State of the Field: The Utility of Ultrasound in the Diagnosis of Rotator Cuff Tears

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Introduction

The rotator cuff is a dynamic stabilizer and is a chief contributor to both glenohumeral joint stability and movement.[1, 2] Tears of the rotator cuff can occur as the result of an acute eccentric load, glenohumeral joint dislocation, or via chronic, age-related tendon degeneration.[3] Injuries can vary in severity from partial-thickness to full-thickness tears and may cause significant pain, decreased shoulder mobility, and irreparable damage to the rotator cuff or glenohumeral joint.[4] Rotator cuff disorders are highly prevalent and are the most common cause of shoulder disability in the United States. Specifically, rotator cuff disorders are responsible for approximately 30-70% of pain-related shoulder conditions and 70% of shoulder-related physician visits, accounting for over 4.5 million annual visits in the US.[5-7] Cadaveric evaluation has indicated the prevalence of partial and full-thickness rotator cuff tears to range from 5-40%. Additional population-based studies of both symptomatic and asymptomatic individuals have found a 21% prevalence of rotator cuff tears.[8, 9]

With over 270,000 rotator cuff surgeries performed annually, the diagnosis and management of rotator cuff injuries has become a significant healthcare burden.[10] Recent analyses have estimated that the diagnosis and repair of rotator cuff injuries account for over $3 billion in total associated healthcare costs.[11, 12] Given the high prevalence and large economic burden of rotator cuff injury, accurate and cost-effective diagnostic modalities are critically important for evaluating patients. Historically, Magnetic Resonance Imaging (MRI) without contrast was the preferred imaging modality for assessment of rotator cuff pathology. Subsequently, direct and indirect MRI with contrast, known as Magnetic Resonance Arthrography (MRA), was developed to provide improved intra-articular enhancement in joints and overall visualization.[13, 14] Although a recent study by Lee et al[15] demonstrated increased specificity and sensitivity for the diagnoses of rotator cuff tears with utilization of MRA, non-contrast MRI remains the preferred diagnostic modality among both sports and shoulder-trained surgeons.

In addition to MRI and MRA, ultrasound has also emerged as an important diagnostic modality throughout the field of orthopaedic surgery. Initially described in 1984, ultrasound evaluation of shoulder pathology started gaining acceptance among orthopaedic surgeons in the 1990s due to improvements in transducer strength, resolution, and operator training.[16, 17] In the early 2000s, ultrasound became more commonly used in the diagnosis of both partial and full-thickness rotator cuff tears, partly as a result of increased musculoskeletal ultrasound training for radiologists.[18, 19] Recent meta-analyses have found the specificity and sensitivity of ultrasound (US) to be similar to that of MRI and MRA for the diagnosis of rotator cuff tears.[20-22] A recent meta-analysis from 2015 identified comparable sensitivity (0.90–0.91) and specificity (0.93–0.95) for ultrasound as compared to both MRI, and MRA in the diagnosis of full-thickness rotator cuff tears. These results were consistent for trained clinicians across multiple sub-specialties including radiologists, orthopaedic surgeons and sonographers.[20] Similar to MRI and MRA, ultrasound appears to be more accurate in the diagnosis of full-thickness rotator cuff tears as compared to partial-thickness tears.[20,23]

Clinicians have traditionally considered diagnostic accuracy to be the most important factor when selecting between diagnostic imaging modalities. With the comparable diagnostic capabilities of US, MRI, and MRA, there are several other factors that make US an appealing option. Ultrasound has essentially no contraindications because it does not utilize rotating magnetic fields or contrast agents. MRI and MRA are contraindicated for patients with implanted devices with ferromagnetic or electrically conductive materials, such as left ventricular assist devices (LVADs), electrically conductive pulmonary artery monitoring catheters, and cochlear implants. Additionally, patients with ferromagnetic foreign bodies, common with metal workers and veterans, may be not be able to obtain a MR evaluation.[24-26] MRA is also contraindicated for patients with renal disease as prolonged exposure to Gadolinium may cause Nephrogenic Systemic Fibrosis.[27] Additionally, MRI and MRA are relatively contraindicated for the 1% of individuals who experience claustrophobic events during MRI.[28]

The recent focus on healthcare cost and expenditure has led to an increased interest

in developing cost-effective and responsible practices and metrics. Specifically, cost-effective imaging modalities are needed as healthcare continues to move from a fee-for-service model towards a value-based model where physicians and other health-care professionals are evaluated based on patient outcomes. Given these important considerations, ultrasound has been shown to be more cost-effective than MRI.[29] Medicare reimbursement for a hospital-based shoulder MRI (CPT:73221) ranges from $303.51 to $387.01, while reimbursement for a hospital-based shoulder ultrasound (CPT:76881) ranges from $144 to $189.37.[30] Studies suggest that this difference may be even greater within private insurance, where the average MRI reimbursement is $999.67 per patient.[31] Furthermore, increased efficiency within healthcare is vital as it allows for greater access to care, providing increased value and improved outcomes while simultaneously limiting cost. Unlike MRI, ultrasound can be performed in the office and, as such, is a more efficient and convenient diagnostic modality. At our institution, shoulder US requires roughly 10 minutes to perform while shoulder MRI requires around 40 minutes. When offered the choice, patients who have undergone both procedures report less discomfort during the ultrasound exam, greater satisfaction following the procedure, and an overall preference for US over MRI of the shoulder.[32] Ultrasound also allows for a dynamic evaluation of the shoulder with identification of pathologies not detectable by MRI or MRA, which are static examinations.[33]

Despite these relative advantages of US over MRI and MRA, integration of ultrasound into clinical practice has been slow. A recent survey of members of the American Shoulder and Elbow Surgeons group (ASES) found that only 55% of respondents used ultrasound in their practice and only 10% felt comfortable using it as their sole imaging modality preoperatively.[34] One reason for this may be that shoulder surgeons are not comfortable conducting or interpreting shoulder ultrasound evaluations and are therefore reluctant to rely solely on the ultrasound report and images captured by the radiologist. These concerns may be valid as US accuracy has been shown to be operator-dependent with considerable training required to reach proficiency. Literature demonstrates that orthopaedic surgeons must scan between 50 to 100 unique shoulders before they achieving diagnostic proficiency comparable to their ability to read MRI.[35, 36] Despite the diagnostic abilities of ultrasound, as demonstrated in the radiology literature, some respondents to the ASES survey also stated that they were not confident that US could determine whether a tear is reparable.[34]

With regards to the development of diagnostic proficiency, ultrasound certifications are readily available via the musculoskeletal sonography certification (RMSK) accredited by The American Registry for Diagnostic Medical Ultrasonography (ARDMS) and the American National Standards Institute (ANSI). Additionally, there are several musculoskeletal ultrasound conferences that provide updates on the current state of ultrasound imaging, which include, but are not limited to, the Musculoskeletal Ultrasound Society and the American Institute of Ultrasound in Medicine. This demonstrates the availability and accessibility of valuable resources to orthopedic surgeons interested in developing diagnostic ultrasound proficiency and accreditation. In addition, further clinical analysis comparing inter- and intra-operator reliability, as well as diagnostic accuracy for partial thickness tears, are needed to establish shoulder ultrasound as an ubiquitous diagnostic modality within the field of orthopaedic surgery.

Penn Insights

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Despite the relative advantages of ultrasound over MRI for rotator cuff tear diagnosis, MRI is still the default study for most orthopedic shoulder surgeons. One of the main reasons for the under-utilization of shoulder ultrasound is that many orthopedic surgeons cannot independently perform or interpret images from a shoulder ultrasound. As a result, these surgeons are completely dependent on the radiology report. Moreover, the diagnostic accuracy of ultrasound is operator dependent and surgeons must establish a high level of trust in the radiologist performing the ultrasound before they feel comfortable acting solely upon the radiologist's ultrasound results. By contrast, most orthopedic surgeons independently assess MRI images in addition to reviewing the radiology report. In addition, MRI allows for complete evaluation of the bony anatomy and soft-tissues about the shoulder whereas there are some limitations to ultrasound. Specifically, ultrasound cannot be used to assess subscapularis muscle atrophy or the glenoid labrum in detail.

The above notwithstanding, ultrasound is very appealing because of its efficiency, decreased cost, and the dynamic nature of the exam as opposed to the static images obtained with MRI. In my own practice, I order shoulder ultrasounds when there is a contraindication for MRI, in some situations when there is pain that cannot be explained by MRI results, or when dynamic pathology with respect to movement needs to be evaluated. I also routinely order an ultrasound for image-guide lavage of calcific tendinitis. As ultrasound becomes more commonly taught in medical student education and orthopaedic surgery residency / fellowship, I believe ultrasound will be more commonly utilized by practicing orthopaedic surgeons.

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While ultrasound is an interesting imaging modality due to its cost-effectiveness and efficiency, MRI is still the more reliable imaging modality for the diagnosis of rotator cuff tears and shoulder pathology. One of the main barriers to the use of shoulder ultrasound is that most orthopaedic surgeons cannot read ultrasound scans. As a result, the surgeon cannot independently evaluate and verify the scans and must make a clinical decision solely based upon the radiology

report. Making a clinical decision without independent verification requires a certain degree of trust which is hard to establish with shoulder ultrasound given the variability in operator experience and quality of scans received. MRI allows orthopaedic surgeons to independently evaluate and verify scans which helps to prevent unnecessary operations and pick up pathology that warrants surgical intervention. Moreover, MRI is standardized across institutions which makes it a very reliable and trustworthy imaging modality. In my own practice, I have used shoulder ultrasound when patients are contraindicated for MRI, but I will still supplement the ultrasound scans with a CT arthrogram to completely evaluate shoulder pathology.

Shoulder ultrasound has a use in orthopaedics when a general evaluation of rotator cuff integrity is necessary. For example, ultrasound may be indicated when checking whether a patient's rotator cuff is intact prior to arthroplasty for arthritis, helping to decide if total or reverse arthroplasty is warranted. However, ultrasound for more detailed evaluation of shoulder pathology is not adequate and not a replacement for MRI due to the increased operator variability and inability to pick up specific pathology such as chondral defects.

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