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Diagnostic performance of ultrasound and magnetic resonance imaging in assessing rotator cuff tears

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Abstract

Background. Rotator cuff tears (RCTs) are common injuries, constituting 60% of shoulder problems, often stemming from repetitive use or traumatic incidents, their prevalence increasing with age. The rotator cuff comprises four muscles, along with their tendinous extensions, crucial for shoulder joint stability and movement. RCTs can be diagnosed with ultrasound (US) and magnetic resonance imaging (MRI) and each of the methods presents with its' benefits and drawbacks.

Aim. This review aims to evaluate the diagnostic capabilities of US and MRI in detecting RCTs.

Methods. The Google Scholar and PubMed databases were used for the narrative literature review, with keywords: "rotator cuff tears", "magnetic resonance imaging", "ultrasound", "diagnostic imaging" in the search fields. 42 articles were selected for further analysis.

Results. Several studies found no significant difference in sensitivity or specificity between MRI and US for diagnosing RCTs. However, US tends to underestimate tear size and retraction, while MRI offers superior reliability for surgical planning, especially in larger tears. Thus, US could be considered the primary diagnostic method for RCTs due to its dynamic nature and cost-effectiveness, with MRI serving to confirm diagnoses in uncertain cases or for detailed anatomical evaluation.

Conclusions. In terms of accuracy, cost, and safety, US emerges as the primary choice, when assessing RCTs. However, it should be noted that US may demand a more specialized expertise. MRI could be used to confirm diagnoses in uncertain cases or for anatomical evaluation prior to surgery.

Keywords: rotator cuff tears, magnetic resonance imaging, ultrasound, diagnostic imaging.

1. Introduction

Rotator cuff tears (RCTs) are a common type of shoulder injury seen in doctor's offices and hospitals, making up 60% of shoulder problems. If they're not diagnosed and treated right, they can lead to disability and trouble using the shoulder properly [1]. RCTs can develop from repetitive use over time, leading to the development of a RCTs within these tendons or traumatic injuries. The likelihood of getting RCTs goes up with age, and both partial and complete tears become much more common after the age of 50 [2,3]. Grunsky et al claims that being older, having the tear in the dominant shoulder, and having a higher body mass index are all separate factors that can lead to a RCTs [4]. RCTs lead to shoulder pain, but the intensity of the pain doesn't always match how severe the tear is, especially until the tears are larger than 2.5 cm [5]. The Rotator Cuff is composed of four muscles – the subscapularis, supraspinatus, infraspinatus, and teres minor – along with their tendinous extensions. These tendons attach to the head of the humerus, playing a crucial role in stabilizing the shoulder joint during movement and enabling rotation of the shoulder [6]. While any of these tendons can tear, the tendons of the supraspinatus and infraspinatus are most commonly affected [7,8]. This type of injury can be diagnosed with ultrasound (US) and magnetic resonance imaging (MRI) and each of the methods presents with its' benefits and drawbacks.

2. Methods

The Google Scholar and PubMed databases were used for the literature review, with keywords and their combinations: "rotator cuff tears", "magnetic resonance imaging", "ultrasound", "diagnostic imaging" in the regular and advanced search fields. For this narrative review 42 articles were selected for further analysis based on their credibility and relevancy on the topic. The ensuing narrative review is structured to unveil prevailing trends and identify existing knowledge gaps.

3. Results

3.1. Ultrasonography for detecting rotator cuff tears

In recent times, ultrasonography has become increasingly favored for identifying (RCTs), as it offers efficient, cost-effective, time-saving shoulder imaging capabilities. The key ultrasound sign of RCTs is tendon discontinuity, often accompanied by tendon retraction. This discontinuity typically appears as fluid-filled gaps, usually anechoic but occasionally echogenic with comet tail artifacts. Additionally, the bursal surface may show focal flattening or concavity at the tear site, with unexplained fluid in the bursa [9,10]. High accuracy rates have been documented in the literature for US detecting RCTs. For example, Liang et al. conducted meta-analysis that included seven prospective studies covering 554 partial and full thickness RCTs in 868 patients. The pooled sensitivity and specificity were respectively 95 % and 72 %, indicating high efficiency of US in diagnosing RCTs [11]. Consistent results have been documented in prior studies when comparing US findings with those obtained from surgical examinations [12,13]. However, it's crucial to recognize that while US excels in detecting full-thickness RCTs, its accuracy diminishes when identifying partial-thickness tears. [14-17]. In the study by Singisetti et al., US revealed 89 % sensitivity and 43 % specificity for supra-spinatus RCTs, and 30 % sensitivity with 100 % specificity for subscapularis RCTs. Among 19 false negatives, one was a full-thickness tear, and 18 were partial-thickness tears, all involving the sub-scapularis tendon. This highlights US's reduced accuracy for smaller and partial tears, especially in the

subscapularis tendon [18]. Thus, surgeons need to be prepared to adapt surgical strategies during arthroscopy to accommodate the differing US accuracy in identifying full-thickness versus partial-thickness RCTs. It is important to note, that US also demonstrates high reliability in identifying recurrent RCTs, as reported by Gilat et al., US showed 80.8 % sensitivity and 100 % specificity for retear diagnosis, rising to 94.7 % sensitivity when partial retears were excluded, with maintained 100 % specificity [19]. Moreover, preoperative shoulder US is also valuable for evaluating RCTs and predicting tendon reparability during surgery. In a prospective study Cox et al. concludes, that visualizing the tear edge suggests a high likelihood of successful arthroscopic repair, while non-visualization indicates moderate chances of irreparability [20]. Nonetheless, there are arguments suggesting that the complex anatomy of the shoulder requires a substantial period to master effective US evaluation. False-positive and false-negative sonographic findings of RCTs can result from various factors such as technique-related issues and anatomical complexities, e.g. anisotropy, transducer positioning and frequency or patient-related factors like obesity [21]. For example, Kim et al. suggests, that novices require approximately 30 scans to achieve competence in detecting RCTs, as third-year residents demonstrate significantly higher diag-nostic accuracy compared to second-year residents [22]. In a study by Rutten et al., only a marginal enhancement was observed as the general radiologist's experience increased, thus the hypothesis that US of the shoulder is highly related to experience could be refuted [23].

3.2. Magnetic resonance imaging for detecting rotator cuff tears.

According to the appropriateness criteria set by the American College of Radiology (ACR), MRI is considered the benchmark for evaluating shoulder pain, whether it results from trauma or not, in cases where rotator cuff disease is suspected. MRI offers detailed and thorough imaging of soft tissue components, particularly the rotator cuff and labrum, making it the preferred diagnostic test [24]. Also, it can assess the dimensions and configuration of the tear, the extent of tendon withdrawal, the visibility of muscle wasting, and the condition of the remaining rotator cuff tendon [25]. Diagnostic accuracy of MRI to accurately identify full-thickness RCTs was substantial, with both sensitivity and specificity ratings exceeding 0.90. In cases of partial RCTs, the specificity remained high (above 0.90), though the sensitivity was reduced, ranging from 0.67 to 0.83 [26]. Various classification systems for RCTs have been suggested. Unfortunately, there is no comprehensive classification system that encompasses all the considerations necessary for managing rotator cuff injuries [27]. When assessing full-thickness tears, MRI stands out as the optimal diagnostic tool, as it provides a comprehensive three-dimensional assessment of all the tendons in the rotator cuff, extending from the point where muscle and tendon join (myotendinous junction) to their attachment points on the greater and lesser tuberosities [28]. Studies on cadaver samples have shown that full-thickness RCTs occur in 5 to 25 % of cases. Meanwhile, a recent investigation involving older individuals with symptoms who had not sought medical attention revealed that imaging tests detected full-thickness tears in 30 % of these individuals [29]. The most definitive indication of such a tear is the observation of a total disruption in the tendon, spanning from the articular side all the way to the bursal side. Typically, this disruption exhibits a fluid-like signal because it contains fluid, along with healing granulation tissue, growth of myofibroblasts,

transformation into chondroid tissue, and/or blood accumulation. In less frequent cases, full thickness tears may show a medium level of T2 signal intensity, likely due to chronic scarring or the blending of signals with nearby histological alterations like scarring or mucoid deterioration [25]. Secondary indicators of full-thickness tears encompass the retraction of the tendon, upward movement of the humeral head, and muscle atrophy [29].

Partial-thickness tears of the rotator cuff affect only a segment of the tendon and can happen on the articular or bursal side, or within the tendon itself, which are known as intrasubstance or interstitial tears [30]. MRI and magnetic resonance angiography (MRA) demonstrated comparable effectiveness in detecting bursal-surface partial-thickness tears. However, the marginal increase of about 5 % in sensitivity and specificity for tears identified through MRA, as opposed to unenhanced MRI, might not justify the additional costs and drawbacks associated with MRA in a clinical setting [31]. Therefore, MRI continues to be among the top diagnostic tools for identifying partial-thickness tears in rotator cuff injuries. The identification of partial-thickness tears in the rotator cuff using MRI is based on morphological characteristics like thinning, fraying, and unevenness, or the presence of fluid signals within the tendon. A low T1 signal combined with a high T2 or short tau inversion recovery (STIR) signal signifies the presence of water, and such a water signal within a tendon is indicative of a tendon tear [32]. MRI plays a crucial role in identifying intratendinous tears that arthroscopy might not reveal, as arthroscopy only allows for the examination of the tendon's external surface. However, these tears are frequently overlooked due to the positioning of the patient. When the arm is placed by the side in an MRI scanner, the rotator cuff layers are pressed together, making it difficult to see tears within the tissue [33].

3.3. Discussion

Assessing the diagnostic capabilities between US and MRI in identifying RCTs is crucial for applying effective treatment plans and optimizing patient outcomes. In a meta-analysis by Jesus et al. no significant difference in either sensitivity or specificity between MRI and US in diagnosing full-thickness tear or partial-thickness RCTs was found [34]. Similar findings were reported in a retrospective analysis by Elmorsy et al., while analyzing patients undergoing shoulder arthroscopy, which had preoperative US or MRI evaluation. After analyzing sensitivity, specificity, positive and negative predictive value, no significant difference was found between US and MRI in detecting any type of RCTs. However, US exhibited higher specificity for detecting partial-thickness tears compared to MRI [35]. Okoroha et al. compared US and MRI in evaluating full-thickness RTCs in 114 patients undergoing arthroscopic repair. It was determined that US tended to underestimate tear size and retraction compared to MRI, with increasing discrepancies between the modalities as the tear size increases. MRI showed superior interobserver reliability for tear size, retraction, and atrophy, Thus, suggesting MRI's superiority for surgical planning for larger tears, as US is less reliable in detecting subtle soft tissue degeneration [36]. Thus, given their similar diagnostic accuracy, US could serve as the primary diagnostic method for RCTs, while MRI could be utilized to confirm diagnoses in uncertain cases, where other shoulder conditions are suspected, such as articular cartilage injuries or labral tears, especially when overlapping with rotator cuff disorders like glenohumeral instability in younger

patients or osteoarthritis in older patients, or for thorough anatomical evaluation prior to surgery. Moreover, US is more dynamic and patient-friendly, reducing both waiting times and costs, given skilled operators [37, 38]. It is important to note, that MRI also has some absolute contraindications, such as the presence of cardiac implantable electronic devices or neurostimulation systems, cochlear implants, cerebral artery aneurysm clips, etc. [39]. While further investigation is necessary, the use of contrast-enhanced ultrasound (CEUS) is emerging as a promising diagnostic tool for RCTs. In their study, Tang et al. evaluated CEUS, MRI and US diagnostic methods, and discovered that CEUS successfully detected lesions in all 31 patients involved, while US and MRI misinterpreted 4 small lesions [40]. Artificial intelligence and machine learning are also gradually being integrated into diagnostic processes, marking a significant shift towards more data-driven and automated medical assessments. This evolution promises to enhance diagnostic accuracy and efficiency, especially for complex RCTs where nuanced interpretation of data is crucial [41,42].

4. Conclusion.

In terms of accuracy, cost, and safety, US emerges as the optimal primary choice, when assessing suspected RCTs. However, it should be noted that US may demand a more specialized radiologist expertise. MRI could be used to confirm diagnoses in uncertain cases or for anatomical evaluation prior to surgery.

References

1. Smith TO, Daniell H, Geere JA, Toms AP, Hing CB. The diagnostic accuracy of MRI for the detection of partial- and full-thickness rotator cuff tears in adults. Magn Reson Imaging. 2012;30(3):336-46.

2. Ghorpade K, Patil J, Patil T, Khambalkar S. Functional outcome of arthroscopic assisted mini open rotator cuff tear repair. Asian Journal of Pharmaceutical and Clinical Research. 2023;16(5):58-62.

3. Frich LH, Fernandes LR, Schrøder HD, Hejbøl EK, Nielsen PV, Jørgensen PH, Stensballe A, Lambertsen KL. The inflammatory response of the supraspinatus muscle in rotator cuff tear conditions. J Shoulder Elbow Surg. 2021;30(6):e261-e275.

4. Zhao J, Luo M, Liang G, Pan J, Han Y, Zeng L, Yang W, Liu J. What Factors Are Associated with Symptomatic Rotator Cuff Tears: A Meta-analysis. Clin Orthop Relat Res. 2022;480(1):96-105.

5. Hinsley H, Ganderton C, Arden NK, Carr AJ. Prevalence of rotator cuff tendon tears and symptoms in a Chingford general population cohort, and the resultant impact on UK health services: a cross-sectional observational study. BMJ Open. 2022;12(9):e059175.

6. Dolan M, Patetta M, Pradhan S, Rybalko D, Bobko A, Shi L, Goldberg B, Amirouche F, Koh J. Muscle Fiber Contribution to Rotator Cuff Moment Arms During Abduction for Intact Rotator Cuff, Complete Supraspinatus Tear, Superior Capsular Reconstruction, and Reverse Shoulder Arthroplasty. Orthop J Sports Med. 2021;9(10 suppl5):2325967121S00333.

7. Schaeffeler C, Mueller D, Kirchhoff C, Wolf P, Rummeny EJ, Woertler K. Tears at the rotator cuff footprint: Prevalence and imaging characteristics in 305 MR arthrograms of the shoulder. *Eur Radiol*. 2011;21:1477–1484.

8. Millett P, Warth R. Posterosuperior Rotator Cuff Tears: Classification, Pattern Recognition, and Treatment. The Journal of the American Academy of Orthopaedic Surgeons. 2014;22:521-524.

9. Datta V, Voci S. Sonographic appearance of rotator cuff tears. Ultrasound Q. 2012;28(2):139-40.

10. Yoon YC. Ultrasonography of the Rotator Cuff. J Korean Soc Ultrasound Med. 2006;25:109-125.

11. Liang W, Wu H, Dong F, Tian H, Xu J. Diagnostic performance of ultrasound for rotator cuff tears: a systematic review and meta-analysis. Med Ultrason. 2020;22(2):197-202.

12. Dinnes J, Loveman E, McIntyre L, Waugh N. The effectiveness of diagnostic tests for the assessment of shoulder pain due to soft tissue disorders: a systematic review. Health Technol Assess. 2003;7(29):111 –166.

13. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears: comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am. 2004;86:708 –716.

14. BET 2: Is ultrasound a reliable way of detecting rotator cuff injuries of the shoulder? Emerg Med J. 2014;31(7):605-607.

15. Toro-Saelzer F, Meleán-Quiroga P, Ruiz-Jiménez F, Moraga-Huerta C, González-Foretic F. Ruptura del manguito rotador: correlación de hallazgos ultrasonográficos y artroscópicos. Acta Ortop Mex. 2011;25(3):146-50.

16. Smith TO, Back T, Toms AP, Hing CB. Diagnostic accuracy of ultrasound for rotator cuff tears in adults: a systematic review and meta-analysis. Clin Radiol. 2011;66(11):1036-48.

17. Milosavljevic J, Elvin A, Rahme H. Ultrasonography of the rotator cuff: a comparison with arthroscopy in one-hundred-and-ninety consecutive cases. Acta Radiol. 2005;46(8):858-65.

18. Singisetti K, Hinsche A. Shoulder Ultrasonography versus Arthroscopy for the Detection of Rotator Cuff Tears: Analysis of Errors. Journal of Orthopaedic Surgery. 2011;19(1):76-79.

19. Gilat R, Atoun E, Cohen O, Tsvieli O, Rath E, Lakstein D, Levy O. Recurrent rotator cuff tear: is ultrasound imaging reliable? J Shoulder Elbow Surg. 2018;27(7):1263-1267.

20. Cox JL, Laughlin MS, Elkousy HA, Baker HM, Badman BL, Ziegler DW, Buford DA, Kruse KK. Determination of rotator cuff tear reparability: an ultrasound-based investigation. JSES Int. 2021;7(1):21-24.

21. Rutten MJ, Jager GJ, Blickman JG. From the RSNA refresher courses: US of the rotator cuff: pitfalls, limitations, and artifacts. Radiographics. 2006;26(2):589-604.

22. Kim DM, Seo JS, Jeon IH, Cho C, Koh KH. Detection of Rotator Cuff Tears by Ultrasound: How Many Scans Do Novices Need to Be Competent? Clin Orthop Surg. 2021;13(4):513-519.

23. Rutten MJ, Jager GJ, Kiemeney LA. Ultrasound detection of rotator cuff tears: observer agreement related to increasing experience. AJR Am J Roentgenol. 2010;195(6):440-6.

24. Amini B, Beckmann NM, Beaman FD, Wessell DE, Bernard SA, Cassidy RC, Czuczman GJ, Demertzis JL, Greenspan BS, Khurana B, Lee KS, Lenchik L, Motamedi K, Sharma A, Walker EA, Kransdorf MJ. ACR Appropriateness Criteria® Shoulder Pain-Traumatic. J Am Coll Radiol. 2018;15(5S):S171-S188.

25. Bencardino JT, Garcia AI, Palmer WE. Magnetic resonance imaging of the shoulder:

rotator cuff. Top Magn Reson Imaging. 2003;14(1):51-67.

26. 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. Br J Sports Med. 2015 ;49(20):1316-28.

27. Chidambaram R, Mukhopadhyay R. Classification Systems in Rotator Cuff Tears. Asian Journal of Arthroscopy. 2021; 6(1): 31-35

28. Gimarc DC, Lee KS. Shoulder MR Imaging Versus Ultrasound: How to Choose. Magn Reson Imaging Clin N Am. 2020;28(2):317-330.

29. Ashir A, Lombardi A, Jerban S, Ma Y, Du J, Chang EY. Magnetic resonance imaging of the shoulder. Pol J Radiol. 2020;85:e420-e439.

30. Fitzpatrick LA, Atinga A, White L, Henry PDG, Probyn L. Rotator Cuff Injury and Repair. Semin Musculoskelet Radiol. 2022;26(5):585-596.

31. Zoga AC, Kamel SI, Hynes JP, Kavanagh EC, O'Connor PJ, Forster BB. The Evolving Roles of MRI and Ultrasound in First-Line Imaging of Rotator Cuff Injuries. AJR Am J Roentgenol. 2021;217(6):1390-1400.

32. Wright T, Yoon C, Schmit BP. Shoulder MRI refinements: differentiation of rotator cuff tear from artifacts and tendonosis, and reassessment of normal findings. Semin Ultrasound CT MR. 2001;22(4):383-95.

33. Plancher KD, Shanmugam J, Briggs K, Petterson SC. Diagnosis and Management of Partial Thickness Rotator Cuff Tears: A Comprehensive Review. J Am Acad Orthop Surg. 2021;29(24):1031-1043.

34. de Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. AJR Am J Roentgenol. 2009;192(6):1701-7.

35. Elmorsy A, Keightley A, Flannery M. Accuracy of Ultrasonography (US) and Magnetic Resonance Imaging (MRI) in Detection of Rotator Cuff Tears in District General Hospital. Pol J Radiol. 2017;82:634-637.

36. Okoroha KR, Mehran N, Duncan J, Washington T, Spiering T, Bey MJ, Van Holsbeeck M, Moutzouros V. Characterization of Rotator Cuff Tears: Ultrasound Versus Magnetic Resonance Imaging. Orthopedics. 2017;40(1):e124-e130.

37. Chauhan NS, Ahluwalia A, Sharma YP, Thakur L. A Prospective Comparative Study of High Resolution Ultrasound and MRI in the Diagnosis of Rotator Cuff Tears in a Tertiary Hospital of North India. Pol J Radiol. 2016;81:491-497.

38. Apostolopoulos AP, Angelis S, Yallapragada RK, Khan S, Nadjafi J, Balfousias T, Selvan TP. The Sensitivity of Magnetic Resonance Imaging and Ultrasonography in Detecting Rotator Cuff Tears. Cureus. 2019;11(5):e4581.

39. Ghadimi M, Sapra A. Magnetic Resonance Imaging Contraindications. [Updated 2023 May 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551669/.

40. Tang YQ, Zeng C, Su XT, Li SS, Yi WH, Xu JJ, Wu GQ, Chen YJ, Li MW, Liu HM. The Value of Percutaneous Shoulder Puncture with Contrast-enhanced Ultrasound in Differentiation of Rotator Cuff Tear Subtypes: A Preliminary Prospective Study. Ultrasound Med Biol. 2019;45(3):660-671.

41. Allaart LJH, Spanning SV, Lafosse L, Lafosse T, Ladermann A, Athwal GS, Hendrickx LAM, Doornberg JN, van den Bekerom MPJ, Buijze GA; Machine Learning Consortium. Developing a machine learning algorithm to predict probability of retear and functional outcomes in patients undergoing rotator cuff repair surgery: protocol for a retrospective, multicentre study. BMJ Open. 2023;13(2):e063673.

42. Familiari F, Galasso O, Massazza F, Mercurio M, Fox H, Srikumaran U, Gasparini G. Artificial Intelligence in the Management of Rotator Cuff Tears. Int J Environ Res Public Health. 2022;19(24):16779.