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Evolution of Musculoskeletal Ultrasound in the United States: Implementation and Practice in Rheumatology

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Introduction

Ultrasonography (US) uses nonionizing sound waves to produce 2- or 3-dimensional gray-scale images. Although adopted earlier in other fields of medicine, the first US descriptions of normal and abnormal musculoskeletal (MS) tissues were published in 1958 and 1972, respectively (1,2). The use of color/power Doppler for synovitis was first described in 1994 (3). Annual publications on MSUS have increased exponentially from 7 in 1991 to 175 in 2011 (4). In addition to orthopedic surgery, physiatry, and podiatry, the use of MSUS has gained increasing acceptance in the field of rheumatology (5,6). Combining clinical findings, a strong understanding of the immunobiology of rheumatic diseases, and the potential for real-time dynamic imaging makes the use of MSUS a powerful addition to the diagnostic skills of the rheumatology provider. Applications of MSUS include the diagnosis of inflammatory and noninflammatory rheumatic disease, the assessment of an individual's response to treatment, and guidance for procedures (7–9) (Table 1).

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MSUS is gaining acceptance as an imaging modality among rheumatologists, but little has been published regarding the experience in the United States. Many entities, including the Ultrasound School of North American Rheumatologists (USSONAR) and the American College of Rheumatology (ACR), have taken a proactive role in the use of MSUS by offering educational courses, training educators, and developing a set of reasonable use criteria and certification. Despite many challenges in academic settings, inroads have been made at the fellowship training level by clinician educators to incorporate MSUS into individual program curricula. This review describes the evolution of this modality with its beginnings in Europe and its further adoption in the United States, reviews the necessary components for its practice, examines the economic and education-related challenges to its implementation, and offers solutions and resources to overcome these barriers.

International experience

With the increasing use of MSUS by rheumatologists, there has been greater demand for training opportunities, including evaluation for competence. Many European rheumatologists incorporated MSUS into their practices earlier than their colleagues in the United States, and a recent review summarizes the European experience (9). In a 2009 survey, acquisition of MSUS-related knowledge and skills varied widely, including self-teaching, attendance at organized courses, mentorship, and as part of fellowship training (10). However, most countries lacked competency assessment. In 19 countries, less than 10% of rheumatologists routinely performed MSUS in clinical practice. The major hurdle was a lack of training opportunities.

The European League Against Rheumatism (EULAR) has supported MSUS training by providing beginner-, intermediate-, and advanced-level courses since 1998. In 2007, faculty developed guidelines for the content and conduct of the courses, including specific objectives and outcomes at each level of coursework, a duration of 20 hours, a maximum of 6 participants per teacher, and 50–

Significance & Innovations

- This review highlights the evolution of musculoskeletal ultrasound (MSUS) in the United States, including training and definitions for its use and standardization.
- This review discusses the pathways to competency and certification in MSUS in the United States.
- This review helps the practicing rheumatology provider understand how to implement MSUS into a private or academic practice setting in the United States.

60% of time to be allocated toward practical scanning sessions (11).

Two sentinel publications by the international rheumatology community deserve mention. In 2001, Backhaus et al published guidelines for MSUS in rheumatology, including recommendations for standard scans based on pathology encountered in the practice of rheumatology (12). In 2005, the Outcome Measures in Rheumatology 7 Ultrasound Special Interest Group published definitions for ultrasonographic pathology (13). Both documents have helped significantly standardize the practice of MSUS.

United States experience

MSUS training for rheumatologists in the United States began around 2000, when courses offered MSUS modules led by international experts. Dedicated MSUS courses for rheumatologists have become increasingly available since 2004, and the ACR offered its first course in 2008. Additional training opportunities and significant improvements in image quality of portable machines have been followed by an increased interest in MSUS among US rheumatology providers (14).

In a 2010 survey conducted by the ACR MSUS Certification Task Force looking at the utilization of MSUS in fellowship programs, 61 (43%) of 142 training directors responded (15). Of that group, 42% had a faculty member who was performing MSUS in their practice; 91% used it for needle guidance and 82% used it for diagnosis. The most common reasons cited for not "personally using" MSUS were lack of training, cost of equipment, and lack of access to equipment. The majority of respondents thought the ACR should play a larger role in expanding MSUS in rheumatology by holding courses for individual providers (84%), setting standards for the use of MSUS (75%), offering certification (75%), and promoting reimbursement for certified (77%) or trained (73%) providers.

In addition to weekend courses, most practitioners understand that training requires substantial practice in order to achieve competency. In 2008, the USSONAR, a not-for-profit organization, was formed. One of its goals was to develop an 8-month–long, web-based training course, where rheumatologists experienced in MSUS could teach rheumatology fellows who did not have a local mentor. In 2010, the Rheumatology Research Foundation funded the Clinician Scholar Educator Award (to EYK) for the development and support of educational scholars to enhance the education for fellowship training programs; in return, the programs would attract the best trainees into a career focused on the rheumatologic health profession. This supported the establishment of an interactive web site for US study submission, review, and feedback generation. In 2011, the ACR contracted with USSONAR to offer the Train-the-Trainer program to address clinician educator faculty development in MSUS at interested fellowship programs, with an initial cohort of 29 educators.

Both the USSONAR fellow and Train-the-Trainer programs assessed competency at program completion through written and practical examinations. Written examination scores for fellows in the first 3 years and fellows plus educators in the fourth year averaged 70% and 80% correct, respectively (16). These scores are similar to average scores generated by rheumatologists with greater than 2 years of MSUS training (average 79%). On the practical examination, fellow mean scores ranged only slightly below those of practitioners with more than 6 years of MSUS experience. These results suggest that the majority of participants achieved competency in MSUS through participation in the programs. A followup survey 6 months after completion of the Train-the-Trainer program revealed that 83% of all 29 participants felt competent in MSUS in more than 50% of cases, and 76% were already teaching MSUS to fellows, whereas the remaining 24% planned to begin teaching within 12 months (Kissin EY: unpublished observations).

ACR advocacy

The ACR has advocated widely for its members in this new field. From 2010 through 2012, a task force on the state of MSUS in the United States was convened to explore avenues for establishing MSUS certification. Subsequent projects resulted from this body of work, including

Table 1. Applications of MSUS in rheumatology*

To detect
Joint synovitis (with or without power Doppler)
Synovial hypertrophy
Joint effusion
Bone erosion
Tenosynovitis (with or without power Doppler)
Enthesitis or other tendon pathology
Bursitis
Osteophyte
Crystalline deposits
Nerve entrapment (median, ulnar, posterior tibial nerves)
Salivary gland pathology in Sjögren's syndrome
To assist
Interventional guidance
Monitoring treatment response
Dynamic evaluation for impingement, subluxation, and dislocation

* A general list of the potential applications of musculoskeletal ultrasound (MSUS) in rheumatology (7–9).

a 2010 publication defining the technical aspects of MSUS and implementation of MSUS into rheumatology clinical practice (17). In order to define reasonable use of MSUS by rheumatologists, a second panel evaluated 954 manuscripts on MSUS pertinent to rheumatology and found that there was reasonable evidence for MSUS use to help diagnose articular and soft tissue disorders of either a mechanical or inflammatory nature, and to guide articular and periarticular needle placement (8). These findings helped to further establish MSUS as a tool particularly suited to the practice of rheumatology. Finally, in 2012, the task force focused on whether to create an independent certification pathway for rheumatologists, or join the pathway being developed by the American Registry for Diagnostic Medical Sonography, for all specialties utilizing MSUS. Guided by the goals of standardizing rheumatology competency in MSUS, and to demonstrate this competency to other stakeholders, the task force recommended proceeding with a certification process specific for rheumatology providers, leading to the creation of a certification examination by the ACR commencing in 2013 (18).

MSUS in fellowship education

US has been part of formalized medical school training in several institutions since 1996, and its use is on the rise (19). MSUS has been shown to enhance the MS educational experience in medical school teaching, with an emphasis on the comprehension of spatial "living" anatomy and the pathologic correlates of rheumatic disease (20). At a residency level in internal medicine training, US learning has been shown to improve identification of structures important in performing invasive procedures (21).

In 2013, the ACR surveyed fellowship program directors about the current state of MSUS in US fellowship training programs, and 58 of 112 program directors responded. Among the respondents, 60% were already teaching MSUS at some level, and 29% planned to start teaching MSUS in the near future (22). With the development of a rheumatology MSUS certification examination and an increasing number of fellowship programs offering training in MSUS, there is enthusiasm for the development of a standardized curriculum among educators in the United States. A group of investigators in the UK has developed an educational framework and curriculum to guide the training of rheumatologists in the field of MSUS (23–26). With the aim of determining what was considered relevant use of US for the field of rheumatology, a sequence of steps was taken to determine the curricular content based on evidence from the medical literature and input from experts, including 20 rheumatologists and 37 radiologists. The process involved 1) situational analysis (25); 2) establishment of indications, anatomic areas, and skills (23); 3) establishment of competency standards (24); and 4) assessment of clinical utility and competency standards (26).

Curricula addressing competencies defined by the Accreditation Council for Graduate Medical Education (ACGME) have been developed and implemented by individual clinician educators to address standards for knowledge and skills related to MSUS during fellowship training (JBH, KDT). These curricula are in concordance with guidelines set by the ACGME and the American Board of Internal Medicine, outlining the need for learners to demonstrate competency in 6 domains, specifically patient care, medical knowledge, interpersonal communication skills, practice-based learning and improvement, professionalism, and systems-based practice. Teaching methods include lectures, hands-on training workshops, experiential learning through US clinics, faculty mentorship, and procedural instruction using cadavers. Assessment methods include utilization of procedure logs, portfolios, case reporting and presentations, multiple-choice question examinations, and evaluation by peers, patients, medical staff, and faculty.

In 2011, a core group of clinician educators from the USSONAR group developed a framework for defining milestones to describe the progression of learners in the process of acquiring knowledge, skills, and attitudes related to MSUS (27). This was initiated in response to efforts by the ACGME to facilitate objective documentation of trainee achievement of competence in the aforementioned 6 competencies (28). These milestones provide an initial and significant step toward a meaningful assessment of outcomes for United States rheumatology trainees.

Best practices in MSUS

Once competency has been achieved, putting MSUS into practice may seem daunting. Understanding that a "best practice" implies an official established system of health care to achieve the goal of better health at the lowest cost, we propose a set of best practices in MSUS based on available literature and the authors' experience as ultrasonographers (Table 2). Table 2 is divided into minimum requirements and optimum resources. The minimum requirements are those absolutely required for performing MSUS, and the optimum resources constitute the best possible environment for obtaining the highest-quality images, studying the complete spectrum of pathology, and performing invasive procedures under guidance.

The minimum training requirement for a physician to begin performing MSUS is the knowledge of its indications and limitations, the ability to adjust the US machine to deliver adequate images, the understanding of anatomy and its sonographic patterns (both normal and abnormal), comprehension of sonographic artifacts, and the skill to manipulate the transducer for image capture. The beginner may acquire competence in one area before another. With the evolution of MSUS skills, competency should be a goal for the practicing rheumatology ultrasonographer. Certification may become an important means for demonstration of competency.

The experienced rheumatology provider can likely perform all elements of an examination without an assistant. However, an assistant familiar with the machine may be helpful, especially for performing and recording MSUS-guided procedures with direct needle visualization.

The minimum US machine requirement is the capability to capture B-mode images. Available machines have a variety of image display characteristics, and it is prudent to try a spectrum of machines for personal preference

Table 2. Proposed best practices in MSUS*

Minimum requirements	Additional optimum resources
Physician trained in basic MSUS	Physician trained in intermediate MSUS
US machine	ACR-certified physician
≥10-MHz linear array transducer	MSUS assistant
Capability for permanent image recording	US machine refinements
HIPAA compliant	Spatial compound imaging
Backup system	Color Doppler
	Video capture
	Foot pedal for image acquisition
	Beam steering software
	Needle enhancement software
US supplies	Additional transducers
Gel	Low-frequency curved array
Cleaning supplies	High-frequency "hockey stick" linear array
	Sterile procedure kits
Educational materials	Educational materials
Anatomy textbook	Model skeleton
MSUS textbook	Current literature access
	Practical sessions in living anatomy
	Standardized image sequence
	Templates for MSUS reporting

* MSUS = musculoskeletal ultrasound; ACR = American College of Rheumatology; HIPAA = Health Insurance Portability and Accountability Act.

before making a final decision. Numerous machine enhancements in recent years have greatly improved image quality. Spatial compound imaging is perhaps the most significant of these improvements, providing much finer detail of MS structures. Color Doppler provides information on blood flow, which is important for detecting hyperemia, a surrogate for inflammation, and also to locate blood vessels during procedures. Video capture is useful for procedure documentation, but is not required. Foot pedals are helpful for hands-free image acquisition, especially if an assistant is not available. Beam steering and needle enhancement software make it easier to identify the needle during procedures.

Transducers with ranges of 18–22 MHz provide the best detail for small and superficial structures, such as the finger and toe joints. A lower-frequency transducer (in the range of 5–8 MHz) will provide the best detail for deeper structures, especially the hip, and a curved array transducer will provide the largest field of view. Some rheumatologists prefer a "hockey stick" transducer for small structures in tight spaces, such as in contracted fingers. The most universal transducer for a machine is a linear array transducer with a frequency between 7.5 and 12 MHz, which will allow for adequate visualization of both superficial and deep structures in most cases.

US gel and transducer cleaning supplies are necessary. The manufacturer will provide direction on appropriate cleaning procedures for their transducers. The use of inappropriate cleansers may damage the transducer and void the warranty. The less experienced rheumatologist may be best served by performing the most direct US-guided procedures using sterilized transducer covers and sterile gel. As experience is gained, the advanced user will learn when it is possible to image the procedure with no threat of contamination of the needle entrance site with nonsterile gel.

The practice of MSUS, like that of rheumatology in general, is one of continual learning. Because MSUS is complementary to physical examination, honing living anatomy skills is the foundation for the mastery of sectional anatomy during MSUS scanning. A basic MSUS textbook and anatomy reference can be invaluable resources. Because the skills of the rheumatologist and technology will change over time, continuing education is important. A model skeleton at the bedside can be beneficial, both for the rheumatologist and for patient education. Access to current literature is critical for staying up to date and investigating unusual findings. Online references and DVD demonstration can also be helpful for skills development.

MSUS will occur in the outpatient setting for most rheumatologists. MSUS occurring in a hospital outpatient or inpatient setting may require credentialing, which can be variable and may involve proof of training, certification, review of cases, or direct observation. Some institutions may also seek additional documentation of appropriateness of practice. The published literature from the ACR MSUS Task Force may aid in providing evidence that this is within the scope of a rheumatology provider's practice (8,17). The American Institute of Ultrasound in Medicine (AIUM) also has a facility credentialing process that does not certify the individual physician and may not be appropriate to the rheumatology practice model, where rheumatologists acquire and read the scans themselves rather than employing a technician (29).

Incorporating MSUS into practice needs to be carefully considered because of time constraints. Directed examinations are done to address a limited anatomic area and to answer a specific question, such as the presence or absence of synovitis. These may be done at the time of the patient's office visit, or if time is insufficient, during a separate appointment dedicated to US.

Secure data storage with access is necessary and required as part of the Health Insurance Portability and Accountability Act laws. A backup system is suggested. Most machines can export images in the Digital Imaging and Communications in Medicine format. These can be sent to a picture archiving and communication system, which is usually managed by radiology departments. Independent practices may also consider open-source solutions such as OsiriX (30). Other options include network storage of proprietary image format or JPEG/MPEG formats. Vendor-specific images can be viewed on workstations using proprietary software. Another option involves exporting the images in JPEG/BMP or videos in MPEG/AVI formats and manually storing them securely under patient folders.

Table 3. Ultrasound resources*

	Resource type†
Online	
ACR certification information: www.rheumatology.org/education/rhmsus/welcome	C, D
ACR Rheumatology Image Bank: http://images.rheumatology.org/	E
AIUM: http://www.aium.org/	A, D
ARDMS: http://www.ardms.org/	C
EFSUMB: http://www.efsumb.org/intro/home.asp	F
ESSR: http://www.essr.org/cms/website.php?id=/en/index/educational_material.htm	A
EULAR: http://www.eular.org/	B, D
EULAR image data bank: http://www.irheum.eu/	E
MedEdPortal: https://www.mededportal.org/	A, E, F
University of Michigan Health System: http://www.med.umich.edu/rad/muscskel/mskus/	A, D
USSONAR: http://www.ussonar.org/	A, B, C, D
Textbooks	
Bruyn GA, Schmidt WA. Introductory guide to musculoskeletal ultrasound for the rheumatologist. Houten (The Netherlands): Bohn Stafleu van Loghum; 2005.	
Bianchi S, Martinoli C. Ultrasound of the musculoskeletal system. Berlin: Springer; 2007.	
Jacobson J. Fundamentals of musculoskeletal ultrasound. Philadelphia: Saunders; 2012.	
Wakefield RJ, D'Agostino MA. Essential applications of musculoskeletal ultrasound in rheumatology. Philadelphia: Saunders Elsevier; 2010.	
Schuenke M, Schulte E, Schumacher U. General anatomy and musculoskeletal system (THIEME Atlas of Anatomy). New York: Thieme; 2010.	

* ACR = American College of Rheumatology; AIUM = American Institute of Ultrasound in Medicine; ARDMS = American Registry for Diagnostic Medical Sonography; EFSUMB = European Federation of Societies for Ultrasound in Medicine and Biology; ESSR = European Society of Musculoskeletal Radiology; EULAR = European League Against Rheumatism; USSONAR = Ultrasound School of North American Rheumatologists.
† Where A = online region-based tutorial, protocols, technical guidelines; B = online training program with certification; C = certification program through written examination; D = on-site courses and/or workshops; E = online teaching slides, anatomy—ultrasound correlation; and F = competency-based assessments and evaluation tools and training recommendations.

A report needs to be generated for each examination. The AIUM has guidelines for the standard elements of a report (31). Each report should include patient demographics, indication, pertinent clinical information, and documentation of the findings in a systematic manner. Templates may be utilized to save time. Abnormal findings, relevant comparisons to the contralateral side, and reasons for additional evaluation or imaging should be clearly documented. The report should accurately reflect the procedure done and informed consent, and justify the billing level. For injection guidance, a description of the procedure, including indications and appropriate precautions, is essential for billing purposes. Pre- and postprocedure images or an image demonstrating the needle in the target tissue should be documented.

In January 2011, two diagnostic US codes were created for sonography of an extremity: Current Procedural Terminology (CPT) code 76881 (US of extremity, nonvascular, real time, with image documentation, complete) and CPT code 76882 (US of extremity, nonvascular, real time, with image documentation, limited). The CPT manual did not define elements of limited and comprehensive scans, but some guidance was offered in the CPT coding assistant (32). According to the coding assistant, complete real-time US scans of the extremity (76881) should include documentation of examination of the joint, muscles, tendon, and other soft tissue structures as well as any identifiable abnormalities. Limited examination of the extremity (76882) may be regarded as documentation of examination of a specific structure (muscle, tendon, soft tissue mass, etc.). Since the interpretation of the code requirements is subject to change, the reader is advised to periodically check the American Medical Association (AMA) CPT coding web site as well as local carrier regulations (33).

The extremity CPT codes are used in conjunction with International Classification of Diseases, Ninth Revision codes, which denote the indication for the examination. When a US examination is done as a separately identifiable service at the time of an office visit, modifier 25 is applied to allow billing of the office visit and the procedure. In a setting where the equipment is owned by the institution, the professional and technical components will need to be billed separately. Modifier 26 is used to bill the professional component, whereas modifier TC is used to bill the technical component.

For needle guidance, the available CPT code is 76942, corresponding to ultrasonic guidance for needle placement (e.g., biopsy, aspiration, injection, localization device), imaging supervision, and interpretation. The appropriate comprehensive or limited diagnostic CPT code may be billed concurrently if clinically indicated.

Medicare reimbursement varies according to geography, and may be referenced at the AMA CPT coding web site (34) and the Centers for Medicare and Medicaid Services (CMS) web site (35). It is advisable also to verify the local Medicare carrier guidelines as well as local insurance coverage nuances. For practitioners who are beginning to pursue MSUS, this information may be obtained from the ACR coding staff. Each CPT code is also associated with relative value units (RVUs), which are multiplied by the conver-

sion factor and a geographic adjustment (geographic practice cost index) to calculate the local reimbursement for the specified code. Some institutions use RVUs to track physician productivity. The RVUs also have professional and technical components. Updated information on RVU assignment to CPT codes may be obtained from the CMS (35) or the AMA (36) web sites.

Challenges

Although gaining momentum, rheumatology providers still face some challenges in the implementation of MSUS into clinical practice. Clearly, a major barrier is training. There is a steep learning curve that takes time and dedication, including mastery of both living and sectional anatomy. Although not an ACGME requirement for training, many fellowship programs are offering training in MSUS. For practicing rheumatologists, courses of variable training levels are offered by the ACR, EULAR, and privately. Inevitably, self-teaching, study, and scanning become critical. Access to the web-based curriculum and scanning guides of USSONAR is available for an annual fee, and this may facilitate self-learning. There are multiple additional web sites and texts that can be utilized, and some suggestions are shown in Table 3.

Access to a machine can be another impediment. If funds are not available for new equipment, some companies offer the purchase of used or demonstration units. In addition, leasing a machine can be a viable option, and programs are available with no payment for 90 days and a low purchase option ($1) for a capital lease to allow depreciation and ownership after 60 payments. Other departments or subspecialists may already own a machine that can be borrowed or shared. In academic settings, research residual monies may exist that can be applied toward machine purchases, and in the Veterans Affairs setting, equipment requests may be available.

Discussion

MSUS is not a substitute for history and physical examination; rather, it augments the provider's ability to deliver immediate state-of-the-art and quality patient care. In addition, MSUS can be educationally valuable for the practicing rheumatology provider. Learning MSUS can enhance knowledge of anatomy and pathology in an unparalleled way that may strengthen the provider's examination and procedural skills, even when MSUS is not available. Most patients are accepting and appreciative for the time spent with them during MSUS, and the authors find it to be an effective patient educational tool. It is extremely rewarding to diagnose, teach, and treat in "real time." Future studies can include assessments of practitioner and patient attitudes, patient compliance with therapy, and outcomes as a result of having had MSUS to validate these perceptions.

Implementation of MSUS into practice will need to be individualized and may take some forethought, creativity, and planning. Going forward, rheumatologists should remain good stewards of MSUS, and make use of the proactive approach the ACR has taken to outline the role of MSUS in the rheumatologist's scope of practice and the pathways to certification. It is important that rheumatologists strive to utilize US technology to its maximum potential for improvement in patient care while minimizing associated costs.

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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. Cannella 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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