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Utility of Musculoskeletal Ultrasound in a Department of Defense Rheumatology Practice: A Four-Year Retrospective Experience

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Objective. **To analyze the utility of musculoskeletal ultrasound (MSUS) in a rheumatology department and characterize relevant clinical trends.**

Methods. **Electronic medical records of all patients (n = 503) requiring MSUS in our department from January 2007 to December 2011 were reviewed. Rheumatologists performed MSUS using MyLab 25 or MyLab 70 systems. Clinical data were collected, including age, sex, symptoms, joint(s) examined, MSUS findings, procedures, further radiologic studies, and additional specialty consults. Results were tabulated from 717 total MSUS encounters and each was categorized as a completed encounter or an incomplete encounter. All magnetic resonance imaging (MRI) reports that followed MSUS were examined for concurrence. Cumulative numbers of MSUS examinations and MRIs were totaled. The Medicare global national average cost for MRIs and potential savings were calculated.**

Results. **A total of 789 joint sites were examined by MSUS. There were 84 US-guided procedures. Overall, 158 specialty consults were generated. After MSUS, 55 additional radiologic studies were ordered. There were 613 (85.5%) primary completed MSUS encounters and 104 cases (14.5%) requiring further imaging studies or an orthopedic consultation. There was an increased use of MSUS and a concurrent decreased use of MRI in our department over 4 consecutive years. We calculated the total potential savings from our rheumatology service to the Department of Defense as approximately $27,937.80 to $38,047.20 over 4 years.**

Conclusion. **MSUS has a positive impact in a rheumatology practice. MSUS augments the clinical examination, influences diagnosis and management, decreases reliance on other imaging modalities, and reduces health care costs.**

INTRODUCTION

Musculoskeletal pain is one of the most common patient symptoms facing health care providers in the US (1). Depending on the severity and duration of clinical symptoms, physicians may ultimately order a radiograph, a computed tomography (CT) scan, magnetic resonance imaging (MRI), or a bone scan as part of the evaluation. Over the past decade, musculoskeletal ultrasound (MSUS) has become another established imaging modality for the diagnosis and followup of patients with rheumatic disease (2).

With its high image clarity, MSUS can be used to assess soft tissue syndromes, detect fluid collection, or visualize cartilage, tendons, ligaments, bones, nerves, blood vessels, and muscles (3). Destructive or reparative hypertrophic changes on the bone surface may even be seen on US before they are apparent on plain films or MRI (2).

Experience with MSUS in rheumatology practices in the US is limited compared to Europe. Some critics challenge the utility of MSUS by rheumatologists. To investigate this question, we performed a retrospective review of a 4-year experience of MSUS utilization in a busy military medical center with a rheumatology fellowship.

PATIENTS AND METHODS

After obtaining institutional review board approval, the electronic medical records of all patients (n = 503) coded for an MSUS study with a Current Procedural Terminology (CPT) code of 76880 (US extremity, nonvascular), 76881

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Significance & Innovations

- This review highlights the clinical characteristics of musculoskeletal ultrasound (MSUS) use in a busy rheumatology department.
- The majority of MSUS encounters were clinically useful alone and did not require further radiologic imaging studies or additional specialty consults.
- There was good concurrence between MSUS assessments and magnetic resonance imaging findings when obtained.

(US extremity, nonvascular complete), 76882 (US extremity, nonvascular limited), or 76942 (US guidance for biopsy) in our rheumatology department from January 2007 to December 2011 were retrospectively reviewed. All MSUS studies were initiated at the clinical discretion of the rheumatologist managing the individual patient. Twelve rheumatologists with 1–6 years of MSUS experience performed the scans using a 7.5–12-MHz linear transducer, a 10–18-MHz linear transducer, or a 2.5–6.6-MHz curved transducer on a MyLab 25 or MyLab 70 XVG system (Esaote Biomedica). One of the authors (JBH), an MSUS educator with >6 years of experience, provided oversight of MSUS performed by less experienced staff rheumatologists.

Demographic and clinical data were collected, including age, sex, symptoms, joint(s) examined, findings, and procedure performed (if any). Data were extracted from progress notes, radiology referrals, and specialty consults. Dates and reports of any further radiologic studies ordered, including MRIs, CT scans, and bone scans, were recorded. In addition, the assessments of specialty consults, including orthopedics, physical therapy, and occupational therapy, were noted.

The results were tabulated from all 717 encounters, and each MSUS examination was categorized as a "completed encounter" or an "incomplete encounter." A completed encounter was defined as a clinical visit that resulted in a diagnosis without the need for further imaging or an orthopedics consult. An incomplete encounter was defined as a clinical visit that needed a referral for further radiologic studies (MRI, CT scan, bone scan) or an orthopedics consult.

Two rheumatologists (JCK, JBH) reviewed all of the ordered MRIs that followed an MSUS study. A comparison was made between the MRI examination reports and the MSUS assessments for overall concurrence. Each study pair was categorized as showing "consistent results" (i.e., leading to the same conclusion), "different results," or "not applicable" (i.e., completely different body sites studied).

The total number of MRIs ordered by our rheumatology department for each year from 2007–2011 was obtained from the business operations division. Using the Centers for Medicare & Medicaid Services web site (www.cms.gov) and their 2012 Medicare Physician Fee Schedule payment rates, the estimated global national average costs and range for MRIs of the upper and lower extremity with or without contrast were obtained. The MRIs were identified by the Healthcare Common Procedure Coding System (HCPCS) codes 73221 (MRI, any joint of upper extremity; without contrast materials), 73222 (MRI, any joint of upper extremity; with contrast materials), 73223 (MRI, any joint of upper extremity; without contrast materials, followed by contrast materials and further sequences), 73721 (MRI, any joint of lower extremity; without contrast material), 73722 (MRI, any joint of lower extremity; with contrast materials), and 73723 (MRI, any joint of lower extremity; without contrast materials, followed by contrast materials and further sequences) (4).

Similarly, the total number and costs of MSUS performed by our rheumatology department for each year from 2007–2011 were obtained. Using the same 2012 Medicare Physician Fee Schedule payment rates, the estimated global national average reimbursements and range for MSUS procedures were obtained. The MSUS procedures were identified by the CPT codes 76880, 76881, 76882, or 76942 (4).

Table 1. Patient and MSUS characteristics*

	Value
Patients, n	503
Sex	
Female	285 (56.7)
Male	218 (43.3)
Age, years	
Mean ± SD	52.7 ± 14.5
Range	15–90
Total encounters, n	717
Encounters with >1 joint site studied, no.	66
Total joint sites studied with MSUS, no.	789
Hand	172 (21.8)
Foot	144 (18.3)
Ankle	109 (13.8)
Knee	105 (13.3)
Shoulder	100 (12.7)
Wrist	92 (11.7)
Elbow	50 (6.3)
Hip	15 (1.9)
Sternoclavicular	2 (0.3)
Most common symptoms, no.	
Pain	596
Swelling	280
Stiffness	154
Warmth	56
Redness	27
Most common clinical diagnoses, no.	
Gout	103
Rheumatoid arthritis	91
Tendinitis	76
Undifferentiated arthritis	75
Osteoarthritis	67
Tenosynovitis	42
Bursitis	28
Edema	22
Psoriatic arthritis	21
Cyst	12

* Values are the number (percentage) unless indicated otherwise.
MSUS = musculoskeletal ultrasound.

Table 2. Musculoskeletal ultrasound–guided procedures

	Total joint procedures (n = 84), no. (%)
Shoulder	18 (21.4)
Foot	16 (19.0)
Knee	14 (16.7)
Wrist	11 (13.1)
Ankle	9 (10.7)
Elbow	7 (8.3)
Hand	7 (8.3)
Hip	2 (2.4)

RESULTS

The electronic medical record query yielded 717 total encounters with MSUS use in 503 patients over a 4-year period. There were 285 women (56.7%) and 218 men (43.3%) with a mean ± SD age of 52.7 ± 14.5 years (range 15–90 years). There were 66 encounters where >1 joint site was studied. A total of 789 joint sites were examined by MSUS, including 172 hands, 144 feet, 109 ankles, 105 knees, 100 shoulders, 92 wrists, 50 elbows, 15 hips, and 2 sternoclavicular joints. The most common patient symptoms were pain and swelling. The most commonly associated rheumatologic diagnoses were gout and rheumatoid arthritis (Table 1).

Table 3. Referrals after MSUS*

	Value
Additional radiologic studies after MSUS, no.	55
MRIs, no.	53
Shoulder	11 (20.0)
Knee	10 (18.2)
Hand	10 (18.2)
Ankle	7 (12.7)
Foot	5 (9.1)
Wrist	3 (5.5)
Hip	2 (3.6)
Elbow	2 (3.6)
Spine	1 (1.8)
LUE soft tissue†	1 (1.8)
Brain‡	1 (1.8)
Bone scan§	1 (1.8)
CT scan¶	1 (1.8)
Additional specialty consults after MSUS, no.	158
Orthopedics	49 (31.0)
Physical therapy	41 (25.9)
Occupational therapy	21 (13.3)
Podiatry	8 (5.1)
Ophthalmology	7 (4.4)
Dermatology	5 (3.2)
Gastroenterology	5 (3.2)
General/vascular surgery	3 (1.9)
Pain management	3 (1.9)
Behavioral health	2 (1.3)
Echocardiogram	2 (1.3)
Neurology	2 (1.3)
Otolaryngology	2 (1.3)
Sleep study	2 (1.3)
Others#	6 (3.8)

* Values are the number (percentage) unless indicated otherwise. MSUS = musculoskeletal ultrasound; MRI = magnetic resonance imaging.
† MRI of the left upper extremity (LUE) soft tissue was negative for any mass lesion.
‡ Brain MRI revealed a focus of demyelination.
§ Bone scan was not consistent with complex regional pain syndrome.
¶ Computed tomography (CT) scan of the chest was consistent with sarcoidosis.
# Other consults included allergy, endocrinology, nephrology, oncology, pulmonary, and rheumatology (civilian).

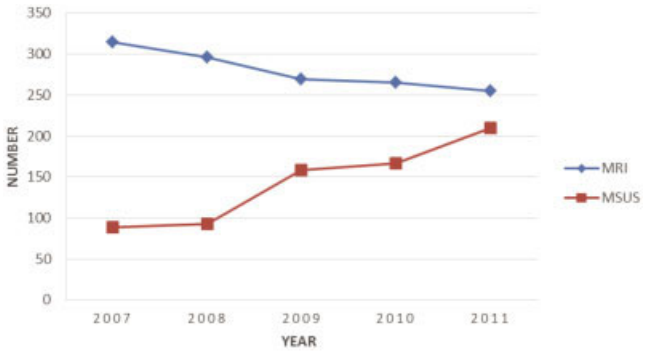

Figure 1. Total number of magnetic resonance images (MRIs) and musculoskeletal ultrasound (MSUS) examinations over a 4-year period.

US guidance was employed in 84 procedure-related encounters, including 18 shoulders, 16 feet, 14 knees, 11 wrists, 9 ankles, 7 elbows, 7 hands, and 2 hips (Table 2). Among the 717 total MSUS encounters, 158 specialty consults were generated, mostly to orthopedics, physical therapy, and occupational therapy. After sonographic evaluation, additional radiologic studies were ordered in 55 cases, with the most common being MRIs for the shoulder, knee, and hand (Table 3). Per our protocol definition, there were 613 (85.5%) completed MSUS encounters for a diagnosis and 104 (14.5%) incomplete MSUS encounters that needed a referral for further radiologic studies or an orthopedics consult.

In the shoulder specifically, 100 MSUS studies were performed. The associated clinical diagnoses of the shoulder were 44 tendonitis, 16 inflammatory arthritis (10 rheumatoid arthritis, 3 undifferentiated arthritis, 1 psoriatic arthritis, 1 juvenile idiopathic arthritis, and 1 crystalline arthritis), 9 arthralgias, 8 osteoarthritis, 7 rotator cuff tears,

Figure 2. Annual costs of magnetic resonance images (MRIs) and musculoskeletal ultrasound (MSUS) examinations over a 4-year period.

5 myalgias, 4 sprains, 3 bursitis, 1 cervical radiculopathy, 1 acquired deformity of the clavicle, 1 chest wall pain, and 1 lipoma.

MSUS findings in the shoulder included 19 partial rotator cuff tendon tears (10 supraspinatus, 6 unspecified, 2 subscapularis, and 1 infraspinatus), 4 complete rotator cuff tendon tears (3 supraspinatus and 1 unspecified), 3 long head of the biceps tendon tears, 22 effusions (10 unspecified, 8 long head of the biceps, 2 acromioclavicular, 1 supraspinatus, and 1 subacromial bursa), 12 calcifications (6 supraspinatus, 2 humeral head, 2 acromioclavicular, 1 subscapularis, and 1 long head of the biceps), 12 osteophytes (5 acromioclavicular, 4 humeral head, and 3 unspecified), 9 impingements, and 7 erosions (4 humeral head, 2 acromioclavicular, and 1 distal clavicle). There were 23 negative MSUS examinations and 18 US-guided procedures in the shoulder.

There were an additional 11 shoulder MRIs obtained after MSUS. In 9 of the 11 MRIs, there was agreement with the MSUS findings, including concurrence on 6 supraspinatus tears. There were 2 shoulder MRIs that were in disagreement with MSUS findings. One negative MSUS assessment revealed subdeltoid bursitis on MRI. Another negative MSUS finding except for impingement on abduction revealed on MRI a high T2 signal within the right supraspinatus tendon as well as a large amount of subacromial/subdeltoid fluid and an increased T2 signal within the superior labrum suggestive of a degenerative tear.

Overall, there were 53 encounters with an MRI ordered following any MSUS study. Only 48 MRIs were completed due to 4 no shows (1 ankle, 1 foot, 1 knee, and 1 wrist) and 1 patient who could not obtain the knee study because of a pacemaker. Among the 48 completed MRIs, we found concurrence with MSUS findings in 31 (64.6%), different results in 13 (27.1%), and not applicable or comparable due to different MRI sites studied in 4 (8.3%).

The total number of MSUS examinations performed in our rheumatology department increased over a 4-year period. Conversely, the total number of MRIs ordered by our rheumatology department decreased over the same time interval (Figure 1). Overall, as the number of MSUS increased at a rate of ~30 MSUS per year, the number of MRIs decreased at a rate of approximately 15 MRIs per year. The annual costs of MRI decreased every year in our rheumatology department from 2007 to 2011. Conversely, the annual costs of MSUS increased overall (Figure 2).

DISCUSSION

The results of our retrospective study demonstrated utility of MSUS over a broad spectrum of inflammatory and noninflammatory rheumatologic disorders. MSUS assisted our rheumatology practice with timely diagnosis and therapy in the outpatient clinic and on the inpatient hospital ward. The MSUS utilization pattern in our practice was driven by patient care requirements in a setting relatively free of fiscal incentives or constraints. Federal rheumatologists do not derive direct monetary gain from performing MSUS and, conversely, the only disincentive to perform MSUS is the additional visit time and effort.

The majority of joints, cysts, and bursae can be readily accessed with MSUS (5). MSUS can also increase the sensitivity of diagnosis, provide prognostic information, and improve the efficacy of procedures while avoiding potential adverse events (3,5,6). It is currently the only modality that allows for real-time assessment of the surrounding soft tissues, bony landmarks, and needle insertion while monitoring the dynamic movement of a joint (7,8). It also permits a quick comparison with the opposite, often asymptomatic side.

The regions most frequently examined in our study were the hand and foot. The most common referrals were to orthopedics, physical therapy, and occupational therapy. The joints requiring the most additional radiologic studies after MSUS were the shoulder, knee, and hand.

Among the 48 total patients who had both an MSUS examination and an additional MRI scan, there were "consistent results" in 31, with concurrent findings. Among the 13 patients with "different results," there were 7 MSUS studies with positive findings, where the subsequent MRI scan revealed no evidence of synovial hyperproliferation (ankle), tenosynovitis (ankle), cortical changes (hand), synovitis (hand), a foreign body (hand), trochanteric bursitis (hip), or a mass lesion (left upper extremity). There were also 6 negative MSUS findings, where the subsequent MRI revealed an adventitial bursa formation rather than a rheumatoid nodule (hand), periarticular edema (hand), a medial meniscal tear (knee), lipoma arborescens (knee), subdeltoid bursitis (shoulder), and a superior labrum tear (shoulder).

There were 4 MSUS assessments with subsequent MRI encounters that were categorized as "not applicable." In the same encounter, 1 patient had an MSUS examination for a shoulder procedure with a referral for a brain MRI scan revealing demyelination. Similarly, a different patient had MSUS for a carpometacarpal procedure with a referral for a knee MRI scan revealing chondromalacia patella. Another patient had a negative ankle MSUS finding for Achilles enthesitis with a lumbar MRI scan revealing moderate to severe bilateral sacroiliitis. The last patient had a negative MSUS finding examining bilateral thenar eminences with the MRI scan revealing marginal erosion along the radial aspect of the second left distal phalanx. These MRIs were not excluded in the cost analysis.

The utility and advantages of MSUS previously have been described to improve diagnosis and treatment strategies (9,10) and are similar to our clinical and study experience. Unlike MRI studies, MSUS has no effect on cardiac pacemakers or metallic objects in the body. MSUS is also relatively inexpensive, widely available, portable, noninvasive, painless, and void of ionizing radiation (7,8). Other benefits of MSUS include immediate bedside diagnosis, decreased costs, and guidance for difficult injections (6,11).

A clinical disadvantage of MSUS is that it does not adequately visualize deep soft tissue abnormalities or intraosseous lesions compared to MRI (5). Additionally, MSUS is operator dependent and requires detailed knowledge of relevant anatomy. The steep learning curve re-

quires both a time commitment and cumulative MSUS experience (7).

In our study, there was an increased use of MSUS and a concurrent decreased use of MRI in our rheumatology department over 4 consecutive years with the same patient population. Combining our data with the 2012 Medicare global national average Physician Fee Schedule payment rates for MRIs of the upper and lower extremity with or without contrast, we calculated the total potential savings from our rheumatology service to the Department of Defense as approximately $27,937.80 to $38,047.20 over 4 years. This was based on a Medicare global cost range of $465.63 to $634.12 per MRI and on a decreased rate of approximately 15 MRIs per year for 4 years (4). Similarly, we calculated an increase in cost due to US studies of $11,638.26 during the same period of time.

Quality in MSUS is becoming better defined, with certification now being offered separately by the American College of Rheumatology (ACR) and the American Registry for Diagnostic Medical Sonography. In addition, the ACR commissioned an MSUS study group to evaluate the current literature and use formal RAND/University of California at Los Angeles methodology to develop guidance on the appropriate use of MSUS by rheumatologists (12).

Our single-center retrospective study has limitations. A total of 12 different staff rheumatologists with varying levels of MSUS expertise performed the scans over 4 years. MSUS is known to be operator dependent, with varying skill and dexterity among users. Although we compared agreement between MSUS and MRI in 48 cases, our study was not designed to determine superiority of either method.

Our longitudinal trend of costs may grossly underestimate the cost savings of MSUS. In conventional rheumatology practices without ready access to MSUS, it may be anticipated that an MRI would be ordered in lieu of many US, markedly increasing the potential cost. For example, if one assumes that all of our patients who were diagnosed by MSUS alone (n = 613) had instead undergone an MRI at the low-end Medicare cost ($465.63), the total MRI cost would be $285,431.19 compared to the high-end estimated MSUS cost ($169.61, assuming all complete studies [4]) of $103,970.93. Our study only looked at aggregate longitudinal costs, and did not fully address this individual practice question. Finally, the science and technology of MSUS are rapidly evolving, which means our capabilities and utilization patterns may not have been uniform over the 4-year study period.

In conclusion, our review highlights the positive impact of MSUS use in a rheumatology practice. MSUS can augment the musculoskeletal examination, influence diagnosis and management, decrease reliance on other imaging modalities, and reduce health care costs. As a nation, the substitution of quality MSUS for musculoskeletal MRI, when indicated, could lead to a projected savings of more than $6.9 billion from 2006 to 2020 for the Medicare beneficiaries (13). There is a practical diagnostic role for MSUS in the near future with rising health care costs and with the implementation of health care reforms.

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AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. Kay had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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