Comparison of MRI Findings After Musculoskeletal Ultrasound: An Opportunity to Reduce Redundant Imaging

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INTRODUCTION

Musculoskeletal (MSK) ultrasound is an advanced imaging modality that can provide results that are comparable, complementary, or even superior to those of MRI for the evaluation of MSK symptoms. However, in the United States, MRI is favored over ultrasound for advanced imaging of MSK conditions [1]. Although the acceptance of ultrasound examination has increased in the past decade, especially for rotator cuff imaging, this modality is still relatively underused in the United States despite its high diagnostic accuracy and cost advantages [2-4]. Currently, MSK ultrasound continues to be an area of interest for radiologists and their clinical colleagues [5,6], and the experience at our institution has directly reflected this trend.

MOTIVATION

Our institution is a large multidisciplinary subspecialty practice at which the MSK ultrasound service has seen exponential growth since its formal establishment in 2009. As part of an effort to streamline and improve processes within the radiology department, the medical director of the MSK ultrasound service (18 years of experience) reviews each ultrasound case on a quarterly basis. Through this review, it was observed that MRI examinations were often ordered and performed after diagnostic ultrasound examinations for the same or similar clinical concerns. We questioned the added diagnostic value of follow-up MRI in these cases. The goal of this project was to determine whether MRI provides additional diagnostic value after an ultrasound examination has been performed. We hypothesized that when used appropriately, ultrasound examinations provide results that are comparable with those obtained with MRI and that MRI performed after ultrasound therefore rarely changes the diagnosis.

DATA COLLECTION

The need to obtain institutional review board approval with informed consent was waived. Data from all MRI examinations performed within 90 days after diagnostic MSK ultrasound examinations over a 47-month period (January 5, 2012, to November 27, 2015) were prospectively collected. The study population included all patients undergoing MRI and ultrasound scanning regardless of the body parts scanned and the clinical indication for scanning. Exclusion criteria were as follows: (1) MRI performed >90 days after ultrasound examination, (2) indication for MRI different from the indication for ultrasound examination, (3) MRI examination covering different area than ultrasound examination, and (4) patient age < 10 years.

A retrospective chart review was performed using electronic medical records. Two MSK radiologists with 28 and 18 years of experience in MSK imaging independently compared ultrasound and MRI reports. Report impressions were categorized as (1) concordant: no difference or minor difference between ultrasound and MRI results; or (2) discordant: potentially clinically important difference between ultrasound and MRI results. Interobserver agreement between the two reviewers with respect to concordant or discordant categorization of a patient's ultrasound and MRI reports was determined, and Cohen's κ statistic (including 95% confidence interval) was calculated.

The ultrasound and MR images in the discordant report category were reviewed on PACS stations by the same two radiologists for consensus reads. Image comparisons were categorized as (1) concordant when both readers agreed that ultrasound and MR images could be interpreted similarly, or (2) discordant when both readers agreed that ultrasound and MR images could not be interpreted similarly. Reasons for discordance were documented for each case and summarized.

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OUTCOMES

During the study period, 149 ultrasound examinations were followed by MRI studies within 90 days, and 129 of these examinations satisfied the inclusion criteria. The two reviewers agreed on concordance and discordance categorization of the ultrasound and MRI reports in 124 of 129 cases (98%; $\kappa = 0.89$; 95% confidence interval, 0.77-1.00). Table 1 summarizes the report categorizations for each reader. Image review of ultrasound and MRI examinations for the 16 discordant report comparisons (12%) demonstrated image concordance (ie, demonstrating the same anatomy and diagnosis) for 11 of the 16 comparisons. The remaining five cases were determined to be discordant in both reports and images.

Figure 1 summarizes the report and imaging comparisons and reasons for discordance. The most common reasons for report discordance despite image concordance were wording variations and differences in radiologist interpretations of imaging findings. For example, in one case, both modalities showed small rounded structures in a large elbow joint effusion. The ultrasound report identified these as joint bodies, whereas the MRI report identified these as synovitis. There were also instances in which the ultrasound and MRI examinations were discordant in both report and imaging findings. The most common reason for this was inappropriate use of the initial ultrasound examination. Specifically, three masses larger than 5 cm and/or deep to the superficial muscular fascia were initially evaluated by ultrasound examination. The limitations of ultrasound for the evaluation of masses larger than 5 cm deep to the superficial fascia have been repeatedly demonstrated in the literature [7-9]. Therefore, these lesions were reported as "indeterminate" on ultrasound examination, and the radiologist appropriately recommended follow-up MRI for complete evaluation. These findings suggest that inappropriate use of ultrasound examination for the initial evaluation of these masses may be a pitfall in our practice and may be an area for further improvement.

Table 1. Concordant and discordant categorization of ultrasound and MRI reports by each radiologist

	Concordant	Discordant	Total Reports Reviewed
Radiologist 1	113	16	129
Radiologist 2	115	14	129

Unexpectedly, only 2% of cases (129 of 6,376) from the 47-month study period fit our inclusion criteria. This reflected a lower incidence of potentially redundant imaging than was expected for our institution. Presumably, this is the result of (1) ongoing formal lectures for referring clinicians regarding the appropriate use of ultrasound examinations, (2) dedicated ultrasound examination schedulers who assess for appropriate indications before scheduling, and (3) diversion of potentially inappropriate requests for approval by the radiologist.

ACCURACY AND COST CONSIDERATIONS

There is a well-established body of evidence regarding the accuracy of ultrasound compared with MRI in the diagnosis of MSK disorders. The evaluation of shoulder and foot and ankle pathology with ultrasound examinations in particular has been shown to have a high level of accuracy compared with MRI and surgical findings [5,10]. As such, ultrasound may be complementary to MRI or even a preferred alternative for a wide range of MSK pathologies [5,11-16]. Our study parallels an analysis by Parker et al [17] in which 3,621 MRI reports for MSK symptoms were reviewed. The review predicted that 45.4% of primary diagnoses and 30.6% of all diagnoses could have been made with ultrasound examinations and that appropriate substitution of ultrasound for MRI could lead to more than $6.9 billion in savings from 2006 to 2020. Our study went a step beyond prediction and directly compared the reports of ultrasound and subsequent MRI examinations and images from discordant reports. Our findings substantiate and support the conclusion that the use of ultrasound in place of MRI does not compromise diagnostic accuracy [3,16,17] and offers the potential for substantial cost savings.

STUDY STRENGTHS AND LIMITATIONS

Our study had several strengths. First, the data stemmed from routine quality assurance practiced at our institution. The results reflect our daily clinical practice, and information gleaned from this study can therefore be directly applied to practice improvement. Second, our study consisted of a fairly large sample of patients (n = 129) who underwent both ultrasound and MRI examinations within a short time frame, allowing us to directly compare ultrasound and MRI reports and images. Another strength was the excellent agreement (98%) between the two readers with respect

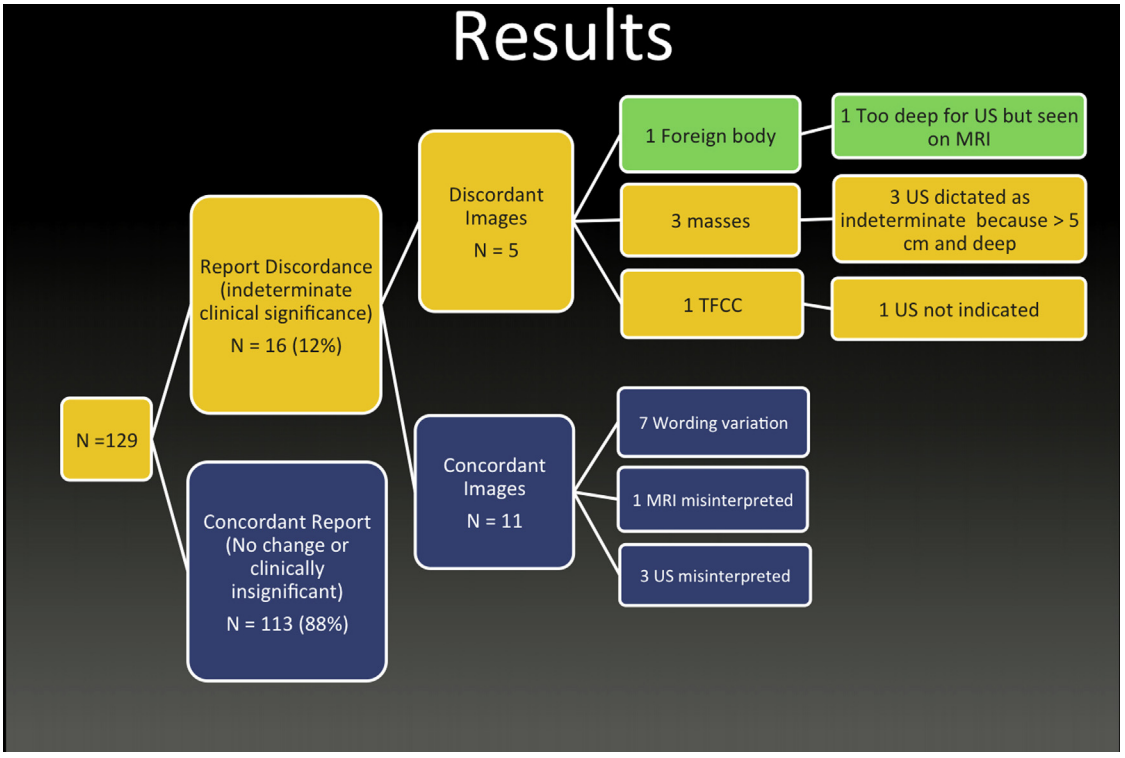

Fig 1. Summary of report and imaging categorizations along with reasons for report and imaging discordance. US = Ultrasound, TFCC = Triangular fibrocartilage complex.

to report and imaging concordance and discordance.

This study also had several limitations. We used the radiologist's report as the end point of diagnostic ultrasound and MRI examinations at our institution; however, in the scope of patient outcomes, the radiologist's report is an intermediate outcome. Because clinical management decisions are multifactorial, this study could not identify (1) why MRI was ordered, (2) the effect of ultrasound and MRI reports on clinical management, or (3) the effect of radiologist reports on patient outcomes [18]. Additionally, a gold standard for diagnosis could not be established for the study. Although we attempted to establish a gold standard by reviewing charts for histological or surgical assessments, inconsistencies in documentation precluded thorough assessment and statistical analysis. Another limitation is that the readers were not blinded to the hypothesis of the study, which could have led to confirmation bias. Our study had selection bias toward patients with persistent clinical concerns after ultrasound, making the likelihood of finding report or imaging discordance higher than in a randomized population. Finally, the images were not reviewed for examinations with report concordance, which constituted a large portion of the sample (88%). We assumed that concordant reports were due to concordant images, but this assumption may have led to an underestimation of imaging discordance.

CONCLUSIONS

Our study demonstrated high concordance between ultrasound and follow-up MRI examination reports (88%) and images (96%) for a variety of MSK indications. A number of factors contributed to report discordance, such as wording variations, interpretation errors, and inappropriate ultrasound examination use. However, ultrasound examinations rarely missed important imaging findings. In light of these results, we suggest that an appropriately ordered MSK ultrasound examination can serve as a definitive advanced imaging modality, limiting the need for an additional MRI examination.

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