Ultra-sonography in the detection of shoulder rotator cuff tears

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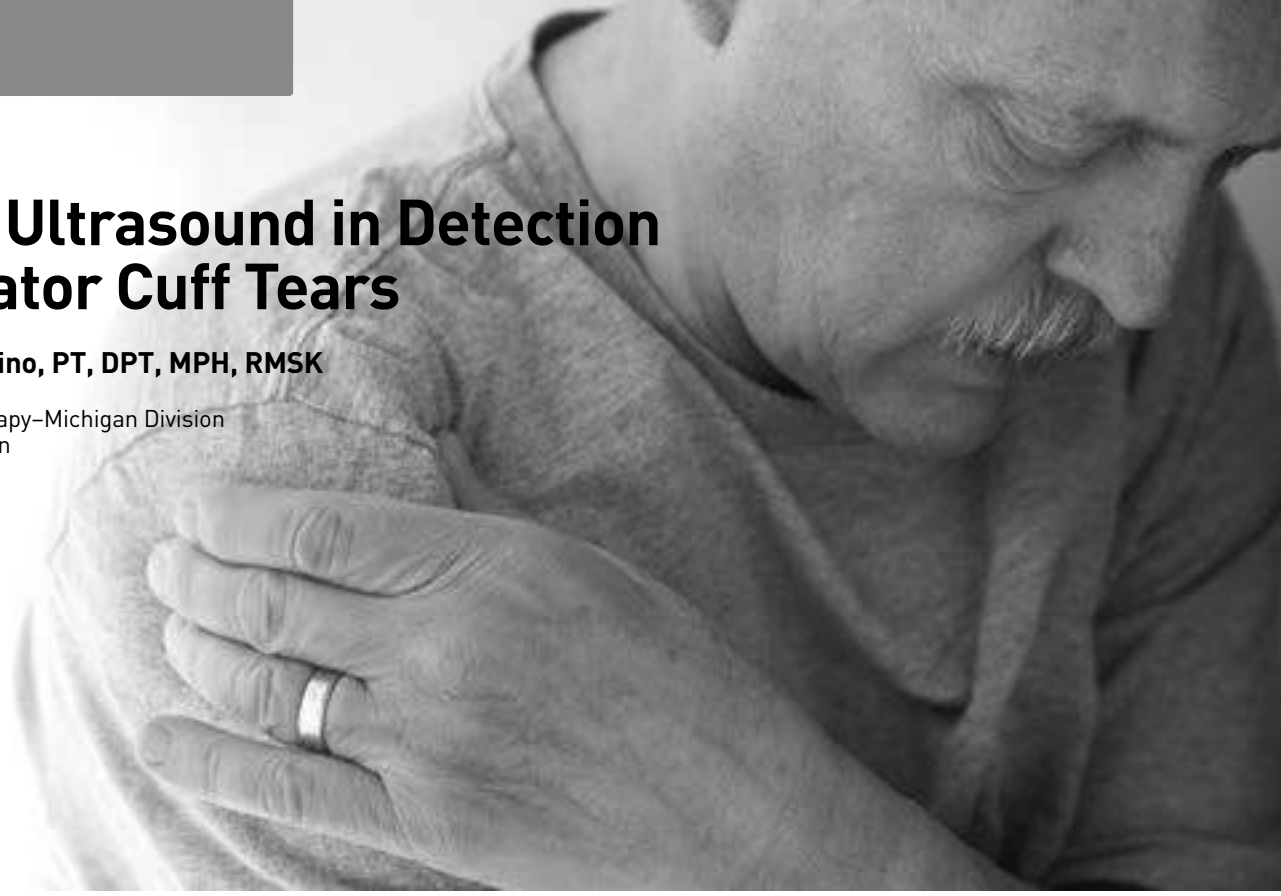

Use of Ultrasound in Detection Of Rotator Cuff Tears

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Musculoskeletal (MSK) injuries are one of the most common pain conditions seen in clinical practice. In 2004, it was estimated that MSK injuries accounted for $510 billion in direct medical costs and an addition $339 billion in lost time and productivity.[1] The Bureau of Labor Statistics recently reported that 387,800 employees missed work due to MSK disorders in 2011.

Shoulder pain represents a significant portion of MSK injuries and typically ranks in the top three MSK complaints seen in physician offices. In 2006 there were over 7.5 million physician visits for shoulder pain and current estimates are that 440 million work days were lost specifically because of shoulder pain and rotator cuff injury.[2] Rotator cuff injuries, in particular, can be painful and debilitating, leading to chronic disability and job loss. In the manufacturing sector where upper extremity motion and cumulative trauma is more likely, the incidence (new cases) of shoulder pain is greater than in the general population.

Clearly, higher vigilance needs to be considered for workplace shoulder injuries, which would include a surveillance approach for those workers with existing injury. The goal in this type of monitoring initiative would be the prevention of further trauma via early and noninvasive interventions.

The use of diagnostic ultrasound (DUS) could figure prominently in this type of preventive and/or early intervention program—and already does with some larger employers. It is within this context of collective pain, disability, and cost generated by shoulder injury management that we review the value of DUS.

Diagnostic Ultrasound

The use of DUS as an imaging source to help guide the diagnostic process in shoulder evaluation has grown exponentially in the last few years. Instead of being the cheaper alternative to the "gold standard" magnetic resonance imaging (MRI), current evidence supports the use of DUS as an accurate primary imaging test for MSK lesions. Indeed, both MRI and DUS are excellent tests for assisting in the diagnosis of rotator cuff tears (RCT) of the shoulder.[3] However, the addition of a contrast agent with MRI probably tips the accuracy rate and diagnostic precision slightly in favor of MRI. So why use DUS? DUS has the advantage of demonstrated cost-effectiveness, ease of use, and patient compliance.

Prevalence of RCT

Why focus attention on prevalence? Prevalence is usually defined by the number of people with the disease over the number of people at risk, and determined at a single point in time. Much has been written about RCT prevalence with seemingly very different values being reported in the literature. It is evident that the reported prevalence in a study is dependent on the actual population under investigation. The various point estimates reported in the literature reflect the varied subsets of population groupings that are available to investigators. For example, the prevalence of symptomatic RCTs is expected to be greater in a population of men working

on an assembly line and over the age of 45 years than their younger counterparts under 30 years of age, reflecting a relative disparity attributable to a single risk factor. Presumably, the physiologic status of a human tendon is a culmination of factors that include wear and tear, genetic factors, nutritional status, and overall health of the persons MSK system, to name but a few.

There are other risk factors that have been associated with a higher than normal risk for rotator cuff tearing, including repetitive work, heavy work, age-related rotator cuff delamination (rotator cuff disease), gender, postural dysfunction, acromial hooking (Bigliani scale), frailty/deconditioning, and metabolic disease.[4] Preoperative diagnosis of a RCT will depend on several key factors, including the capabilities of the diagnostic tool and the experience/skill of the interpreter. As a result, the literature reports varying diagnostic accuracy indicis while using DUS to detect RCTs and is even stratified them, in some cases, based on professional category such as radiologist, orthopedic surgeon, chiropractor, podiatrist, physical therapist, and physiatrist. The practitioner performance reporting actually serves several important functions:

- Reports practional-specific accuracy rates (competency)
- Identifies a specific practitioner group capability (capacity)
- Assists in validating professional groups' claim to a test or technology (utility)
- Provides useful data for professional policy makers in lobbying for expanding profession-specific scope of practice.

Rationale for Testing

The general assumption that all RCTs lead to pain and dysfunction has been challenged repeatedly. We now understand that not everything that appears "damaged or abnormal" is symptomatic. In cases where we have a partial tendon tear through non-traumatic processes, as in age-related rotator cuff delamination, it is entirely feasible and very likely "probable" that there is little if any pain—even when exertions are placed on the shoulder. We would expect very poor mobility and strength-generating capabilities in this shoulder, but not necessarily pain.

By contrast, a more acute and less severe condition such as a strain could conceivably generate significantly more pain signals, leading to weakness through reflex joint inhibition as a result of pain and swelling. The message then becomes that we must all be careful with the assumptions that are made on the relationship between what we see versus what patients are reporting as symptoms.

All this preamble is not to downgrade the value of a diagnostic test; rather it is to help clarify why there is so much variation in how validity indicis are reported in reference to the ultrasonography detection of RCTs in the shoulder. After all, is there any aspect of a diagnostic test that impacts its usefulness more than the ability of that test to accurately detect the lesion of interest? Cost, availability, patient acceptance, feasibility, and other factors are certainly important, but at the end of the day, if the test suffers from poor intrinsic measurement capabilities such as reliability and validity, then the utility of that test becomes compromised.

A shoulder is examined for various reasons such as pain, weakness, deformity, swelling, and/or motion deficits. Sometimes only one of these is present, other times all are present. The reason why clinicians do not rely solely on images to establish a diagnosis is that shoulder pain, weakness, or range of motion (ROM) deficits are not attributes that can necessarily be captured in a picture. We cannot see pain nor do we have a universally accepted and agreed upon method to objectively measure pain.

Mobility deficits and weakness are domains measured indirectly through strength and motion measuring devices, which rely on patient involvement including effort, motivation, understanding, and compliance to achieve. As a result of our inabilities to measure many of the signs and symptoms that patients present with, we tend to fill in the missing information with assumptions based on our many years of training and experience. For instance, it would be reasonable to assume that a RCT would be painful, but we now know that there are just as many, if not more, asymptomatic RCT-compromised shoulders.[4] Studies that select broader populations of both painful and non-painful shoulders have identified this pattern.

Another interesting finding is that in a review of cadaveric and radiologic-studies, which presumably should contain both symptomatic and asymptomatic subjects, the radiological prevalence of tears exceeds the cadaveric prevalence.[5] I think this finding is useful to keep in mind because it could signal a couple of important points: there is measurement error in any test that partially explains over reading tests, and failure to recognize this first point could lead to over diagnosis and the subsequent erroneous conclusion to order further expensive and risky testing/intervention.

Assessing the Rotator Cuff

Oxygen levels appear to be a critical determinant of healing in injured and post-surgical shoulders. Recent research has elucidated the role of externally applied oxygen (O_2) monitors as an immediate and future predictor of rotator cuff health and recovery, especially in surgically repaired shoulders.[6] Therefore, any method that can demonstrate cost effectiveness in monitoring O_2 levels of the rotator cuff tendon will

likely have a high usefulness in clinical medicine and rehabilitation.

Recent preliminary testing of the Inspectra O_2 shock assessment device (Hutchinson Labs), which is typically used in Level I trauma centers to quickly measure O_2 concentrations in seriously injured or compromised patients, has shown promise in clinical rehabilitation settings. The device has demonstrated both high test/re-test reliability and responsiveness (ie, the ability to detect meaningful measures of clinically important change).[7] Inducing rotator cuff perfusion by application of superficial heat (hydrocollator pack), targeting shoulder exercise (concentric contractions), and acoustic compression energy are all expected to increase rotator cuff capillary bed perfusion (blood flow), which can be measured by this external O_2 measuring device.

DUS has demonstrated the ability to be an accurate functional imaging tool in the differential diagnosis of RCT evaluation.[8-13] There appears to be a diagnostic hierarchy in terms of the various methods available to evaluate the rotator cuff tendons, with respect to tear size, with open surgeries and post mortem cases perhaps providing the best assessments (verification) of rotator cuff tearing and used as a reference standard (gold standard) for comparative evaluations. Using correlation analysis (PPMCC), Bryant et al compared estimated RCT size with the findings at open operation in 33 consecutive patients with a presumptive diagnosis of RCT. Arthroscopy estimates of tear size correlated best with actual tear size (Pearson correlation coefficient r = 0.92; P <.001). Magnetic resonance imaging (r = 0.74; P <.001) was similar to ultrasonography (r = 0.73; P <.001).[14]

The psychometric properties of DUS have been well established, including test/re-test reliability and validity.[15,16] The most cited disadvantage of DUS has been its reliance on operator training and experience. Later studies that examined inter-tester reliability confirmed the value of experience with an increasing inter-observer agreement as level of experience rises. The only exception might be when radiologists inexperienced with MSK ultrasound are compared with their experienced counterparts. Then, the inter-observer agreement (Kappa value) is high, with both groups showing comparable accuracy.[17] In regards to diagnostic MSK ultrasound there are two take-home points; the first is that DUS can be highly accurate as a diagnostic test; the second is, you can only achieve high accuracy with formal training and experience.

Examples of RCT

Figures 1 and 2, page 66, both represent scans of a shoulder with a RCT. The tear is visualized as a focal hypoechoic region (darker) relative to the surrounding tissue, which is a combination of white (speckled) and dark areas uniformly distributed (homogenous), representing healthy tissue. This relative difference in echogeneity is one of the characteristic or hallmark indicators of, in this case, loss of tendon fibrillar density. Ultrasonography is useful in detecting both partial and full thickness tears, along with associated comorbidities such as subacromial/subdeltoid bursitis, bicipital long head tendonitis, and deltoid muscle ruptures.

Normal scans in both short- and long-axis views (Figures 3 and 4, page 66) show the various layers commonly encountered when scanning for shoulder pathology. Irregularities in normal anatomy are identified by the sonographer as having either distinct appearances and/or unique artifact pattern. Understanding the biophysics of acoustic energy transmission explains the artifacts seen in MSK ultrasound. These can be anticipated based on a fundamental comprehension of how sound waves interact with varying tissue morphology. DUS may be the only imaging method where error or noise in the system can actually increase the likelihood of making the correct diagnosis for a select group of pathologies.

Conclusion

Ultrasound imaging is accurate, affordable for virtually any practice, well tolerated by patients, has no known adverse effects, transportable, reimbursable, provides real time data, and is functional. That is an impressive list of advantages, which will only continue to add to the popularity of this imaging test. DUS can be used simply as an imaging tool to aid in a differential diagnosis, or a patient education tool to demonstrate and provide visual feedback on core muscle activation in a patient with low back pain secondary to core insufficiency.

Another growing application is the use of DUS in research. DUS can be used as an outcome measure to confirm whether there has been healing in soft tissue as a result of a particular intervention. It is also being used as a surveillance tool to monitor the effects of certain workplace exposures such as assembly line repetitive stress on upper extremity soft tissues. The ability to visualize and actually measure a tear, cyst, mass, fluid collection, foreign objects—along with comparative normal anatomy such as tendons, ligaments, muscle thickness, nerve diameters, etc.—provides a powerful tool in the measurement of status change. The ability to demonstrate and quantify change is a central tenet of evidence-based medicine. Before and after measures allow us to quantitatively measure and objectively report the characteristics of target tissue such as a tendon, hematoma, or bursal effusion. Until DUS, these were abstractions without dimension in most clinical settings. They are now concrete

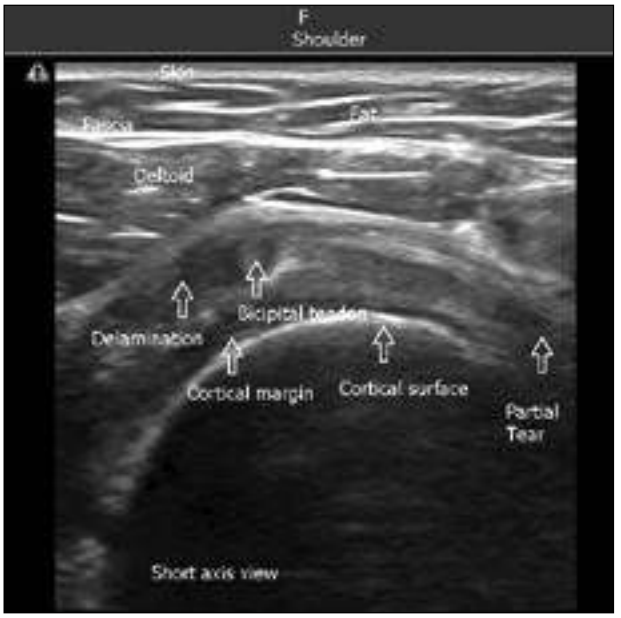

Figure 1. Short-axis view of diagnostic ultrasound in a patient with a partial rotator cuff tear (hypo-echoic region).
Images courtesy of Terason.

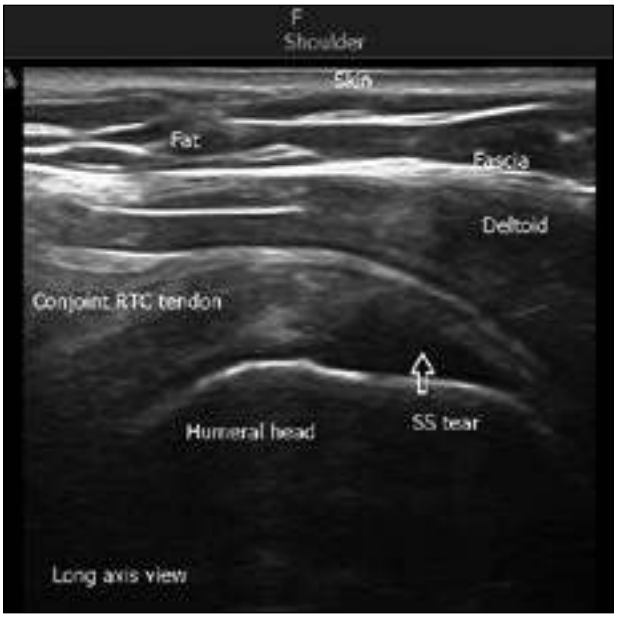

Figure 2. Long-axis view of same patient.

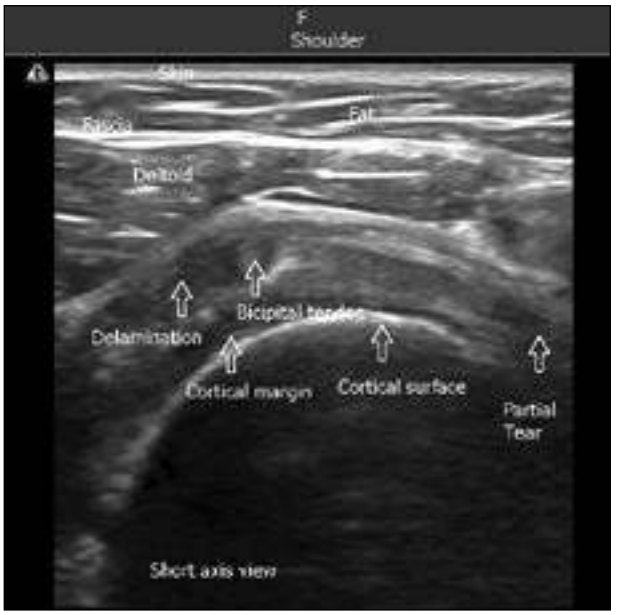

Figure 3. Short-axis view of normal shoulder.
Images courtesy of Dr. Steve Skurow, Terason.

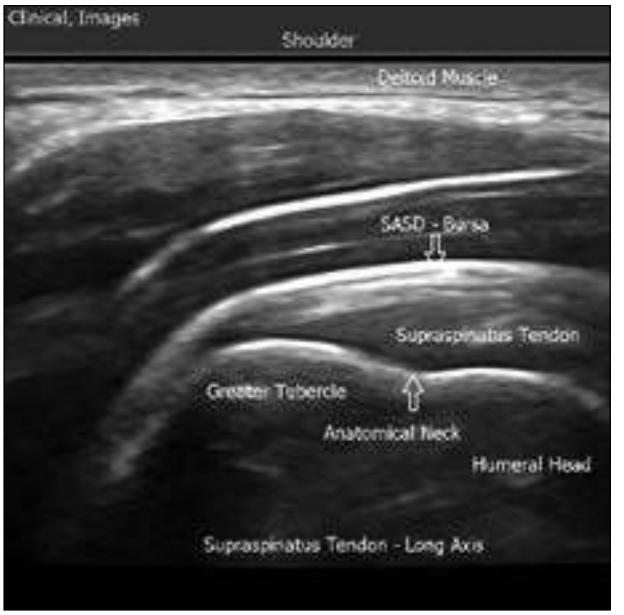

Figure 4. Long-axis view of same patient.

and measureable variants in the human condition, and if we can measure it, we can change it.■

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