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USE OF TWO SLICE TOUCH RULE IN MR DIAGNOSIS OF MENISCAL TEARS IN TRAUMA, TAKING ARTHROSCOPY AS GOLD STANDARD

Original Research

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ABSTRACT

Background: Meniscal injuries are among the most common knee pathologies resulting from trauma, often requiring precise diagnosis for effective management. Magnetic Resonance Imaging (MRI) has emerged as a non-invasive modality for evaluating meniscal tears, with the two-slice touch rule offering a simplified diagnostic criterion. Despite its widespread use, variability in diagnostic performance necessitates further validation against arthroscopy, the gold standard, particularly in diverse populations with traumatic knee injuries.

Objective: To determine the diagnostic accuracy of MRI using the two-slice touch rule for detecting meniscal tears following knee trauma, using arthroscopy findings as the reference standard.

Methods: A prospective cross-sectional validation study was conducted at the Department of Radiology, Armed Forces Institute of Radiology and Imaging, Rawalpindi, from May 2023 to May 2024. A total of 120 patients, aged 18 to 80 years, clinically suspected of having meniscal tears due to trauma, were enrolled. MRI was performed using a 1.5 Tesla scanner with a dedicated knee coil. Imaging criteria included hyperintense signal extending to the articular surface on at least two consecutive slices. Arthroscopies were performed by an experienced orthopedic surgeon. Data were recorded and analyzed using SPSS version 25.0. Diagnostic accuracy metrics including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using a 2×2 contingency table.

Results: The study population had a mean age of 46.39 ± 15.45 years, with 76.7% males. MRI identified meniscal tears in 64.2% (n=77) of cases, while arthroscopy confirmed 60.8% (n=73). The sensitivity, specificity, PPV, and NPV of MRI were 83.56%, 65.96%, 79.22%, and 72.09%, respectively. The overall diagnostic accuracy of MRI was 76.67%.

Conclusion: MRI demonstrated substantial reliability as a diagnostic tool for meniscal tears using the two-slice touch rule, providing a valuable, non-invasive alternative to arthroscopy in the evaluation of traumatic knee injuries.

Keywords: Arthroscopy, Knee, Magnetic Resonance Imaging, Meniscal Tear, Trauma.

INTRODUCTION

Meniscal tears represent one of the most frequently encountered knee injuries, particularly in the context of sports-related trauma, and often necessitate surgical intervention due to associated pain and functional impairment (1). These tears typically result from shear stress exerted between the femoral and tibial condyles, with younger patients commonly sustaining such injuries following a torsional force applied to a flexed, weight-bearing knee (2). Over recent years, the reported incidence of meniscal injuries has shown a notable rise, a trend likely influenced by the increased accessibility and utilization of advanced diagnostic modalities such as Magnetic Resonance Imaging (MRI). While a conservative estimate places the incidence at approximately 60 cases per 100,000 individuals, it is widely believed that the true prevalence is substantially underestimated (3,4). The prompt and accurate identification of meniscal tears remains a cornerstone in the effective management of knee joint trauma. MRI has emerged as the standard non-invasive imaging modality, offering high sensitivity and specificity in the detection of meniscal pathology (5). Among the various diagnostic approaches within MRI, the "two-slice touch rule" has gained popularity due to its simplicity and reproducibility. This rule posits that a meniscal tear is likely present if increased signal intensity is observed in the meniscus on two or more consecutive slices (6). Despite its widespread use, the clinical applicability and diagnostic accuracy of this rule, particularly in acute trauma settings, continue to warrant investigation (6,7).

Arthroscopy, while considered the gold standard for diagnosing and treating meniscal injuries, is inherently invasive and carries associated procedural risks (8). Although it offers direct visualization, the use of diagnostic arthroscopy alone without preceding imaging may be inappropriate given these risks (9). Consequently, establishing the diagnostic value of non-invasive criteria such as the two-slice touch rule, in relation to arthroscopic findings, is essential in refining preoperative decision-making. Such analysis may contribute to minimizing unnecessary invasive interventions and improving patient outcomes by enhancing diagnostic precision. The objective of this study is to evaluate the diagnostic accuracy of the MRI-based two-slice touch rule in detecting traumatic meniscal tears by comparing its findings with arthroscopic outcomes, thereby addressing a critical gap in trauma-related knee injury assessment and promoting evidence-based clinical practice.

METHODS

This prospective, cross-sectional validation study was carried out at the Department of Radiology, Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, Pakistan, over a period of one year, from May 2023 to May 2024. Ethical approval for the study was obtained from the institutional review board prior to its commencement, and written informed consent was secured from all participants. The study enrolled male and female patients aged between 18 and 80 years who were clinically suspected of having sustained meniscal tears secondary to traumatic knee injury. All participants underwent a structured clinical history-taking process, followed by detailed physical examination, MRI of the knee, and diagnostic arthroscopy. Participants were excluded if they had a previous history of ipsilateral knee surgery, fractures, bilateral knee injuries, pacemaker implantation, or underlying joint-destructive diseases such as rheumatoid arthritis, septic arthritis, or tuberculous arthritis. Additionally, individuals with degenerative joint disease or other chronic inflammatory arthropathies were excluded to minimize confounding variables. The calculated sample size was 120 subjects, based on a sensitivity of 94.9%, specificity of 85.7% (10), and an assumed prevalence of 44.4% for meniscal injuries (11), using a 95% confidence level and a 9% margin of error.

MRI examinations were performed using a 1.5 Tesla scanner equipped with a dedicated knee coil. The imaging protocol followed departmental standards and included multiplanar, multi-sequence scans with sagittal T1-weighted, sagittal and coronal T2-weighted, and axial T2-weighted images. Reporting of the MRI scans was undertaken by consultant radiologists with a minimum of three years of teaching experience. The normal meniscus was identified by its homogenous low signal intensity and characteristic triangular morphology on both sagittal and coronal views. Anatomical considerations such as the relative horn length were noted, with equal lengths expected in the anterior and posterior horns of the lateral meniscus, while the anterior horn of the medial meniscus typically appeared shorter. Direct MRI signs of a meniscal tear included hyperintense intra-meniscal signal reaching the articular surface in at least two consecutive slices—corresponding to the “two-slice touch rule”—as well as displaced meniscal fragments or absence of

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meniscal tissue. Indirect signs included subchondral bone marrow edema beneath the meniscus or the presence of parameniscal cysts. All arthroscopies were conducted by an experienced orthopedic surgeon blinded to MRI findings, ensuring unbiased confirmation of intra-articular pathology. Patient demographic data and clinical findings were recorded using a structured data collection form. Data analysis was conducted using SPSS version 25.0. A 2 × 2 contingency table was generated to calculate diagnostic performance metrics of MRI, including sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy, using arthroscopy as the reference standard. Stratified analyses were conducted to assess the influence of effect modifiers such as patient age, gender, laterality of the affected knee, and anatomical site of the meniscal tear.

RESULTS

The study population exhibited a male predominance, with 76.7% (n=92) males and 23.3% (n=28) females. The mean age of participants was 46.39 ± 15.45 years. A stratified age distribution revealed that 15.8% (n=19) were aged ≤30 years, 38.3% (n=46) between 31 and 45 years, and 45.8% (n=55) were older than 45 years. Notably, the mean age was slightly lower in males (45.23 ± 15.14 years) compared to females (50.21 ± 16.12 years). Meniscal injuries were equally distributed between the right and left knees (50.0%, n=60 each), though the right knee demonstrated higher sensitivity and specificity in MRI-based diagnosis. In terms of anatomical site, the posterior horn was the most frequently affected location (30.8%, n=37), followed by the body of the meniscus (25.8%, n=31), anterior horn (10.8%, n=13), and multiple sites (32.5%, n=39). Medial meniscus involvement was most common (75.8%, n=91), with lateral meniscus involvement in 18.3% (n=22), and both medial and lateral in 5.8% (n=7). MRI detected meniscal tears in 64.2% (n=77) of cases, whereas arthroscopy confirmed tears in 60.8% (n=73). The two-slice touch rule applied to MRI demonstrated a sensitivity of 83.56%, specificity of 65.96%, positive predictive value (PPV) of 79.22%, and negative predictive value (NPV) of 72.09%. The overall diagnostic accuracy was 76.67%, with a positive likelihood ratio of 2.45 and a negative likelihood ratio of 0.25.

Stratification analysis showed that females had a higher diagnostic accuracy (85.71%) than males (73.91%). Sensitivity in females was 88.89% and specificity was 80.0%, while in males these values were 81.82% and 62.16%, respectively. The age group ≤30 years demonstrated the highest overall diagnostic accuracy (84.21%) with sensitivity of 86.67% and specificity of 75.0%. The 31–45 age group had an accuracy of 73.91%, while those >45 years showed a slightly higher accuracy of 76.36% but the lowest specificity at 54.55%. When stratified by knee side, sensitivity and specificity were higher for the right knee (86.67% and 66.67%, respectively) compared to the left knee (81.4% and 64.71%, respectively), though both sides showed equal diagnostic accuracy (76.67%). Among the meniscal regions, the body exhibited the highest diagnostic metrics with a sensitivity of 94.12%, specificity of 71.43%, and accuracy of 83.87%. Anterior horn tears showed 80.0% sensitivity and 66.67% specificity, while multiple site injuries had the lowest overall accuracy at 71.79%. A perfect diagnostic performance (100% sensitivity, specificity, PPV, NPV, and accuracy) was recorded in the small subgroup of patients with combined medial and lateral meniscal tears.

Table 1: Demographic and clinical details of the study subjects (n=120)

Variable	Frequency	Percentage
Gender		
Males	92	76.7
Females	28	23.3
Age Groups		
≤30 Years	19	15.8
31 – 45 Years	46	38.3
> 45 Years	55	45.8
Knee Side		
Right	60	50.0
Left	60	50.0
Location of Meniscal Injury		
Anterior Horn	13	10.8

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Variable	Frequency	Percentage
Posterior Horn	37	30.8
Body	31	25.8
Multiple Sites	39	32.5
Involved Meniscus		
Medial	91	75.8
Lateral	22	18.3
Medial & Lateral Both	07	5.8

Table 2: Diagnostic accuracy of MRI using (two-slice-touch rule) for identifying the meniscal tears keeping arthroscopy findings as gold standard

Meniscal tears on MRI	Meniscal tears on Arthroscopy		
	POSITIVE	NEGATIVE	TOTAL
POSITIVE	61 (True Positives)	16 (False Positives)	77
NEGATIVE	12 (False Negatives)	31 (True Negatives)	43
Total	73	74	120

Table 3: Diagnostic accuracy of MRI using (two-slice-touch rule) for identifying the meniscal tears keeping arthroscopy findings as gold standard (stratification analysis for various effect modifiers)

Effect Modifiers	Sensitivity	Specificity	PPV	NPV	Accuracy
Gender					
Males	81.82	62.16	76.27	69.70	73.91
Females	88.89	80.0	88.89	80.0	85.71
Age Groups					
≤30 Years	86.67	75.0	92.86	60.0	84.21
31 – 45 Years	72.0	76.19	78.26	69.57	73.91
> 45 Years	90.91	54.55	75.0	80.0	76.36
Knee Side					
Right	86.67	66.67	72.22	83.33	76.67
Left	81.4	64.71	85.37	57.89	76.67
Location of Meniscal Injury					
Anterior Horn	80.0	66.67	88.89	50.0	76.92
Posterior Horn	86.36	60.0	76.0	75.0	75.68
Body	94.12	71.43	80.0	90.91	83.87
Multiple Sites	75.0	66.67	78.26	62.50	71.79
Meniscus Involved					
Medial	84.31	65.0	75.44	76.47	75.82
Lateral	75.0	66.67	85.71	50.0	72.73
Medial & Lateral (Both)	100.0	100.0	100.0	100.0	100.0

PPV: Positive Predictive Value, NPV: Negative Predictive Value

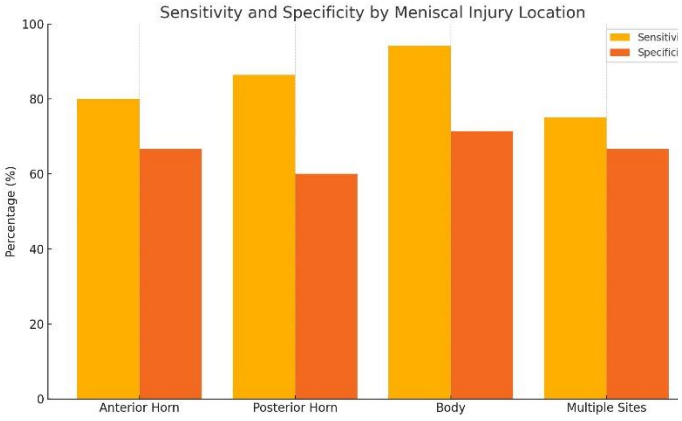

Figure 1 Sensitivity and Specificity by Meniscal Injury Location

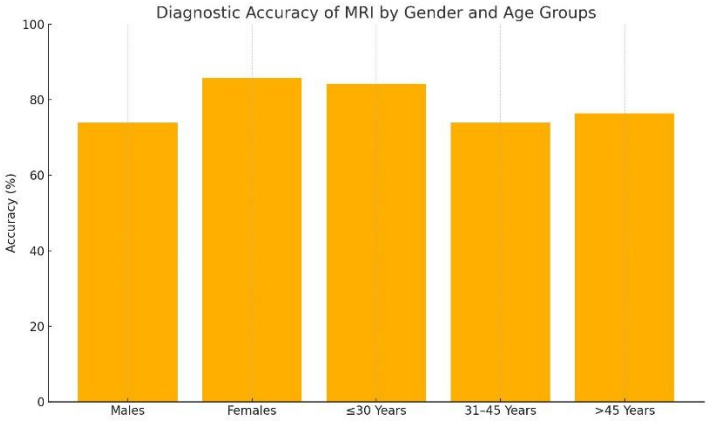

Figure 2 Diagnostic Accuracy of MRI by Gender and Age Groups

DISCUSSION

This study evaluated the diagnostic performance of MRI using the two-slice touch rule in detecting meniscal tears, taking into account age, gender, and anatomical distribution of the lesions. A higher prevalence of meniscal injuries was observed in individuals over 45 years of age, which is in line with existing evidence linking age-related degenerative changes and occupational stressors to increased susceptibility to meniscal damage (12). While many studies attribute such injuries to degenerative processes in this age group, the current study focused on patients with clear traumatic etiology, adding nuance to the understanding of injury mechanisms in older populations. The observed male predominance aligns with prior findings suggesting that men are more frequently affected due to greater participation in high-impact activities and physically demanding occupations (13). Age-stratified analysis revealed that individuals over 45 years exhibited the highest sensitivity, suggesting that more pronounced or structurally evident tears in this age group may enhance MRI detectability. Conversely, younger participants, particularly those ≤30 years, showed lower sensitivity and specificity, potentially due to less pronounced morphological changes or subtle injury patterns that are harder to capture radiologically. The anatomical distribution highlighted the posterior horn as the most frequently involved site, followed by multiple-site injuries, the body, and then the anterior horn. This distribution mirrors the biomechanical burden borne by the posterior horn during flexion and weight-bearing, supporting its vulnerability to trauma (14,15).

MRI demonstrated an overall diagnostic accuracy of 76.67%, with a sensitivity of 83.56% and specificity of 65.96%. These findings are consistent with previous studies that reported sensitivity and specificity ranges of 85–95% and 70–85%, respectively (16–18). Comparable trends were noted regarding the positive and negative predictive values, with high true positive rates but moderate specificity, highlighting the risk of false positives. This reiterates the importance of correlating imaging findings with clinical assessments and reserving arthroscopy as the definitive diagnostic tool. While some previous studies have reported higher specificity or diagnostic yield, variability in equipment, imaging protocols, and reader experience could account for these differences. The current study provided valuable insights into how gender, age, and tear location influence diagnostic performance. Females showed higher diagnostic accuracy than males, diverging from some earlier research (19). This could reflect anatomical, hormonal, or biomechanical differences, or possibly differences in the extent and pattern of injury. While both knees were equally involved, MRI showed marginally better sensitivity and specificity in detecting tears in the right knee. Though subtle, these findings hint at possible differences in biomechanics, limb dominance, or injury mechanisms, warranting further exploration (20). The meniscal body showed the highest diagnostic indices, possibly due to its central anatomical location, which may allow better visualization on MRI sequences. Posterior horn injuries remained the most prevalent and detectable, reaffirming their clinical significance and the need for optimized imaging protocols focusing on this region (21,22).

Strengths of the study include its prospective design, clearly defined inclusion and exclusion criteria, standardized imaging protocol, and the incorporation of stratified analyses for demographic and anatomical variables. These features enhance both internal and external validity. Additionally, the use of arthroscopy as a reference standard ensured reliable diagnostic benchmarking. However, several

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limitations were also acknowledged. The single-center nature of the study may limit generalizability to broader populations. MRI interpretations were conducted by a single radiologist, introducing potential observer bias and limiting assessment of inter-rater reliability. The exclusion of patients with chronic or degenerative meniscal injuries may also restrict the applicability of findings across the full spectrum of meniscal pathology. Furthermore, the time interval between MRI and arthroscopy was not specified, which could affect correlation due to interval changes in pathology. Despite these limitations, the findings reinforce the role of MRI as a reliable non-invasive diagnostic tool, particularly in identifying posterior horn and body lesions. The relatively high sensitivity ensures that most true positive cases are identified, thereby facilitating early intervention. However, the moderate specificity necessitates cautious interpretation to avoid overdiagnosis and unnecessary arthroscopic procedures. Emphasizing region-specific MRI protocols and encouraging interdisciplinary communication between radiologists and orthopedic surgeons could help bridge the diagnostic gap and enhance clinical outcomes. Future studies should aim for multicenter participation, include multiple readers for interobserver validation, and incorporate a wider range of meniscal pathologies to further refine the diagnostic criteria and strengthen clinical applicability.

CONCLUSION

This study underscores the valuable role of MRI, particularly the two-slice touch rule, as a non-invasive diagnostic tool for identifying meniscal tears in traumatic knee injuries. While the findings affirm MRI's strong potential in detecting true cases across various patient groups and anatomical sites, the moderate specificity and reliance on the interpreter's expertise highlight areas for refinement. The study contributes to clinical practice by reinforcing MRI as a reliable first-line investigation, supporting its use to reduce unnecessary invasive procedures. However, standardization of imaging protocols and expansion through multi-center research are essential next steps to enhance diagnostic precision and applicability within broader clinical settings.

AUTHOR CONTRIBUTION

Author	Contribution
Rabia Haq*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Zeeshan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Khawaja Baqar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sara Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aliya Halim	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sarah Nathaniel	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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