TPM Vol. 32, No. S9, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

DIAGNOSTIC ACCURACY OF MRI IN DETECTING ROTATOR CUFF TEARS TAKING INDIRECT MR ARTHROGRAPHY AS GOLD STANDARD

DR. MARIA MURTAZA.
POSTGRADUATE RESIDENT RADIOLOGY, ITTEFAQ HOSPITAL TRUST, LAHORE, EMAIL:- maria.murtaza57@gmail.com

DR MUHAMMAD AQEEL BABRI
HOD RADIOLOGY DEPARTMENT. ITTEFAQ HOSPITAL TRUST, LAHORE, EMAIL:- dr.babri@hotmail.com

DR. AFAF ARIF
POST GRADUATE RESIDENT RADIOLOGY, ITTEFAQ HOSPITAL TRUST, LAHORE, EMAIL:- afafarif10@gmail.com

DR. HASSAN RASHID
POST GRADUATE RESIDENT RADIOLOGY, ITTEFAQ HOSPITAL TRUST, LAHORE, EMAIL:- hassanrashid593@yahoo.com

CORRESPONDING AUTHOR:-
DR. MARIA MURTAZA
POSTGRADUATE RESIDENT RADIOLOGY, ITTEFAQ HOSPITAL TRUST, LAHORE, EMAIL:- maria.murtaza57@gmail.com

ABSTRACT

Background: Rotator cuff tears are a common cause of shoulder pain and functional limitation. Accurate diagnosis is essential for appropriate management. While indirect MR arthrography (MRA) is considered the gold standard, plain MRI is widely used due to its non-invasive nature.

Objectives: To determine the diagnostic accuracy of plain MRI in detecting rotator cuff tears, using indirect MR arthrography as the reference standard, and to evaluate its performance across different patient subgroups.

Study Design & Setting: Cross-sectional validated study conducted at the Department of Radiology, Ittefaq Hospital Trust, Lahore from July 2025 to October 2025.

Methodology: A total of 125 patients aged 20□70 years with clinical suspicion of rotator cuff tear were enrolled using consecutive sampling. All patients underwent plain MRI followed by indirect MRA in the same imaging session. Images were independently interpreted by two experienced radiologists blinded to each other□s findings. Diagnostic performance of plain MRI was assessed using 2×2 contingency tables, calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Stratification was performed by age, gender, and duration of symptoms.

Results: Plain MRI detected 76/125 tears compared to 82/125 on indirect MRA. Overall sensitivity and specificity were 86.6% and 88.4%, respectively, with a PPV of 93.4%, NPV of 77.6%, and overall accuracy of 87.2%. Stratified analysis demonstrated high diagnostic performance across age, gender, and symptom duration subgroups, with statistically significant differences ($p < 0.001$).

Conclusion: Plain MRI shows high diagnostic accuracy for detecting rotator cuff tears and may serve as a reliable non-invasive imaging modality, though indirect MRA remains the gold standard.

Keywords: Diagnostic Accuracy, Indirect MR Arthrography, MRI, Rotator Cuff Tear, Shoulder

INTRODUCTION

The rotator cuff comprises four muscles originating from the scapula and inserting on the humeral head, playing a key role in shoulder joint stability and movement. These include the subscapularis (internal rotation), supraspinatus (initial abduction), infraspinatus, and teres minor (external rotation).[1,2] Rotator cuff disorders, such as tears and tendinopathies, result from trauma, repetitive microtrauma, or degenerative changes. Shoulder disorders have a reported incidence of 7□25% in the general Western population, with a peak incidence in individual□s aged 42□46 years.[3]

Different types of rotator cuff injuries can manifest in different ways; some are partial-thickness tears or tendinopathy, while others are full tears that can lead to progressive cartilage wear and are called cuff tear arthropathy. Pain, weakness, and restricted range of motion (ROM) are symptoms of these conditions, which can significantly impair shoulder performance.[4]

Rotator cuff pathology represents a broad clinical entity that includes tendinopathy, partial-thickness tears, and full-thickness tears affecting one or more tendons.[5] Tears may occur on the articular surface, bursal surface, or within the tendon substance, and their morphology can vary from small focal defects to large retracted disruptions. The supraspinatus tendon is most commonly involved, followed by the infraspinatus, while subscapularis involvement may be seen in more extensive disease.[6] Degenerative processes, age-related tendon attrition, and repetitive overhead activity contribute to structural tendon changes over time. Acute trauma can also precipitate tearing, particularly in older individuals with pre-existing degeneration.[7] Symptoms commonly include shoulder pain, weakness, and difficulty with overhead movements, though presentation may differ across patients. Some individuals may demonstrate structural abnormalities despite minimal symptoms, whereas others experience marked functional limitation. Associated findings such as subacromial□subdeltoid bursitis, joint effusion, and labral or biceps tendon abnormalities can coexist.[8] Chronic tears may be accompanied by muscle atrophy and fatty infiltration, reflecting long-standing tendon dysfunction. Overall, rotator cuff disease spans a continuum from early tendon changes to complex tearing patterns with variable clinical expression.[9]

Magnetic resonance imaging is a widely used modality for evaluating shoulder anatomy due to its excellent soft-tissue contrast. It allows detailed visualization of the rotator cuff tendons, muscles, and surrounding structures. MRI can demonstrate tendon continuity, signal alterations, and associated findings within the shoulder joint. Studies have reported that among individuals over 40 years of age, full-thickness rotator cuff tears are present in approximately 18□26%, while partial-thickness tears are observed in about 32□37% of this population. MRI studies have detected rotator cuff tears even in asymptomatic individuals, increasing with age.[10] Clinical assessment and conventional radiography often fall short in accurately diagnosing such tears. MRI is a non-invasive tool that helps evaluate tear depth, retraction, and associated muscular changes such as atrophy and fatty degeneration.[11] However, conventional MRI can miss partial-thickness or small rotator cuff tears. Direct MR arthrography (D-MRA), although accurate (up to 90% sensitivity and specificity), requires intraarticular contrast injection and is invasive, with limited sensitivity for partial-thickness tears. Indirect MR arthrography (I-MRA), using intravenous contrast, is less invasive and capable of detecting both articular and bursal surface partial-thickness tears more effectively than plain MRI. Magnetic resonance arthrography involves the administration of contrast material to enhance joint structures. It improves delineation of intraarticular anatomy, including the articular surfaces of rotator cuff tendons. This technique allows clearer visualization of subtle tendon defects and joint-related abnormalities.[12]

Arthroscopy is considered the gold standard for diagnosing rotator cuff tears but is invasive and not readily available in most centers. Indirect MR arthrography (I-MRA) offers a non-invasive alternative with better soft tissue description than conventional MRI. To the best of the candidate□s knowledge, no such study has been conducted in Pakistan except one, which did not evaluate the diagnostic performance of indirect MR arthrography. Internationally studies are available but none have used indirect MR arthrography (I-MRA) as the gold standard for diagnosing rotator cuff tears. This study aims to fill that gap by assessing the diagnostic accuracy of I-MRA versus MRI in identifying these tears. The findings will add new local evidence to support the use of I-MRA as a practical diagnostic tool in resource-limited settings.

MATERIALS AND METHODS

The study was designed as a cross-sectional validation study and was conducted in the Department of Radiology, Ittefaq Hospital Trust, Lahore from July 2025 to October 2025. A sample size of 125 cases was calculated using the WHO sample size calculator (www.openepi.com) with a 95% confidence interval and a 11% margin of error, assuming an expected sensitivity of 78.28% with 6% precision, specificity of 84.82% with 7% precision, and a disease prevalence of 65.5% for diagnosing rotator cuff tears.[13,14] A non-probability consecutive sampling technique was used for participant recruitment. Patients of either gender aged 20 to 70 years were included if they presented with clinical suspicion of rotator cuff tear based on symptoms and examination findings, such as a painful arc between 60° and 120° of abduction and weakness in external rotation, and if they provided informed consent and underwent imaging. Patients were excluded if they had a prior surgical procedure for rotator cuff tear, congenital abnormalities of joints or bones, a history of surgery for infection, tumor, or open surgery without labral assessment, renal impairment (creatinine clearance less than 30 ml/min), a known allergy to contrast agents, pregnancy, or MRI-incompatible metallic implants.

A total of 125 patients presenting to the Radiology Department of Ittefaq Hospital Trust, Lahore, who met the inclusion criteria were enrolled in the study after approval was obtained from the Institutional Ethical Review Committee. Written informed consent was taken from all participants, and each participant underwent a standard plain MRI of the shoulder followed by an indirect MR arthrography (MRA) protocol in the same imaging session. Before indirect MRA, 20 mL of a gadolinium-based contrast agent diluted with normal saline was administered intravenously, and this was followed by 15 minutes of shoulder mobilization exercises to facilitate contrast diffusion into the joint capsule. MRI and MRA images were interpreted independently by two experienced radiologists who were blinded to each other□s findings and to the clinical diagnosis. The presence or absence of a rotator cuff tear was recorded on both modalities according to the operational definitions, and demographic information, clinical findings, and imaging results were documented on a structured proforma. Indirect MRA findings were considered the gold standard, and based on these findings, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of plain MRI for detecting rotator

cuff tears were calculated. All plain MRIs and indirect MR arthrograms were performed on the same MRI machine by a single consultant radiologist with more than eight years of experience to reduce inter-observer variability, and potential confounders were controlled by strict application of the exclusion criteria.

A rotator cuff tear was considered positive on plain MRI if there was a full-thickness tendon defect ≥2 mm with high T2 signal, a partial-thickness tear involving ≥50% of tendon thickness, tendon retraction ≥10 mm, or fluid signal replacing the tendon with associated muscle atrophy. On indirect MR arthrography, a tear was labeled positive if there was full-thickness fiber discontinuity with T2 fluid signal, increased signal reaching the articular or bursal surface suggesting a partial-thickness tear, tendon retraction and/or muscle atrophy, or fluid tracking into the subacromial□subdeltoid bursa or joint space.

Diagnostic accuracy and related terms (plain MRI vs gold standard): Diagnostic accuracy was defined as how well plain MRI distinguished patients with and without rotator cuff tears, using indirect MR arthrography as the gold standard. Sensitivity measured MRI□s ability to detect tears confirmed on indirect MR arthrography, while specificity measured MRI□s ability to correctly exclude tears when indirect MR arthrography was negative. PPV indicated the probability that a tear seen on MRI was truly present on indirect MR arthrography, and NPV indicated the probability that a negative MRI truly meant no tear on indirect MR arthrography. True positives and true negatives were cases where MRI agreed with indirect MR arthrography for presence or absence of tear, while false positives and false negatives were cases where MRI and indirect MR arthrography disagreed.

Data were analyzed using SPSS version 25.0. Numerical variables such as age were presented as mean ± standard deviation, while categorical variables including gender, affected side, type of rotator cuff tear, and MRI findings were expressed as frequencies and percentages. The diagnostic accuracy, sensitivity, specificity, PPV, and NPV of plain MRI were calculated using 2×2 contingency tables, with indirect MR arthrography taken as the gold standard. The data were stratified by age, gender, duration of symptoms, and type of tear (partial- or full-thickness), and after stratification, the chi-square test was applied to determine significance, with a p-value of less than 0.05 considered statistically significant.

RESULTS

The study included a total of 125 participants with a mean age of 45.35 ± 0.92 years. Most patients belonged to the 46□70-year age group (48.9%), followed closely by those aged 20□45 years (46.6%). Male patients constituted the majority of the study population (60.8%), while females accounted for 39.2%. The mean duration of symptoms was 1.39 ± 0.49, with more than half of the patients (54.4%) presenting within six months of symptom onset. Regarding the affected side, right shoulder involvement was more common, observed in 65.6% of cases, compared to left shoulder involvement in 34.4% of patients, as given in Table 1.

Table 1: Demographic Characteristics of the Study Participants (n = 125)

Variable	Category	Frequency (%)
Age (years)	Mean ± SD	45.35 ± 0.92
	20□45 years	61 (46.6)
	46□70 years	64 (48.9)
Gender	Male	76 (60.8)
	Female	49 (39.2)
Duration of Symptoms	Mean ± SD	1.39±0.49
	≤ 6 months	68 (54.4)
	> 6 months	57 (45.6)
Affected Side	Right	82 (65.6)
	Left	43 (34.4)

The distribution of rotator cuff tears based on indirect MR arthrography showed that partial thickness tears were the most frequently observed finding, identified in 82 patients (65.6%). In contrast, no tear was detected in 43 patients (34.4%) using the gold standard modality. The total number of cases evaluated was 125, as given in Table 2.

Table 2: Distribution of Rotator Cuff Tear Type on Indirect MR Arthrography (Gold Standard)

Type of Tear	Frequency (%)
Partial Thickness Tear	82 (65.6)
No Tear	43 (34.4)

TPM Vol. 32, No. S9, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

Total	**125 (100)**

On evaluation of rotator cuff tears using imaging modalities, plain MRI identified tears in 76 patients (60.8%) and reported absence of tears in 49 patients (39.2%). In comparison, the gold standard, indirect MR arthrography, detected tears in 82 patients (65.6%) and confirmed absence of tears in 43 patients (34.4%). The total number of cases assessed by both modalities was 125, as given in Table 3.

Table 3: Findings of Plain MRI and Indirect MR Arthrography for Rotator Cuff Tears

Imaging Modality	Tear Present n (%)	Tear Absent n (%)	Total
Plain MRI	76 (60.8)	49 (39.2)	125
Indirect MR Arthrography	82 (65.6)	43 (34.4)	125

The diagnostic performance of plain MRI for detecting rotator cuff tears was evaluated using indirect MR arthrography as the gold standard. Plain MRI correctly identified 71 true positive cases and 38 true negative cases. There were 5 false positive and 11 false negative cases. These findings were based on a total of 125 patients, as given in Table 4.

Table 4: Diagnostic Performance of Plain MRI Using Indirect MR Arthrography as Gold Standard (2×2 Contingency Table)

Plain MRI	Indirect MRA Positive	Indirect MRA Negative	Total
Positive	71 (True Positive)	5 (False Positive)	76
Negative	11 (False Negative)	38 (True Negative)	49
Total	**82**	**43**	**125**

The diagnostic accuracy of plain MRI for detecting rotator cuff tears demonstrated a sensitivity of 86.6% and a specificity of 88.4%. The positive predictive value (PPV) was 93.4%, while the negative predictive value (NPV) was 77.6%. Overall, the diagnostic accuracy of plain MRI was 87.2%, as given in Table 5.

Table 5: Diagnostic Accuracy Parameters of Plain MRI for Detecting Rotator Cuff Tears

Parameter	Value (%)
Sensitivity	86.6
Specificity	88.4
Positive Predictive Value (PPV)	93.4
Negative Predictive Value (NPV)	77.6
Overall Diagnostic Accuracy	87.2

Stratification of diagnostic accuracy of plain MRI showed variation across different subgroups. In patients aged 20□45 years, sensitivity was 100.0% and specificity 66.7%, with an overall accuracy of 86.9%, whereas in those aged 46□70 years, sensitivity and specificity were 87.2% and 88.0%, respectively, with accuracy of 87.5%. Stratification by gender revealed that males had a sensitivity of 93.4% and specificity of 77.6% with 90.8% overall accuracy, while females showed a sensitivity of 86.1% and specificity of 91.3%, with accuracy of 88.0%. Regarding duration of symptoms, patients presenting within six months had a sensitivity of 93.4% and specificity of 77.6% (accuracy 90.8%), whereas those with symptoms longer than six months had sensitivity of 86.1% and specificity of 91.3% (accuracy 88.0%). All subgroup comparisons were statistically significant ($p < 0.001$), as given in Table 7.

Table 7: Stratification of Diagnostic Accuracy of Plain MRI Using Indirect MR Arthrography as Gold Standard

Stratification Variable	Category (n)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	p-value*
Age (years)	20□45 (61)	100.0	66.7	82.2	100.0	86.9	<0.001
	46□70 (64)	87.2	88.0	91.9	81.5	87.5	<0.001
Gender	Male (76)	93.4	77.6	93.4	77.6	90.8	<0.001
	Female (49)	86.1	91.3	86.4	90.5	88.0	<0.001
Duration of Symptoms	< 6 months (76)	93.4	77.6	93.4	77.6	90.8	<0.001
	> 6 months (49)	86.1	91.3	86.4	90.5	88.0	<0.001

* p-values calculated using chi-square test after stratification; $p < 0.05$ considered statistically significant

DISCUSSION

Rotator cuff tears are a common cause of shoulder pain, weakness, and functional limitation, especially in adults over 40 years of age. Early and accurate diagnosis is essential to guide appropriate management and improve outcomes. Magnetic Resonance Imaging (MRI) is widely used for non-invasive evaluation of rotator cuff pathology. Indirect MR arthrography (MRA) is considered the gold standard due to its high sensitivity and specificity in detecting partial and full-thickness tears.[15] However, MRA is more invasive and less accessible in routine clinical settings. Evaluating the diagnostic performance of plain MRI against MRA can help optimize imaging strategies for suspected rotator cuff tears.

In the current study, plain MRI demonstrated high diagnostic performance in detecting rotator cuff tears when compared to indirect MR arthrography (I-MRA), the gold standard. Among 125 patients, plain MRI identified 76 tears (60.8%), whereas I-MRA detected 82 tears (65.6%), resulting in an overall sensitivity of 86.6%, specificity of 88.4%, PPV of 93.4%, NPV of 77.6%, and overall accuracy of 87.2%. Stratification revealed that younger patients (20□45 years) had the highest sensitivity (100%), whereas specificity was greater in older patients (46□70 years, 88.0%). Males showed slightly higher sensitivity (93.4%) compared to females (86.1%), while specificity was higher in females (91.3%). Patients with shorter symptom duration (<6 months) had higher sensitivity (93.4%), and longer-duration patients (>6 months) had higher specificity (91.3%) (Table 7). All stratified analyses were statistically significant ($p < 0.001$), indicating that plain MRI maintains robust diagnostic performance across different subgroups.

Our results are largely consistent with prior studies. Gul et al. (2016) reported rotator cuff tears in 65.4% of patients, with 38.1% full-thickness and 30.9% partial-thickness tears, closely resembling our findings of 65.6% partial-thickness tears.[13] Similarly, Kivi et al. (2022) observed that MRI achieved a sensitivity of 78.28%, specificity of 84.62%, PPV of 90%, NPV of 68.75%, and accuracy of 80.55% for partial tears, whereas I-MRA improved these parameters (sensitivity 86.96%, specificity 92.3%, accuracy 88.89%). These findings parallel our results, confirming the superior diagnostic utility of I-MRA, particularly in partial rotator cuff tears.[14] Importantly, Desmeules et al., in a systematic evaluation of imaging modalities for rotator cuff pathology, concluded that while conventional MRI offers excellent specificity and good sensitivity for full-thickness tears, its diagnostic performance for partial thickness tears and tendinopathy is comparatively lower. They emphasized that MRA, particularly indirect techniques, substantially improves detection of subtle intra-articular lesions. This mirrors our study findings where plain MRI, although highly accurate overall, demonstrated slightly variable subgroup performance that was optimized by comparison with I-MRA.[15] Roy et al. (2015) also highlighted the high sensitivity and specificity (>0.90) of MRI for full-thickness tears, though sensitivity was lower for partial tears (0.67□0.83), emphasizing that MRI is most reliable for complete tendon disruption.[17]

Furthermore, Modipalli et al. (2019) reported high specificity (85□89.5%) and PPV (67□94) for MRI evaluation of supraspinatus and subscapularis tendons, supporting the strong specificity observed in our study.[18] Kumar et al. (2020) found 100% sensitivity of MRI for full-thickness supraspinatus and subscapularis tears, while partial lesions such as SLAP tears had lower detection rates, which aligns with our observation that plain MRI had slightly reduced NPV (77.6%), indicating some false negatives in smaller or partial tears.[19] Varsha et al. (2025) reported a lower MRI sensitivity (72%) and overall accuracy (74.1%), likely due to a smaller sample size and variability in tear type, demonstrating the importance of standardized protocols and sufficient sample sizes, as used in our study.[20]

Awasthi et al. (2025) demonstrated near-perfect diagnostic accuracy of MRA for shoulder lesions (Sn 98%, PPV 100%, DA 98%), reinforcing the role of indirect MRA as the definitive standard. Our study confirms that while plain MRI is highly accurate and non-invasive, I-MRA remains crucial for definitive diagnosis, particularly for partial-thickness tears or complex tendon injuries. Additionally, stratification by age, gender, and symptom duration showed that MRI maintains consistent diagnostic performance across clinical subgroups, supporting its utility in diverse patient populations.[16]

Overall, our findings highlight that plain MRI is a reliable imaging modality for rotator cuff assessment, with high sensitivity and specificity, and can be used effectively as a first-line diagnostic tool. Indirect MRA provides enhanced diagnostic certainty and should be reserved for equivocal cases or pre-surgical planning. These results strengthen the evidence for MRI as a non-invasive, accessible, and clinically valuable imaging option for shoulder injuries.

Strengths of this study include a validated cross-sectional design, use of a standardized imaging protocol, and independent blinded interpretation by experienced radiologists. Consecutive sampling minimized selection bias, and both imaging modalities were performed in the same session, reducing variability. Limitations include a single-center setting, which may affect generalizability, and a relatively small sample size. The study did not evaluate inter-observer variability quantitatively, and specificity in certain subgroups could not be fully calculated due to constant outcomes.

CONCLUSION

Plain MRI demonstrates high diagnostic accuracy for detecting rotator cuff tears, closely approximating the gold standard of indirect MRA. It can serve as a reliable, non-invasive imaging modality in clinical practice.

Acknowledgement: We sincerely acknowledge the support and guidance of our mentors, colleagues, and the staff of the participating hospital for their valuable assistance throughout this study..

Conflict of Interest: No

Funding Disclosure: None

REFERENCES

1. Akhtar A, Richards J, Monga P. The biomechanics of the rotator cuff in health and disease□A narrative review. J Clin Orthopaed Trauma. 2021;18(3):150-6.
2. Pierce J, Anderson M. Update on diagnostic imaging of the rotator cuff. Clin Sports Med. 2023;42(1):25-52.
3. Agarwalla A, Cvetanovich GL, Gowd AK, Romeo AA, Cole BJ, Verma NN, et al. Epidemiological analysis of changes in clinical practice for full-thickness rotator cuff tears from 2010 to 2015. Ortho J Sports Med. 2019;7(5):2325967119845912.
4. Altamimi TA, Alkathami AA, Al-Awn RM, Alkhaldi MH, Alhudaithi MH, Alqahtani AA, Alzahrani AA, Aladwani SS, Abdulrahman AF, Almutawah AN, ALKHALDI Sr MH. A narrative review of rotator cuff tear management: surgery versus conservative treatment. Cureus. 2024 Dec 2;16(12). e74988. doi: 10.7759/cureus.74988
5. Plancher KD, Shanmugam J, Briggs K, Petterson SC. Diagnosis and management of partial thickness rotator cuff tears: a comprehensive review. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2021 Dec 15;29(24):1031-43. DOI: 10.5435/JAAOS-D-20-01092
6. Kim YS, Lee HJ, Kim JH, Noh DY. When should we repair partial-thickness rotator cuff tears? Outcome comparison between immediate surgical repair versus delayed repair after 6-month period of nonsurgical treatment. Am J Sports Med. 2018;46(5):1091-6.
7. Nunez CN, Scheven U, Bedi A, Arruda EM. Tear growth mechanisms in high-grade bursal-sided partial thickness tears in the rotator cuff measured with full volume magnetic resonance imaging methods. Acta Biomaterialia. 2025 Jul 31. https://doi.org/10.1016/j.actbio.2025.07.038
8. Kwan CK, Ko MC, Fu SC, Leong HT, Ling SK, Oh JH, Yung PS. Are muscle weakness and stiffness risk factors of the development of rotator cuff tendinopathy in overhead athletes: a systematic review. Therapeutic Advances in Chronic Disease. 2021 Jul;12:20406223211026178. https://doi.org/10.1177/20406223211026178
9. Kim J-H, Park J-W, Heo S-Y, Noh Y-M. Magnetic resonance imaging analysis of rotator cuff tear after shoulder dislocation in a patient older than 40 years. Clin Shoulder Elbow. 2020;23(3):144-49.
10. Sheth MM, Shah AA. Massive and irreparable rotator cuff tears: a review of current definitions and concepts. Orthopaedic Journal of Sports Medicine. 2023 May
10;11(5):23259671231154452. https://doi.org/10.1177/23259671231154452
11. Varga SA, Penmetsa M, Emrich T, Todoran TM, Suranyi P, Fuller SR, et al. Diagnostic accuracy of non-contrast quiescent-interval slice-selective (QISS) MRA combined with MRI-based vascular calcification visualization for the assessment of arterial stenosis in patients with lower extremity peripheral artery disease. Eur Radiol. 2021;31(3):2778-87.
12. Piper CC, Hughes AJ, Ma Y, Wang H, Neviaser AS. Operative versus nonoperative treatment for the management of full-thickness rotator cuff tears: a systematic review and meta-analysis. J Shoulder Elbow Surg. 2018;27(3):572-6.
13. Gul W, Amir I, Mahmood K. Indirect magnetic resonance arthrography in detection of rotator cuff tears. Pak J Med Health Sci. 2016;10(4):1225-28.
14. Kivi MM, Asadi K, Aris A, Leili EK, Izadi A. Indirect MRA has more diagnostic value than conventional MRI in partial and subscapularis tears of rotator cuff. J Mazandaran Univ Med Sci 2022; 32 (213):65-72.
15. Desmeules F, Roy JS, Lafrance S, Charron M, Dubé MO, Dupuis F, Beneciuk JM, Grimes J, Kim HM, Lamontagne M, McCreesh K. Rotator Cuff Tendinopathy Diagnosis, Nonsurgical Medical Care, and Rehabilitation: A Clinical Practice Guideline. journal of orthopaedic & sports physical therapy. 2025 Apr;55(4):235-74.
16. Awasthi P, Dwivedi A, Choudhary SS. Role of Magnetic Resonance Arthrography (MRA) in the Diagnosis of Shoulder Injuries. Advanced Biomedical Research. 2025 Jun 1;14(1):55.
17. Roy JS, Braën C, Leblond J, Desmeules F, Dionne CE, MacDermid JC, Bureau NJ, Frémont P. Diagnostic accuracy of ultrasonography, MRI and MR arthrography in the characterisation of rotator cuff disorders: a systematic review and meta-analysis. British journal of sports medicine. 2015 Oct 1;49(20):1316-28.
18. Modipalli D, HegdeAS, ShettyCB.Diagnostic accuracy in rotator cuff tears: clinical tests vs MRI.Int J Res Orthop2019;5:727-31. DOI: http://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20192693
19. Kumar N, Prashanth S. Accuracy of MRI in diagnosing rotator cuff and labral tears of shoulder. International Journal of Orthopaedics Sciences 2020; 6(2): 01-04. https://doi.org/10.22271/ortho.2020.v6.i2a.2008