across the knee joint and contributes to early cartilage degeneration and osteoarthritis, even in younger individuals [5,6]. Meniscal injuries are among the most common knee injuries, with an incidence of 12–14% and a prevalence of approximately 61 cases per 100,000 population [7].

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Previous studies have suggested that meniscal morphology may influence susceptibility to injury, with broader menisci potentially exposed to greater mechanical stress and therefore more vulnerable to structural failure [8,4]. Morphometric variations such as discoid meniscus have also been associated with increased tear prevalence [9]. However, despite the recognized importance of meniscal morphology, limited data are available regarding the specific relationship between posterior horn dimensions of the medial meniscus and posterior horn tears.

The present study aimed to evaluate the association between medial meniscus posterior horn size and posterior horn tears in young individuals using MRI-based morphometric assessment and to derive a candidate threshold within the study cohort.

Material and Methods

Patient Selection

A total of 604 patients were assessed. Among them 50 were excluded due to failure to meet inclusion criteria. The final cohort comprised 554 patients, of whom 273 (49.3%) had posterior horn medial meniscus tears, while 281 (50.7%) had no tear (Figure 1). Eligible participants were aged between 15 and 40 years and had undergone knee MRI for clinical indications including knee pain, swelling, restricted range of motion, sensations of locking or catching, episodes of giving way, inability to bear weight, or knee pain following trivial trauma. Patients with a prior history of knee surgery, high-impact trauma, multiple ligamentous injuries, or contraindications to MRI —such as non-MRI-compatible implants or claustrophobia—were excluded.

Based on MRI findings, patients were categorized into two groups: those with and those without medial meniscus posterior horn tears.

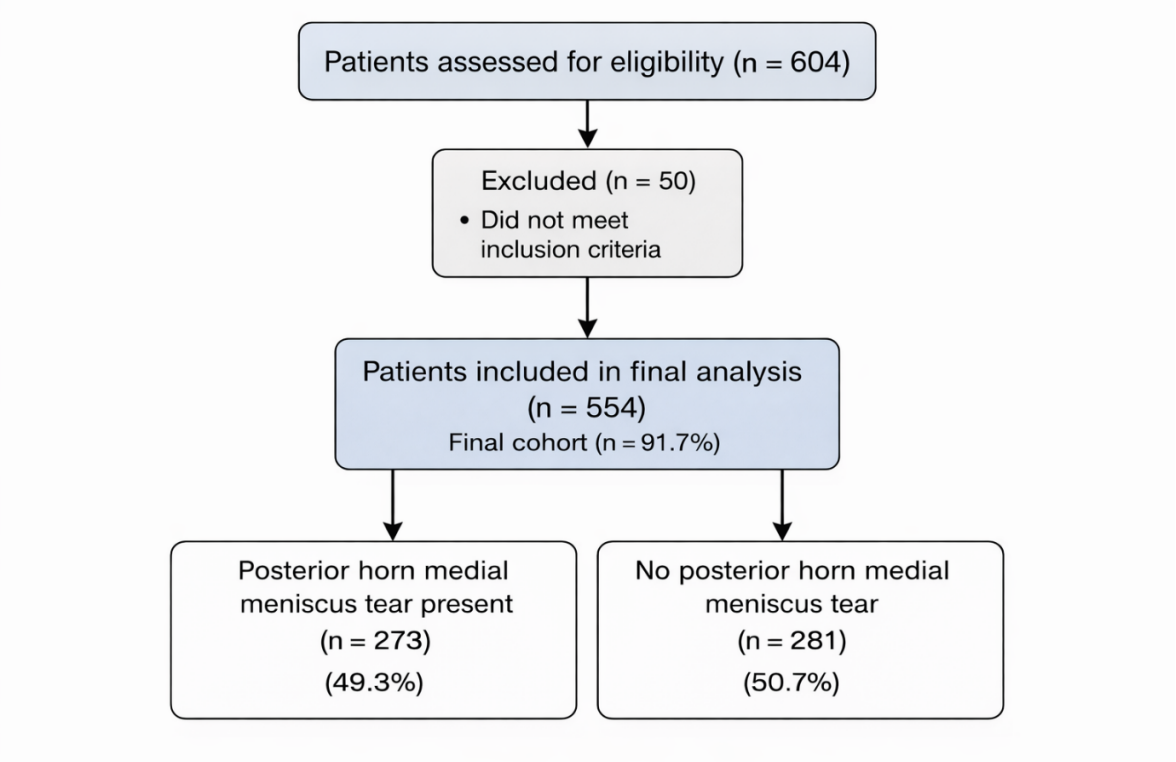


Figure 1. Flowchart illustrating patient selection and distribution of study participants based on the presence or absence of posterior horn medial meniscus tears.

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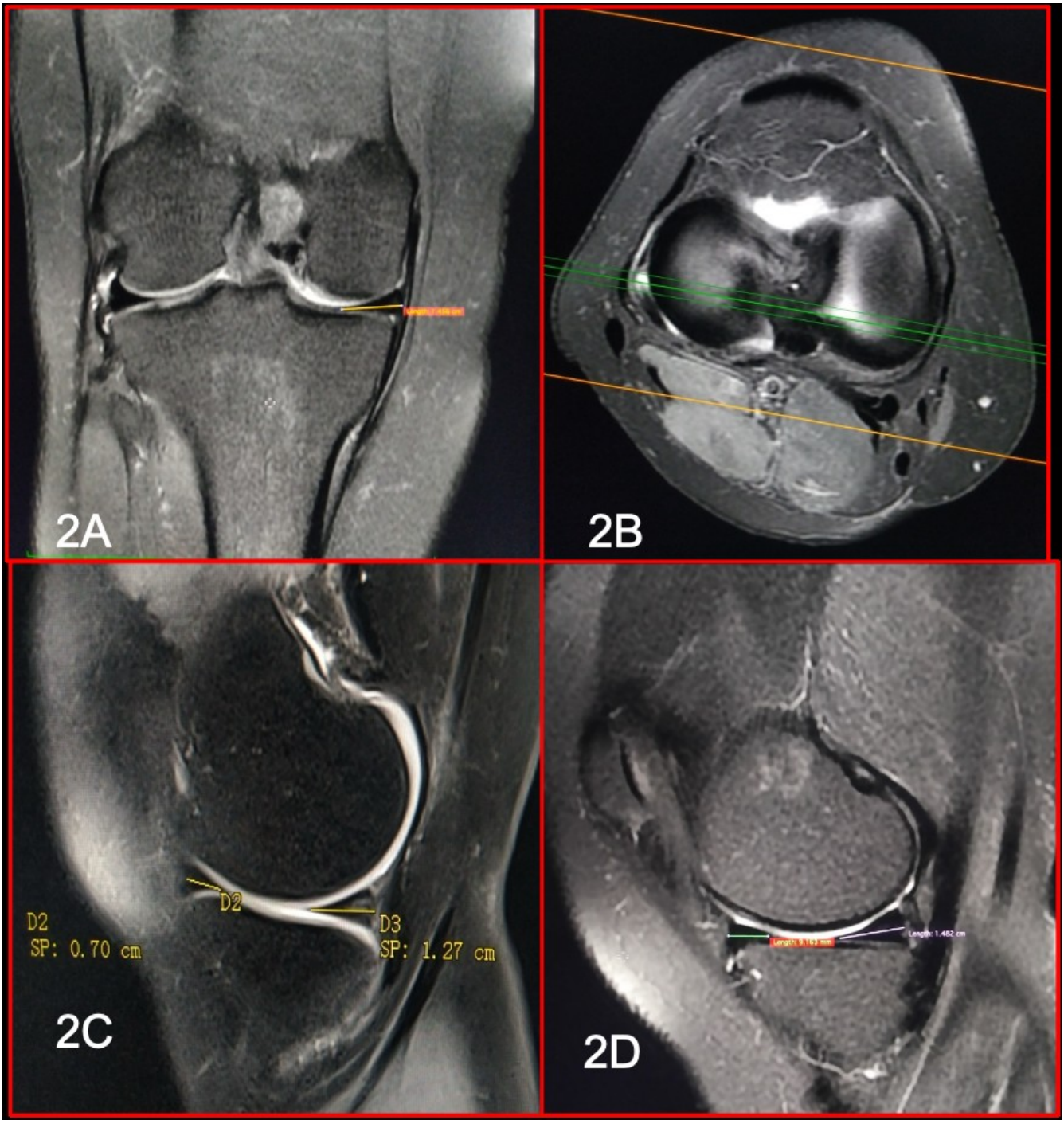


Figure 2. MRI-based measurement technique for medial meniscus posterior horn dimensions in normal menisci. (A) Coronal proton density fat-saturated (PD FS) image demonstrating measurement of the transverse diameter of the posterior horn from the section immediately anterior to the posterior horn–root ligament junction. (B) Corresponding axial T2 fat-saturated image showing slice selection for coronal measurement. (C) Sagittal PD FS image demonstrating measurement of the anteroposterior (AP) diameter of the posterior horn at its maximum extent. (D) Sagittal T2 fat-saturated image showing comparative AP measurement of the anterior horn in the same patient. All measurements were performed along preserved meniscal contours using standardized anatomical landmarks.

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Imaging Protocol and Meniscal Assessment

All MRI examinations were performed using a 1.5-Tesla MRI system (GE Healthcare Brivo MR355, USA) equipped with an 8-channel phased-array knee coil.

A three-plane localizer was acquired at the beginning of each examination to accurately plan subsequent imaging sequences. The routine knee MRI protocol included imaging in sagittal, coronal, and axial planes, comprising sagittal proton density (PD)/T2 fat-saturated (FS), sagittal T1 fast spin-echo (FSE), sagittal MERGE, coronal PD FS, coronal T1-weighted, coronal short tau inversion recovery (STIR), and axial PD FS sequences.

For detailed meniscal evaluation, coronal intermediate-weighted turbo spin-echo images (repetition time/echo time, 2325/30 ms; echo train length, 12; section thickness, 3 mm; in-plane resolution, 0.5–1 mm) and sagittal T2 fat-saturated images (repetition time/echo time, 2270/24 ms; echo train length, 5; section thickness, 3 mm; in-plane resolution, 0.5–1 mm) were utilized.

Meniscal size assessment focused on two measurements of the medial meniscus posterior horn: the anteroposterior (AP) diameter and the transverse diameter. The AP diameter was measured on sagittal images demonstrating the maximum anteroposterior extent of the posterior horn (measurement “a”). For comparative purposes, the AP diameter of the anterior horn was measured in the same sagittal section (measurement “b”) (Figure 2). The transverse diameter was measured on coronal images, specifically from the section immediately anterior to the slice demonstrating the posterior horn along with the meniscal root ligament (measurement “c”), as illustrated in Figure 2.

To minimize measurement bias related to tear-associated deformation, posterior horn dimensions were measured only along preserved and clearly identifiable meniscal contours. In cases with posterior horn tears, measurements were performed at the maximum dimension of the posterior horn where the native meniscal morphology remained intact and the outer contour could be reliably delineated. Areas showing marked distortion, fragmentation, displaced meniscal fragments, or severe maceration were avoided during measurement. All measurements were obtained using the picture archiving and communication system (PACS) digital caliper tool by identifying the slice demonstrating the maximum measurable posterior horn dimensions while preserving anatomical contour integrity.

Patients with severely deformed posterior horn tears in whom accurate anatomical delineation of the meniscal margins was not possible were excluded from quantitative morphometric analysis. This approach was adopted to reduce the potential influence of tear-related morphological alteration on measured meniscal size and to ensure that the recorded dimensions reflected the original meniscal morphology as accurately as possible.

Meniscal tears were defined as linear high-signal intensities on fluid-sensitive sequences extending to either the superior or inferior articular surfaces of the meniscus and visualized on at least two consecutive image slices. Based on these criteria, patients were classified into medial meniscus posterior horn tear and non-tear groups.

Two independent radiologists, each with more than 10-years of experience in MRI interpretation, independently measured the posterior horn dimensions while blinded to the clinical details and tear status of the patients. Measurements were performed using the same predefined anatomical landmarks as described above.

To assess measurement reproducibility, interobserver reliability analysis was performed for the anteroposterior (AP) and transverse diameter measurements of the medial meniscus posterior horn. Interobserver agreement was evaluated using the intraclass correlation coefficient (ICC) with a two-way random-effects model and absolute agreement definition. ICC values were interpreted as follows: values less than 0.50 indicated poor agreement, 0.50–0.75 moderate agreement, 0.75–0.90 good agreement, and greater than 0.90 excellent agreement. Ninety-five percent confidence intervals (95% CI) were also calculated for each ICC value.

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Statistical Analysis

Data were recorded using Microsoft Excel spreadsheets. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as percentages. Differences in posterior horn dimensions between patients with and without meniscal tears were analyzed using the independent samples t-test.

To evaluate whether posterior horn dimensions were independently associated with medial meniscus posterior horn tears, multivariable logistic regression analysis was performed. The presence of posterior horn tear (tear present vs. tear absent) was used as the dependent variable. Independent variables included posterior horn anteroposterior (AP) diameter, posterior horn transverse diameter, age, sex, and body mass index (BMI).

Adjusted odds ratios (ORs) with 95% confidence intervals (95% CI) were calculated for each variable. Variables with p-values less than 0.05 were considered statistically significant independent predictors of posterior horn tears. The regression model was used to assess whether increased posterior horn dimensions remained significantly associated with tears after controlling for demographic and anthropometric factors.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of posterior horn anteroposterior (AP) and transverse diameters for identifying medial meniscus posterior horn tears. The optimal cut-off value for each measurement was determined using the Youden Index (sensitivity + specificity − 1), which identifies the threshold providing the best balance between sensitivity and specificity.

In addition to sensitivity and specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated to further assess the clinical usefulness of the selected cut-off values. Area under the curve (AUC) with 95% confidence intervals was also used to assess overall discriminative performance.

Results

The study population comprised 554 individuals aged 15 to 40 years, with a mean age of 30.51 ± 6.72 years.

No statistically significant difference in age was observed between patients with and without meniscal tears. Anthropometric parameters, including height, weight, and body mass index (BMI), also did not differ significantly between tear and non-tear groups. Similarly, no statistically significant difference in tear prevalence was observed between male and female patients.

The medial meniscus posterior horn diameter was significantly greater in knees with medial meniscus posterior horn tears compared to those without tears in both dimensions. In the transverse plane, the mean diameter was higher in the tear-present group (19.48 ± 2.75 mm) than in the tear-absent group (14.45 ± 1.63 mm) ($p < 0.001$). Similarly, the anteroposterior diameter was significantly increased in cases with tears (18.77 ± 2.29 mm) compared to non-tear cases (14.36 ± 1.64 mm) ($p < 0.001$) (Table 1) (Figure 3).

Using a cut-off value of ≥17 mm, both anteroposterior and transverse posterior horn diameters showed strong diagnostic performance for identifying MRI-defined medial meniscus posterior horn tears within this cohort. The AP diameter demonstrated a sensitivity of 85.7% and specificity of 90.7%, while the transverse diameter showed higher sensitivity (92.3%) with the same specificity (90.7%). These findings indicate that a posterior horn diameter ≥17 mm, particularly in the transverse dimension, is strongly associated with the presence of medial meniscus posterior horn tears (Table 3, 4) (Figure 4).

Interobserver reliability analysis demonstrated excellent agreement for both posterior horn measurements. The ICC for the anteroposterior (AP) diameter of the medial meniscus posterior horn was 0.91 (95% CI: 0.87–0.94), indicating excellent reproducibility. Similarly, the transverse diameter showed excellent interobserver agreement with an ICC of 0.92 (95% CI: 0.90–0.96). These findings support measurement reproducibility; they do not independently validate the proposed threshold.

Multivariable logistic regression analysis demonstrated that both posterior horn AP diameter and transverse diameter were independently associated with medial meniscus posterior horn tears after adjustment for age, sex, and BMI.

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For each 1 mm increase in posterior horn AP diameter, the odds of having a posterior horn tear increased significantly (adjusted OR: 1.82; 95% CI: 1.56–2.13; p < 0.001). Similarly, each 1 mm increase in transverse diameter was independently associated with a higher likelihood of tear (adjusted OR: 2.04; 95% CI: 1.71–2.42; p < 0.001) (Table 2).

Age, sex, and BMI did not demonstrate statistically significant independent associations with posterior horn tears in the adjusted model (p > 0.05 for all variables).

These findings confirm that increased posterior horn dimensions are independently associated with posterior horn medial meniscus tears, irrespective of baseline demographic or anthropometric characteristics.

ROC analysis demonstrated excellent diagnostic performance for both posterior horn AP and transverse diameters in predicting medial meniscus posterior horn tears, with AUC values of 0.943 and 0.955, respectively (Figure 5). The optimal cut-off value for both measurements was identified as ≥17 mm based on the highest Youden Index.

For the AP diameter, a cut-off of ≥17 mm showed a sensitivity of 85.7%, specificity of 90.7%, positive predictive value (PPV) of 90.0%, and negative predictive value (NPV) of 86.7%. For the transverse diameter, the same cut-off demonstrated sensitivity of 92.3%, specificity of 90.7%, and a positive predictive value of 90.6% (Table 3). The diagnostic accuracy of the ≥17 mm threshold was 88.3% for the AP diameter and 91.5% for the transverse diameter. These findings indicate that a posterior horn diameter of ≥17 mm is strongly associated with the presence of posterior horn tears.

Table 1

Medial meniscus posterior horn diameter in transverse and anteroposterior dimensions with presence and absence of tear.

Dimension	Tear status	N	Mean (mm)	SD (mm)	SE of mean	p-value
Transverse	Present	273	19.48	2.75	0.167	<0.001
Transverse	Absent	281	14.45	1.63	0.097	
Anteroposterior	Present	273	18.77	2.29	0.139	<0.001
Anteroposterior	Absent	281	14.36	1.64	0.098	

Table 2

Multivariable logistic regression analysis for posterior horn medial meniscus tear.

Variable	Adjusted OR	95% CI	p-value
Posterior horn AP diameter (per 1 mm increase)	1.82	1.56–2.13	<0.001
Posterior horn transverse diameter (per 1 mm increase)	2.04	1.71–2.42	<0.001
Age	1.03	0.98–1.07	0.214
Sex	1.11	0.79–1.56	0.532
BMI	1.05	0.97–1.13	0.188

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Table 3

Diagnostic performance of the ≥17 mm cut-off value for posterior horn medial meniscus tear detection.

Dimension	Cut-off (mm)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC	Accuracy (%)
Anteroposterior	≥17	85.7	90.7	90.0	86.7	0.943	88.3
Transverse	≥17	92.3	90.7	90.6		0.955	91.5

Table 4

Diagnostic performance of medial meniscus posterior horn measurements for tear identification.

Variable	Cut-off (mm)	Sensitivity % (95% CI)	Specificity % (95% CI)	AUC
AP diameter	14	99.27 (97.38–99.91)	31.67 (26.27–37.46)	0.943
	15	97.07 (94.31–98.73)	53.74 (47.72–59.68)	
	16	94.87 (91.55–97.17)	79.72 (74.53–84.26)	
	17	85.71 (80.99–89.64)	90.75 (86.74–93.87)	
	18	71.79 (66.06–77.05)	96.44 (93.55–98.28)	
	19	49.08 (43.01–55.18)	97.86 (95.41–99.21)	
	20	36.90 (30.20–41.90)	99.64 (98.03–99.99)	
Transverse diameter	14	99.27 (97.38–99.91)	28.11	0.955
	15	98.17 (95.78–99.40)	53.38 (47.36–59.33)	
	16	96.34 (93.37–98.23)	78.65 (73.39–83.29)	
	17	92.31 (88.91–95.47)	90.75 (86.74–93.87)	
	18	80.22 (74.99–84.78)	96.09 (93.10–98.03)	
	19	63.37 (57.35–69.10)	97.15 (94.47–98.76)	
	20	47.62 (41.57–53.72)	99.64 (98.03–99.99)	
AP height	—	—	—	0.801

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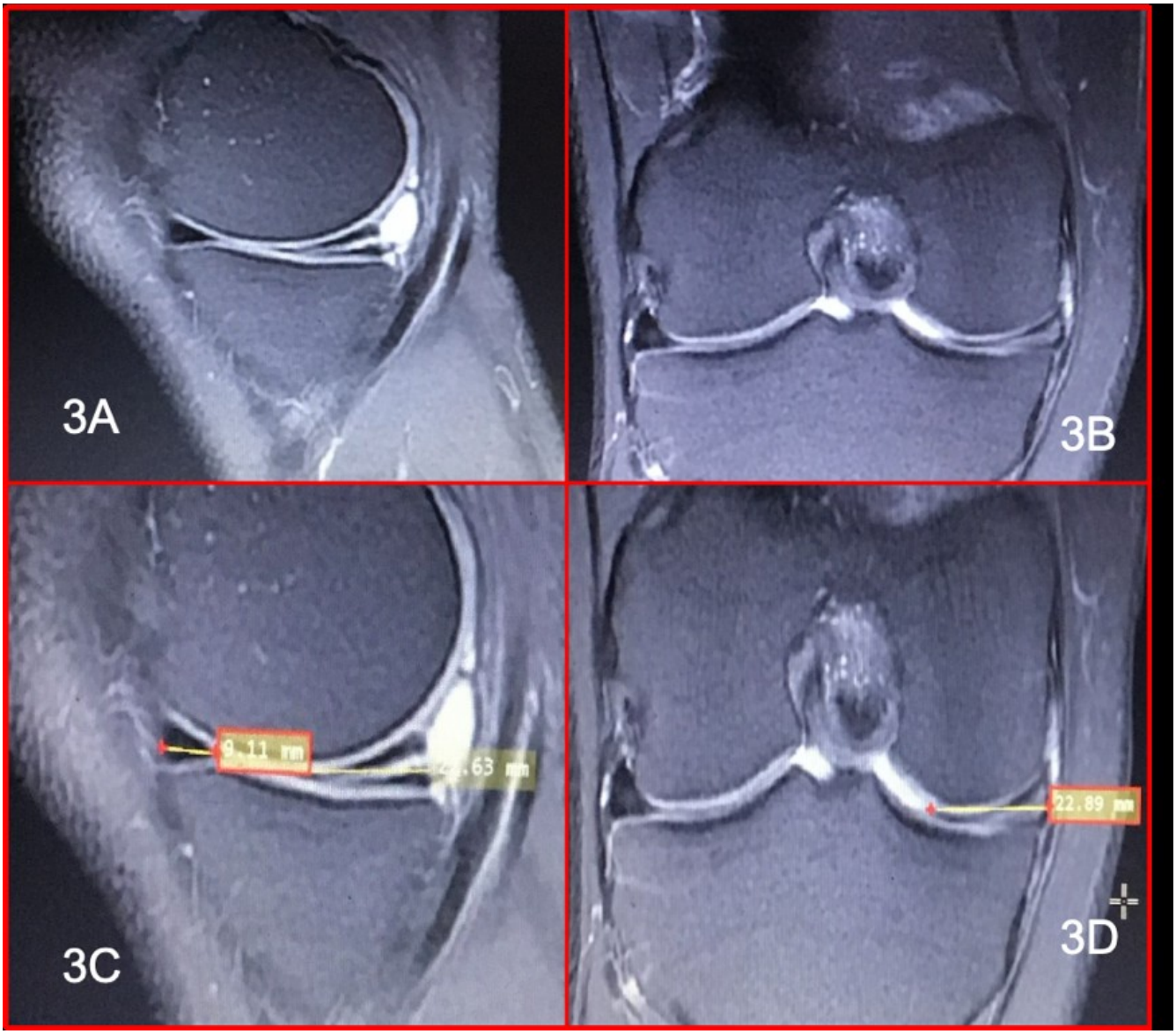


Figure 3. MRI appearance of a complete undisplaced horizontal cleavage tear of the posterior horn of the medial meniscus with a multiloculated parameniscal cyst. Sagittal T2 FS (3A) and coronal PD FS (3B) images demonstrate the tear and adjacent parameniscal cyst. Sagittal T2 FS (3C) and coronal PD FS (3D) images show the measurement markers for anteroposterior and transverse posterior horn dimensions.

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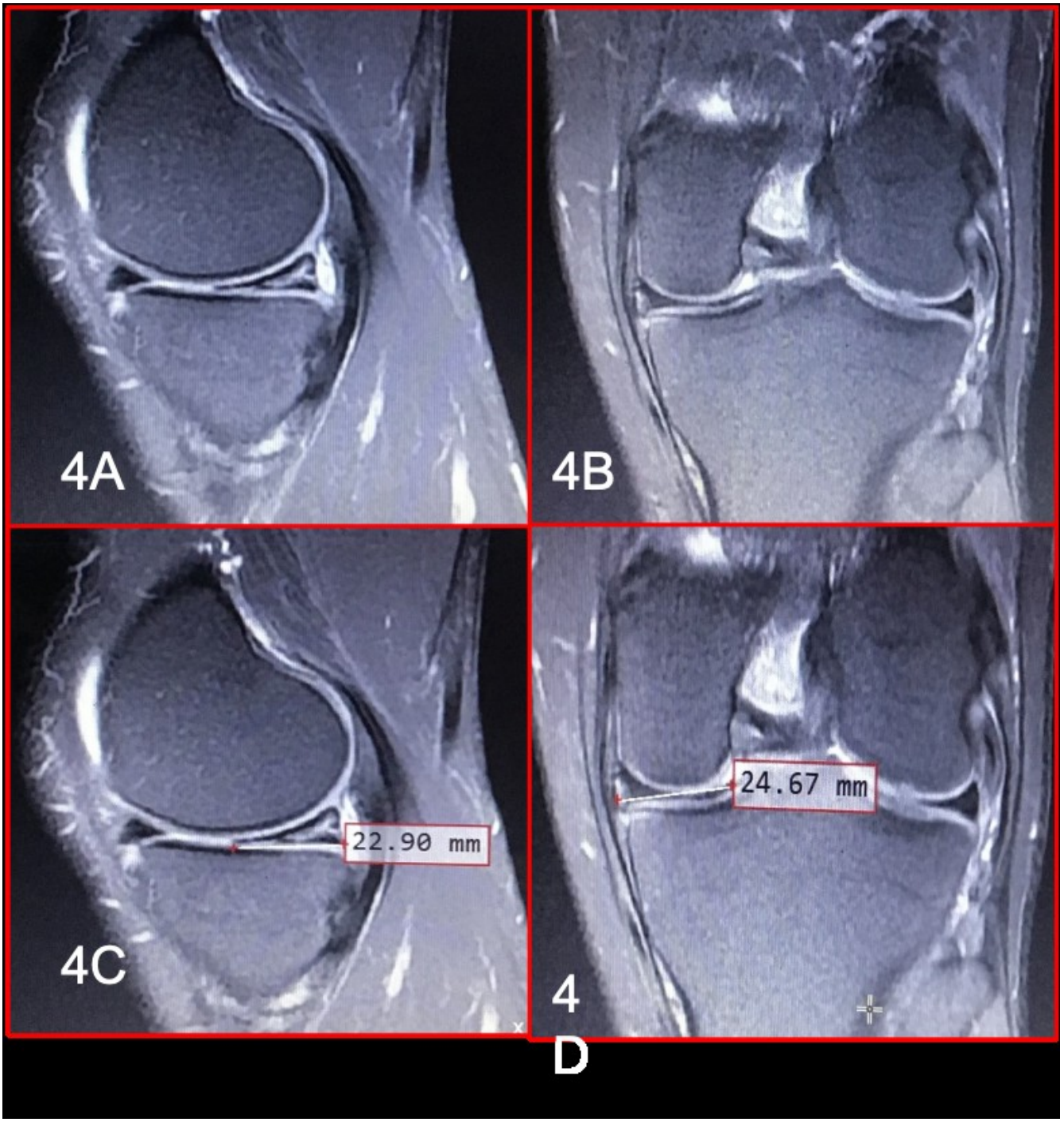


Figure 4. MRI images showing a complete oblique tear of the posterior horn of the medial meniscus with associated parameniscal cyst. Sagittal T2 FS (4A) and coronal PD FS (4B) images demonstrate an oblique tear extending from the meniscocapsular junction to the inferior articular surface. Sagittal T2 FS (4C) and coronal PD FS (4D) images show the measurement markers for anteroposterior and transverse posterior horn dimensions.

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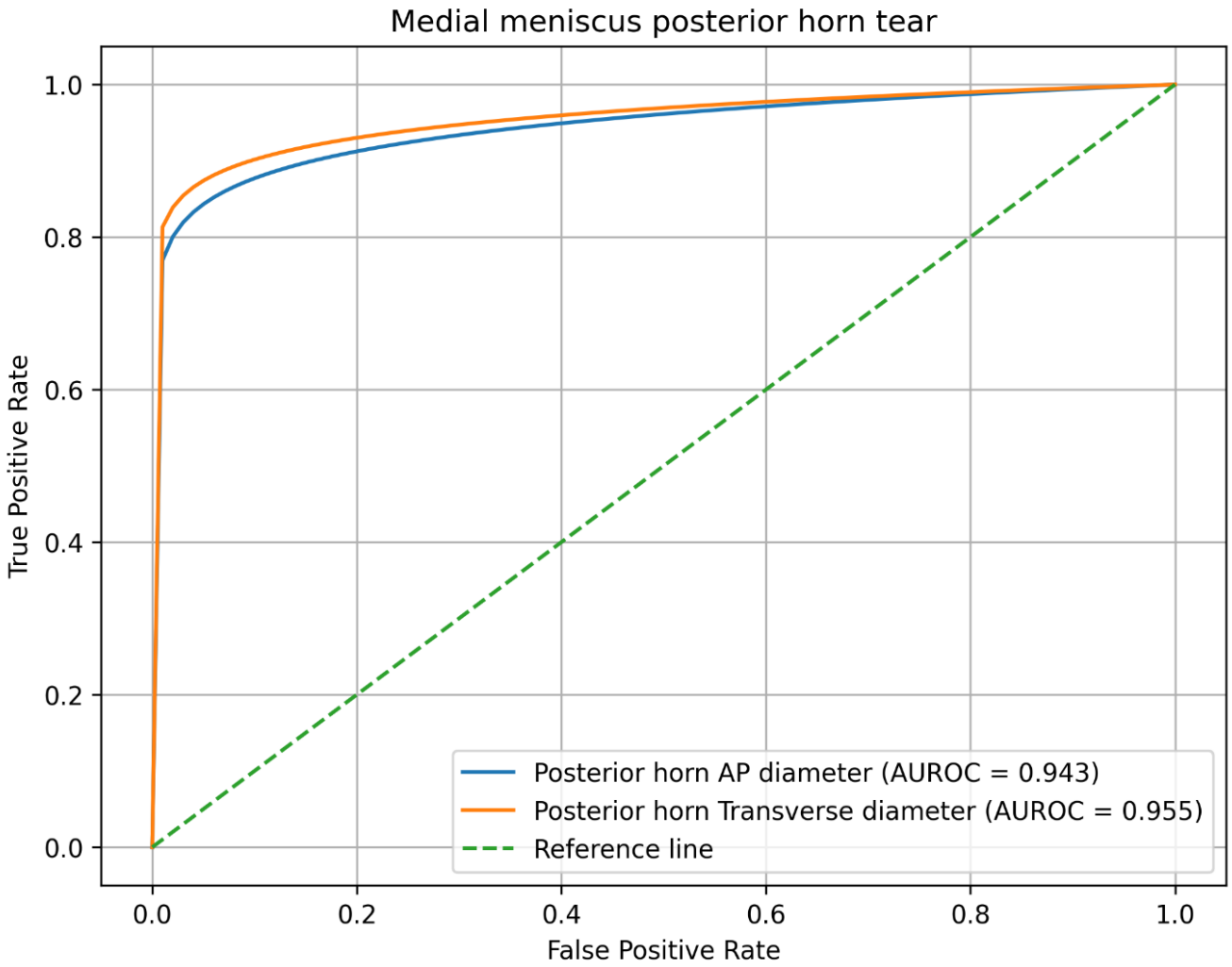


Figure 5. Receiver operating characteristic (ROC) curves for posterior horn meniscal size and MRI-defined medial meniscus posterior horn tear in this study cohort.

Discussion

The primary objective of this study was to evaluate the relationship between meniscal size and the prevalence of medial meniscus posterior horn tears, with particular emphasis on determining whether increased posterior horn dimensions are associated with tearing. Earlier observations have suggested that a broader meniscus may be more vulnerable to injury; however, quantitative thresholds defining this association have remained inadequately explored [4,9]. The present study addresses this gap by systematically measuring posterior horn dimensions and correlating them with tear prevalence.

This study demonstrated that the medial meniscus posterior horn is significantly enlarged in knees with posterior horn tears compared with those without tears, in both AP and transverse dimensions. The observed increase in posterior horn size in the tear group suggests that large meniscal morphology may be associated with structural failure of the meniscus. These findings support the hypothesis that quantitative meniscal measurements on MRI can serve as imaging biomarkers for increased risk of meniscal pathology.

In the present study, both AP and transverse diameters showed statistically significant differences between tear and non-tear groups ($p < 0.001$). ROC curve analysis demonstrated excellent diagnostic performance for posterior horn measurements, with AUC values of 0.943 for AP diameter and 0.955 for transverse diameter, indicating high discriminative ability.

Multivariable logistic regression analysis demonstrated that posterior horn dimensions remain significantly associated with tears even after adjustment for age, sex, and BMI. Both AP and transverse diameters showed strong independent associations, indicating that increased posterior horn size is not merely a reflection of general anthropometric variation but may represent a distinct morphological factor associated with meniscal pathology.

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Among the two parameters, the transverse diameter demonstrated the highest overall diagnostic performance, with an AUC of 0.955 and diagnostic accuracy of 91.5%.

The ≥17 mm threshold showed discrimination between MRI-defined tear and non-tear groups in this study cohort. Its diagnostic performance reflects assessment in the same cohort used to select the threshold. Independent validation is needed before routine clinical use or treatment decisions. The measurements may be investigated as an adjunct to conventional MRI interpretation; this study does not establish improved diagnostic confidence, patient outcomes, or treatment planning.

Cut-off analysis revealed that a posterior horn diameter of ≥17 mm provided the optimal balance between sensitivity and specificity for identifying MRI-defined medial meniscus posterior horn tears in this cohort. At this threshold, the transverse diameter demonstrated higher sensitivity (92.3%) compared to the AP diameter (85.7%), with both measurements showing high specificity (90.7%). Higher cut-off values (≥18 mm) resulted in increased specificity but reduced sensitivity.

One of the key strengths of this study lies in its quantitative approach. While previous investigations have postulated an association between meniscal morphology and tear susceptibility, few have established objective measurement criteria or defined size thresholds indicative of increased risk. The measurements employed in this study are derived from routinely acquired MRI sequences, are simple to perform, and can be obtained from standard MRI sequences. Another important strength of the present study is the demonstration of excellent interobserver reliability for both AP and transverse posterior horn measurements. Because the study derives an exploratory quantitative MRI-based threshold, reproducibility of these measurements is essential. The high ICC values observed for both dimensions indicate that the measurement technique is consistent and can be reliably reproduced by different observers using standard MRI sequences and clearly defined anatomical landmarks.

In addition to the quantitative findings, we observed a distinct morphological pattern in a subset of patients characterized by a markedly enlarged posterior horn, particularly when the posterior horn diameter exceeded 19 mm, with relative absence of a well-defined meniscal body and apparent direct continuity between the anterior and posterior horns. This configuration was descriptively referred to as a “mega- posterior horn.” At present, this observation should be considered a preliminary morphological hypothesis rather than a formally defined anatomical variant, as specific subgroup analysis and longitudinal validation were beyond the scope of the present study. Nevertheless, recognition of this morphology may be clinically relevant, particularly during preoperative MRI assessment and arthroscopic planning, where altered meniscal architecture may influence surgical decision-making. Future prospective studies with dedicated morphometric and clinical correlation are needed to determine whether this pattern represents a true anatomical variant or an advanced manifestation of meniscal remodeling associated with chronic pathology.

Several limitations of this study should be acknowledged. First, this was a retrospective single-center study, which may introduce selection bias and limit the generalizability of the findings to broader populations. The study population consisted primarily of young individuals undergoing MRI for symptomatic knee complaints, and therefore the results may not be directly applicable to older patients, asymptomatic individuals, or populations with different demographic and clinical characteristics.

Second, because of the cross-sectional retrospective design, causal relationships cannot be established. Although larger posterior horn dimensions were strongly associated with posterior horn tears, it remains unclear whether increased meniscal size represents a pre-existing morphological characteristic associated with tears or whether it develops secondary to the tear process itself. Longitudinal prospective studies are required to clarify this relationship.

Third, the presence of a meniscal tear itself may alter the apparent size and morphology of the posterior horn, potentially introducing measurement bias. To reduce this effect, measurements were performed only on preserved meniscal contours where the native anatomical margins could be clearly identified, and severely deformed or fragmented tears were excluded from analysis. However, subtle tear-related distortion may still have influenced some measurements.

Finally, although excellent interobserver agreement was demonstrated for posterior horn measurements, intraobserver reliability was not assessed in the present study. Future studies including both interobserver and intraobserver reproducibility across larger multicenter cohorts would further strengthen the clinical applicability of the proposed measurement thresholds.

These limitations should be considered when interpreting the proposed ≥17 mm cut-off value and the descriptive concept of the “mega-posterior horn,” both of which require further prospective validation.

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Conclusion

Larger medial meniscus posterior horn dimensions were associated with MRI-defined posterior horn tears in this retrospective cohort. A threshold of ≥17 mm was derived and evaluated in the same study cohort. It should be regarded as an exploratory morphometric marker rather than an independently validated clinical decision threshold. These findings do not establish that larger dimensions precede or cause tears.

Correspondence

Arshed Hussain Parry, M.D. · Department of Radiodiagnosis, Government Medical College, Srinagar, Jammu & Kashmir, India. Telephone: 91-9103106637.

arshedparry@gmail.com · ORCID: https://orcid.org/0000-0001-5079-3430

Declarations

Consent for publication: The author clarifies that written informed consent was obtained and the anonymity of the patient was ensured. This study submitted to Swiss J. Rad. Nucl. Med. has been conducted in accordance with the Declaration of Helsinki and according to requirements of all applicable local and international standards. All authors contributed to the conception and design of the manuscript, participated in drafting and revising the content critically for important intellectual input, and approved the final version for publication. Each author agrees to be accountable for all aspects of the work, ensuring its accuracy and integrity.

Conflict of interest: The authors declare that there were no conflicts of interest within the meaning of the recommendations of the International Committee of Medical Journal Editors when the article was written.

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