HHS Public Access

Author manuscript

Am J Phys Med Rehabil. Author manuscript; available in PMC 2016 December 01.

Published in final edited form as:

Am J Phys Med Rehabil. 2015 December ; 94(12): 1095–1103. doi:10.1097/PHM.0000000000000337.

Resident-Perceived Benefit of a Diagnostic and Interventional Musculoskeletal Ultrasound Curriculum:

A Multifaceted Approach Using Independent Study, Peer Teaching, and Interdisciplinary Collaboration

Jennifer Luz, MD, **Imran Siddiqui, MD**, **Nitin B. Jain, MD, MSPH**, **Minna J. Kohler, MD**, **Jayne Donovan, MD**, **Paul Gerrard, MD**, and **Joanne Borg-Stein, MD**

Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, Harvard Medical School, Boston, Massachusetts (JL, IS, JB-S); Department of Physical Medicine and Rehabilitation, Vanderbilt University Medical Center, Nashville, Tennessee (NBJ); Division of Rheumatology, Allergy, and Immunology, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts (MJK); Department of Physical Medicine and Rehabilitation, Kessler Institute of Rehabilitation/Rutgers New Jersey Medical School, Newark, New Jersey (JD); and New England Rehabilitation Hospital of Portland, Portland, Maine (PG)

Abstract

Musculoskeletal ultrasound (MSUS) training is now a required component of physiatry residency, but formal curriculum guidelines are not yet required or established. The authors' objective was to assess the educational value of a collaborative residency MSUS training program. The authors designed a structured MSUS training curriculum for residents based on the authors' experience and previous literature. Twenty-five residents participated in this MSUS curriculum designed by faculty and chief residents. Resident volunteers were trained by the faculty as "table trainers" who taught their peers in small groups. Handson MSUS training sessions were led by a Physical Medicine and Rehabilitation faculty MSUS expert. A Likert scale–formatted questionnaire assessed resident-perceived value of the curriculum. Response rate was 96% (22 of 23). Self-reported MSUS knowledge comparing precurriculum and postcurriculum implementation resulted in significant improvement ($P = 0.001$). Peer teaching was highly valued, with 86% of residents rating it "very" or "extremely" beneficial (mean [SD] score, 3.9 [1.1]). Self-guided learning, by supplemental scanning and reading, was rated "beneficial" or "very beneficial" by 73% of residents (3.0 [0.7]). The authors' successful pilot program may serve as a teaching model for other residency programs.

All correspondence and requests for reprints should be addressed to: Jennifer Luz, MD, Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, 300 First Ave, 2nd Floor, Charlestown, MA 02129.

Disclosures:

This work was presented as a poster presentation at the American Academy of Physical Medicine & Rehabilitation, Annual Assembly, San Diego, November 2014.

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

Keywords

Resident Feedback; Curriculum Development; Internship and Residency; Physical and Rehabilitation Medicine; Questionnaires; Rheumatology; Musculoskeletal Ultrasound

In recent years, there has been burgeoning interest in the use of ultrasound (US) in medicine. US is relatively inexpensive, does not require radiation exposure, and can be performed in outpatient settings by the same clinician who performed the history and physical examination on a patient (point-of-care). In the field of Physical Medicine and Rehabilitation (PM&R), there has been substantial interest in using US for musculoskeletal diagnostic and interventional purposes.[1,2] Progressive responsibility in the use of musculoskeletal ultrasound (MSUS) is now a mandatory Accreditation Council for Graduate Medical Education (ACGME) requirement of PM&R residency training. Specifically, it is stipulated that residents gain experience in "acute and chronic musculoskeletal syndromes, including sports-related injuries, occupational injuries, rheumatologic disorders, and use of musculoskeletal ultrasound."[3] However, despite this requirement, there is lack of specific curriculum guidance for MSUS training in PM&R residency.

Although the ACGME traditionally published requirements regarding standards that residents must meet for graduation, it has also given a high degree of autonomy to individual training programs in terms of how to meet these requirements. The ACGME accreditation method is now shifting to a milestone system in which resident exposure to diagnoses and procedures is becoming more explicit. MSUS, being a relatively new aspect in the field of PM&R, may pose a challenge. The Mayo Clinic PM&R residency program led this initiative by sharing its experience with MSUS education in its PM&R residency program. The program published a sample set of educational objectives in the form of checklists to demonstrate competency in MSUS.[4] This publication provided a groundwork upon which future MSUS educational curricula could be developed. The authors present a modified MSUS curriculum adapted from the curricula of Finnoff et al.[4–6] The unique aspects of the authors' curriculum may aid in the implementation of MSUS curricula at other residency programs.

CURRICULUM

Before the initiation of a formal MSUS curriculum in the authors' program, resident exposure to US was very limited. All residents were required to spend 2 mos on rotations, which used MSUS for both diagnostic and interventional purposes. Additional time could be spent on electives to gain more experience with MSUS, but few residents selected this opportunity.

Curriculum Development

At the authors' program, barriers to implementing a successful MSUS curriculum included participation of expert MSUS educators, securing sufficient hands-on time with a US machine, the need for repeated clinical exposure to solidify acquired MSUS skills, and an objective method to determine achievement of educational goals. Before implementing the curriculum, a set of clear educational objectives, primary reading materials, a structured

didactic component, a plan to optimize valuable expert faculty time, and plenty of hands-on MSUS training time were established.

The development of the authors' curriculum was a collaboration between program leadership, US experts on the authors' faculty, and residents. Under the guidance of the authors' faculty (JBS and NBJ) with expertise in MSUS, the chief residents were tasked with developing educational goals for the curriculum, organizing the didactic structure of the curriculum, and obtaining feedback from other residents. One of the chief residents (PG) attended two national MSUS courses and spent elective time with experienced MSUS faculty members in the department to gain experience in MSUS education. Once the initial framework for the MSUS curriculum was developed, it was further refined and managed by two fellowship trained expert PM&R faculty in MSUS (JBS and NBJ). Both faculty members teach MSUS at national workshops and one specifically oversees each of the six separate MSUS curriculum hands-on workshops (JBS).

In recognizing that residents may not have the expertise of an experienced MSUS PM&R faculty member, the authors' first goal was to highlight an approach to learning US that does not simply teach residents to locate anatomic structures but encourages them to explore the anatomy systematically, allowing for independent study. Specifically, the authors adopted an approach that emphasized identifying muscle/tendon attachments both proximally and distally. Individual teaching sessions expanded to exploration of a body region, not simply a single joint, enabling novice learners to be successful. This approach was used to modify the checklists provided by Finnoff et al.[4]

Next, the authors considered several reading materials for inclusion in the curriculum. Cost of materials, often a barrier in residency programs, was weighed against the potential to enhance learning. The authors used a relatively comprehensive text with high-quality pictures.[7] Additionally, the authors selected the European Society of Skeletal Radiology Ultrasound Guidelines, which are brief pictorial guides to the MSUS examination of single joints that are available for download, free of cost.[8]

The time commitment and expertise of the authors' core teaching faculty were critical to the implementation and success of the authors' curriculum. Although several experienced core PM&R faculty were involved in the MSUS curriculum, the program also reached out to other academic departments, including rheumatology, with expertise in MSUS at the authors' institutions. This approach provided an interdisciplinary learning experience to the residents. The need for easy access to a US machine presented a challenge for residents. After investigating numerous potential options, the residency program obtained a US machine dedicated to resident independent study at all times.

The Final Curriculum

Peer-Taught Hands-on MSUS Workshops—The core of the curriculum consisted of six workshops that were each 3 hrs in length. The curriculum's workshops schedule and the required readings paired with each workshop are detailed in Table 1. The workshops occurred every 3 mos over an 18-mo cycle, designed to be completed twice by each resident through their training. The six workshops were as follows: (1) shoulder and elbow, (2) wrist

and hand, (3) hip and pelvis, (4) knee and leg, (5) foot and ankle, and (6) interventional procedures. Approximately 25% of workshop time was formal instruction, whereas 75% was hands-on scanning. Residents were separated into small groups. Resident-to-machine ratio in each of the small groups was 4:1. One of the four residents was a “table trainer” guiding the other three residents through the workshop curriculum. There was at least one expert faculty member (and on most occasions, two) present at each workshop to rotate throughout the small groups to supervise, support, and answer questions.

Peer Training—The table trainers were volunteer residents who spend an extra teaching session with expert faculty members in the days before the residency hands-on workshop, learning the US anatomy and scanning in detail. Selection of table trainers was based on postgraduate year (PGY) level and previous experience as a trainer. Preference was given to senior residents who have not previously been table trainers to allow everyone an opportunity to teach.

Independent Study

Given that there were only four hands-on US workshops per academic year, independent study was a major facet of the curriculum. Residents were required to complete assigned reading before workshops (Table 1). In addition, after each training workshop, each resident was required to independently obtain images of all the major anatomic structures covered in the workshop with appropriate labeling. These practice images were sent to the corresponding table trainer who reviewed the images for quality and accuracy. Faculty members were available for table trainers to answer any questions or review images. Access to a dedicated US machine was imperative to allow residents to practice what they learn in workshops and obtain practice images for peer review.

Clinical Experience

The residents had significant clinical exposure to MSUS. PGY-2 residents had required rotations of 2 mos duration with one of the MSUS curriculum directors (JBS). PGY-3 residents spent 1 mo in a rheumatology MSUS clinical rotation (MJK). They also spent 1 mo with a sports medicine physiatrist who incorporates MSUS into her practice (KM). PGY-4 residents spent 1 mo with an expert faculty member in MSUS who specializes in shoulder disorders and was also the curriculum codirector (NBJ). In addition to the 5 mos of clinic that use MSUS on a regular basis, residents were encouraged to use MSUS in their resident continuity clinic and on their inpatient services when deemed clinically appropriate, under attending supervision. Residents could also select an elective rotation with a faculty member with expertise in MSUS. Extracurricular activities offered through the rheumatology MSUS clinic included additional hands-on practice sessions and MSUS research. Based on their performance during the rheumatology MSUS clinical rotation, residents were given the opportunity to teach medical students basic US concepts and anatomy.

RESULTS

Six months after implementation of the curriculum, a resident feedback questionnaire was administered to 23 residents. There were 25 residents in the PM&R program, of which two resident authors (JL and IS) were excluded from the survey. Of 23 residents, 22 (96%) responded. The survey consisted of 20 five-point Likert scale questions. Resident knowledge of MSUS before the first session was minimal, with 91% of residents reporting no or some knowledge of the modality (Likert mean [SD] score, 1.7 [0.6]; Table 2).

The independent study approach was rated as beneficial or very beneficial by 73% of the residents (Likert mean [SD] score, 3.0 [0.7]). Most (86%) of the residents found using residents as table trainers during the course to be beneficial, very beneficial, or extremely beneficial to their learning (mean [SD] score, 3.9 [1.1]). Overall, 68% of the residents rated the course as good to excellent based on didactic sessions, hands-on practice sessions, and independent study (mean [SD] score, 4.0 [0.8]).

Of the six PGY-3 and four residents who attended the rheumatology clinical rotation, five reported a beneficial, very beneficial, or extremely beneficial impact on their learning (3.8 [1.2]). These residents also reported higher confidence levels in performing independent MSUS diagnostic and procedural imaging. Six of seven residents who participated as instructors in teaching medical students reported higher confidence levels in their diagnostic and procedural imaging skills. Most of the residents who attended extracurricular opportunities including clinical rotations, rheumatology hands-on practice sessions, and medical student teaching sessions rated these opportunities as good to excellent (3.6 [0.9]).

DISCUSSION

The authors provide an MSUS resident curriculum that directs the learner via stated learning goals and objectives. The authors have provided a framework for an MSUS curriculum that other residency programs may modify and implement to suit the needs of their residents while fulfilling ACGME requirements. Most current US curricula use a blended approach, with both virtual or Web-based simulation and real-time patient encounters.[10] The authors highlight several aspects of their newly implemented curriculum that made it successful, including expert faculty mentorship, resident peer-to-peer teaching and independent study, availability of US machines, clinical rotations that provide experience in MSUS, and collaboration with other departments at the authors' affiliated hospitals.

The curriculum has a great reliance on peer-to-peer teaching and independent study. The medical education literature has studied the feasibility and value of peer assessment, which can be used to evaluate clinical performance and competence, professionalism, interpersonal skills, and leadership ability.[11,12] There is evidence to suggest that students perform similarly on objective measures whether taught by student-teachers or faculty in certain circumstances.[13–16] Curriculum faculty carefully select and train the residents who serve as table trainers, thus standardizing the hands-on experience. In 2010, a randomized controlled trial studying student-teachers in the self-guided learning of MSUS skills demonstrated this successfully.[15] A small group of medical students in their third and fourth year were

instructed in MSUS of the shoulder in one didactic session. These students then taught the skills to their classmates. Results of a multiple choice questionnaire and an Objective Structured Clinical Examination demonstrated no statistical difference between students who were instructed by their peers and those taught by faculty. When using independent study, extensive didactic training is not necessary to produce effective student-teachers. Filippucci et al.[16] demonstrated that competency in MSUS can be achieved even through a Web-based learning portal. The collaboration between faculty and table trainers was paramount for the success of this curriculum.

Entrusting residents to self-guide their learning was a success in the curriculum. The burdens of a busy residency and limitations of teaching faculty are assuaged by empowering the learner. By having a dedicated US machine available to residents for education purposes, residents had ample opportunity to prepare, participate, and review. During the larger group sessions, one table trainer was usually assigned to three residents. This allowed for the faculty to rotate around each of the small groups and focus on teaching/demonstrating specific aspects of the curriculum while the table trainers were able to provide a comprehensive review. The ratio of faculty to US machine was very low using this approach.

A significant demonstration of clinical confidence is the ability of the residents to teach basic MSUS to first year medical students. Nationally, medical schools are successfully incorporating US into their curricula.[17–25] Through a medical school MSUS curriculum, the residents have the opportunity to teach basic concepts to a small group of medical students. This curriculum is a part of a new pilot US curriculum within the medical school.[25] Following the medical school's new teaching philosophy, self-directed learning strategies are encouraged in which the professor becomes a "coach" who does not instruct but guides the learner in their self-guided pursuit of knowledge.[17] By using the skills learned in the residency curriculum, the residents' procedural confidence and clinical knowledge is further tested and reinforced through instruction of the medical students.

Many aspects of the curriculum were based on the example provided by Finnoff et al.[4] The authors also used a similar approach to study resident-perceived benefit by surveying the resident group regarding the success and feasibility of the new curriculum. The curriculum highlights several new ideas that were developed in response to the thoughtful challenges to curriculum implementation posed by Finnoff et al. including adequately trained faculty and access to a sufficient number of US machines. The authors' solutions included table trainers, increased US access, and interdisciplinary collaboration. By using senior residents as table trainers, the experienced faculty member(s) guiding each workshop were free to circulate throughout the room and focus on challenging aspects of the curriculum. Interdisciplinary collaboration has proven to be invaluable, providing additional expert faculty and various perspectives on the clinical use of MSUS. Each resident benefitted from low resident/machine ratios as well, as it created a safe psychologic learning environment as evidenced by the fact residents felt comfortable to ask questions of their peers.[26] With regard to US access, there was a US machine dedicated to resident use with which to practice and provide independent images for feedback after each workshop.

Limitations

The authors present a single institution's experience with implementing a formal MSUS curriculum. It is likely that all elements of this curriculum will not be generalizable to other institutions, but many of the challenges described in this report may be applicable to other PM&R residency programs. The authors also recognize that implementation of a similar curriculum relies upon a significant commitment from the academic department, expert faculty, and motivated resident learners to follow through with independent scanning practice and reading.

There are also several educational concerns that were identified as a result of the program survey, such as resident feedback and assessment of competency. This is a challenge in all fields of medicine; as demonstrated in a survey of practicing musculoskeletal radiologists, only 33% reported receiving formal feedback at regular intervals.[27] The curriculum currently relies on peer-to-peer image review and feedback. This is supplemented by direct feedback of resident US skills provided at regular intervals, in private, by an experienced faculty member in relevant musculoskeletal clinics.[27] Direct feedback regarding US skills has been shown to be associated with significantly higher scores on a practical examination compared with colleagues receiving no feedback.[28]

CONCLUSION

PM&R departments nationally are faced with implementing MSUS learning for their trainees to comply with ACGME guidelines and to meet the demands of patients with musculoskeletal issues.[1,29–34] Although implementing a formal MSUS curriculum is a daunting task, the authors present a systematic assessment of barriers and available institutional resources that can be incorporated into a formal MSUS curriculum. Focus on independent study, peer-to-peer training, and participation of expert faculty are key aspects of the authors' proposed curriculum.

Acknowledgments

The authors thank the leadership at Spaulding Rehabilitation Hospital, Drs Ross Zafonte and Kevin O'Connor, for enabling the implementation of the MSUS curriculum into the residency program. The authors thank Dr Kelly McInnis (referred to as KM in the article) for her role in teaching MSUS to the residents.

References

1. Criscione-Schreiber LG, Bolster MB, Jonas BL, et al. Competency-based goals, objectives, and linked evaluations for rheumatology training programs: A standardized template of learning activities from the Carolinas Fellows Collaborative. Arthritis Care Res. 2013; 65:846–53.
2. Ozçakar L, Tok F, Kesikburun S, et al. Musculoskeletal sonography in physical and rehabilitation medicine: Results of the first worldwide survey study. Arch Phys Med Rehabil. 2010; 91:326–31. [PubMed: 20159141]
3. Accreditation Council for Graduate Medical Education Program Requirements for Graduate Medical Education in Physical Medicine and Rehabilitation. [Accessed April 2014] 2013. https://www.acgme.org/acgmeweb/Portals/0/PFAssets/ProgramRequirements/340_physical_medicine_rehabilitation_07012014.pdf
4. Finnoff JT, Smith J, Nutz DJ, et al. A musculoskeletal ultrasound course for physical medicine and rehabilitation residents. Am J Phys Med Rehabil. 2010; 89:56–69. [PubMed: 19884807]

5. Finnoff JT, Lavallee ME, Smith J. Musculoskeletal ultrasound education for sports medicine fellows: A suggested/potential curriculum by the American Medical Society for Sports Medicine. Br J Sports Med. 2010; 44:1144–8. [PubMed: 21156766]
6. Finnoff JT, Berkoff D, Brennan F, et al. American Medical Society for Sports Medicine recommended sports ultrasound curriculum for sports medicine fellowships. Br J Sports Med. 2015; 49:145–50.
7. Jacobson, JA. Fundamentals of Musculoskeletal Ultrasound. Philadelphia, PA: Elsevier; 2013.
8. European Society of Skeletal Radiology. [Accessed April 2014] Musculoskeletal Ultrasound Technical Guidelines. http://www.essr.org/cms/website.php?id=/en/essr_home.htm
9. Smith J, Finnoff JT. Diagnostic and interventional musculoskeletal ultrasound: Part 1. Fundamentals PM R. 2009; 1:64–75. [PubMed: 19627875]
10. Lewiss RE, Hoffmann B, Beaulieu Y, et al. Point-of-care ultrasound education: The increasing role of simulation and multimedia resources. J Ultrasound Med. 2014; 33:27–32. [PubMed: 24371095]
11. Speyer R, Pilz W, Van Der Kruis J, et al. Reliability and validity of student peer assessment in medical education: A systematic review. Med Teach. 2011; 33:e572–85. [PubMed: 22022910]
12. Ahn JS, French AJ, Thiessen ME, et al. Training peer instructors for a combined ultrasound/physical exam curriculum. Teach Learn Med. 2014; 26:292–5. [PubMed: 25010242]
13. Naredo E, Moller I, Moraques C, et al. Interobserver reliability in musculoskeletal ultrasonography: Results from a “Teach the Teachers” rheumatologist course. Ann Rheum Dis. 2006; 65:14–9. [PubMed: 15941835]
14. Scheel AK, Schmidt WA, Hermann KG, et al. Interobserver reliability of rheumatologists performing musculoskeletal ultrasonography: Results from a EULAR “Train the trainers” course. Ann Rheum Dis. 2005; 64:1043–9. [PubMed: 15640263]
15. Knobe M, Munker R, Sellei RM, et al. Peer teaching: A randomised controlled trial using student-teachers to teach musculoskeletal ultrasound. Med Educ. 2010; 44:148–55. [PubMed: 20040056]
16. Filippucci E, Meenagh G, Ciapetti A, et al. E-learning in ultrasonography: A web-based approach. Ann Rheum Dis. 2007; 66:962–5. [PubMed: 17329310]
17. Dienstag JL. Evolution of the New Pathway curriculum at Harvard Medical School: The new integrated curriculum. Perspect Biol Med. 2011; 54:36–54. [PubMed: 21399382]
18. Dreher SM, DePhilip R, Bahner D. Ultrasound exposure during gross anatomy. J Emerg Med. 2014; 46:231–40. [PubMed: 24113480]
19. Bahner DP, Goldman E, Way D, et al. The state of ultrasound education in U.S. Medical schools: Results of a national survey. Acad Med. 2014; 89:1681–6. [PubMed: 25099238]
20. Bahner DP, Jasne A, Boore S, et al. The ultrasound challenge: A novel approach to medical student ultrasound education. J Ultrasound Med. 2012; 31:2013–6. [PubMed: 23197555]
21. Bahner DP, Royall NA. Advanced ultrasound training for fourth-year medical students: A novel training program at The Ohio State University College of Medicine. Acad Med. 2013; 88:206–13. [PubMed: 23269306]
22. Mircea PA, Badea R, Fodor D, et al. Using ultrasonography as a teaching support tool in undergraduate medical education-time to reach a decision. Med Ultrason. 2012; 14:211–6. [PubMed: 22957326]
23. Tshibwabwa ET, Groves HM, Levine MA. Teaching musculoskeletal ultrasound in the undergraduate medical curriculum. Med Educ. 2007; 41:517–8. [PubMed: 17470098]
24. Wright SA, Bell AL. Enhancement of undergraduate rheumatology teaching through the use of musculoskeletal ultrasound. Rheumatology. 2008; 47:1564–6. [PubMed: 18703529]
25. Rempell, J.; Saldana, F.; Kumar, N., et al. A Pilot Study of Ultrasound Education at Harvard Medical School: First Year Experience. Abstract presented at the Third Annual World Congress Ultrasound in Medical Education annual meeting of The Society of Ultrasound in Medical Education (SUSME); 2014;
26. Clapper TC. Creating the safe learning environment. PAILAL. 2010; 3:1–6.
27. Yablon CM, Wu JS, Newman LR, et al. A needs assessment of musculoskeletal fellowship training: A survey of practicing musculoskeletal radiologists. AJR Am J Roentgenol. 2013; 200:732–40. [PubMed: 23521440]

28. Kissin EY, Niu J, Balint P, et al. Musculoskeletal ultrasound training and competency assessment program for rheumatology fellows. J Ultrasound Med. 2013; 32:1735–43. [PubMed: 24065254]
29. American College of Rheumatology Musculoskeletal Ultrasound Task Force. Ultrasound in American rheumatology practice: Report of the American College of Rheumatology musculoskeletal ultrasound task force. Arthritis Care Res. 2010; 62:1206–19.
30. Cannella AC, Kissin EY, Torralba KD, et al. Evolution of musculoskeletal ultrasound in the United States: Implementation and practice in rheumatology. Arthritis Care Res. 2014; 66:7–13.
31. Kissin EY, Nishio J, Yang M, et al. Self-directed learning of basic musculoskeletal ultrasound among rheumatologists in the United States. Arthritis Care Res. 2010; 62:155–60.
32. Larche MJ, McDonald-Blumer H, Bruns A, et al. Utility and feasibility of musculoskeletal ultrasonography (MSK US) in rheumatology practice in Canada: Needs assessment. Clin Rheumatol. 2011; 30:1277–83. [PubMed: 21484225]
33. Narouze SN, Provenzano D, Peng P, et al. The American Society of Regional Anesthesia and Pain Medicine, the European Society of Regional Anaesthesia and Pain Therapy, and the Asian Australasian Federation of Pain Societies Joint Committee recommendations for education and training in ultrasound-guided interventional pain procedures. Reg Anesth Pain Med. 2012; 37:657–64. [PubMed: 23080347]
34. Pineda C, Reginato AM, Flores V, et al. Pan-American League of Associations for Rheumatology (PANLAR) recommendations and guidelines for musculoskeletal ultrasound training in the Americas for rheumatologists. J Clin Rheumatol. 2010; 16:113–8. [PubMed: 20375820]

TABLE 1

Spaulding PM&R residency MSUS curriculum workshops and required reading

Joint Region	Reading	Anatomic Structures
Introduction	• Jacobson,[7] Chapters 1 and 2, pp. 1–2 • Smith and Finnoff[9]	• Basic overview of MSUS physics • Demonstration of the normal appearance of bone, cartilage, tendon, muscle, ligament, nerve, artery, and vein • Demonstration of transducer positioning to optimize images, that is, translation, heel-toe, tilt, rotation, pressure, and compression
Shoulder	• Jacobson, pp. 3–109 • European Society of Skeletal Radiology (ESSR) shoulder protocol (http://www.essr.org/html/img/pool/shoulder.pdf)	• Biceps in the bicipital groove • Supraspinatus • Subscapularis • Biceps between supraspinatus and subscapularis • Acromioclavicular joint • Infraspinatus • Posterior glenohumeral joint • Spinoglenoid notch • Supraspinatus • Dynamic rotator cuff evaluation—supraspinatus during abduction; subscapularis during internal and external rotation
Shoulder to elbow	• Jacobson, pp. 3–109 • ESSR shoulder protocol (http://www.essr.org/html/img/pool/shoulder.pdf) • ESSR elbow protocol (http://www.essr.org/html/img/pool/elbow.pdf)	• Biceps brachii • Brachialis muscle • Musculocutaneous nerve • Triceps • Radial nerve • Radial groove • Ulnar nerve
Elbow	• Jacobson, pp. 3–109 • ESSR elbow protocol (http://www.essr.org/html/img/pool/elbow.pdf)	• Brachial artery and vein • Brachioradialis muscle • Anterior humeroradial joint • Radial fossa • Anterior humeroulnar joint • Coronoid fossa • Pronator teres
Elbow to hand	• Jacobson, pp. 110–161 • ESSR elbow protocol (http://www.essr.org/html/img/pool/elbow.pdf)	• Brachioradialis • Flexor carpi radialis • Palmaris longus • Flexor carpi ulnaris • Flexor digitorum superficialis • Flexor digitorum profundus • Extensor digitorum communis

Joint Region	Reading	Anatomic Structures
		• Median nerve • Radial nerve • Ulnar nerve
Wrist	• Jacobson, pp. 110–161 • ESSR wrist protocol (http://www.essr.org/html/img/pool/wrist.pdf)	• Flexor retinaculum • Median nerve in the carpal tunnel • Ulnar nerve in the Guyon canal • Carpal bones • 6 extensor compartments and associated tendons
Hand	• Jacobson, pp. 110–161	• DIP joints • PIP joints • Flexor pulleys: A1–A5; C1–C3
Hip	• Jacobson, pp. 162–211 • ESSR hip protocol (http://www.essr.org/html/img/pool/hip.pdf)	• Anterior hip joint, femoral head, femoral neck, and capsule • Anterior labrum • Iliopsoas tendon • Femoral artery, vein, and nerve • Pubic bone and symphysis • Gluteus medius • Gluteus minimus • Gluteus maximus and greater trochanteric bursa • Ischial tuberosity • Conjoint tendon
Hip to knee	• Jacobson, pp. 162–211 • ESSR hip protocol (http://www.essr.org/html/img/pool/hip.pdf)	• Tensor fascia and iliotibial band • Sartorius muscle • Quadriceps muscle from ASIS to patella—rectus femoris, vastus lateralis, vastus medialis, vastus intermedius • Adductor muscles • Hamstring muscles from ischial tuberosity to distal insertions—biceps femoris long and short head; semimembranosus, semitendinosus • Sciatic nerve and its division into tibial and common peroneal nerves
Knee	• Jacobson, pp. 212–256 • ESSR knee protocol (http://www.essr.org/html/img/pool/knee.pdf)	• Suprapatellar recess • Patella and prepatellar bursa • Patellar tendon • Superficial infrapatellar bursa • Tibial tubercle • Distal femoral cartilage • MCL • Pes anserine tendons and bursa • Medial meniscus

Joint Region	Reading	Anatomic Structures
		• LCL • Iliotibial band bursa • Lateral meniscus • Biceps femoris tendon • Popliteus tendon • Popliteal fossa • Medial gastrocnemius muscle, tendon, bursa • Baker cyst • Popliteal artery and vein • Tibial nerve • Common fibular nerves • Lateral gastrocnemius muscle and tendon
Knee to foot	• Jacobson, pp. 257–337 • ESSR ankle protocol (http://www.essr.org/html/img/pool/ankle.pdf)	• Tibialis anterior • Extensor hallucis longus • Extensor digitorum longus • Deep peroneal nerve • Posterior tibialis • Flexor digitorum longus • Posterior tibial nerve • Tibial artery and vein • Flexor hallucis longus • Peroneus longus • Plantaris
Ankle	• Jacobson, pp. 257–337 • ESSR ankle protocol (http://www.essr.org/html/img/pool/ankle.pdf)	• Peroneus brevis • Superior peroneal retinaculum • Anterior joint recess • Anterior joint capsule • Deltoid ligament • ATFL • CFL • PTFL • Sural nerve • Achilles tendon
Foot	• Jacobson, p. 257–337 • ESSR ankle protocol (http://www.essr.org/html/img/pool/ankle.pdf)	• Medial and lateral plantar nerves • Plantar fascia • Plantar fat pad • Dorsalis pedis artery
Interventional procedures	• Jacobson, Chapter 9, pp. 338–369	• Patient selection and appropriate diagnoses • Safety and accuracy of US-guided injection • Aseptic technique and preprocedure planning

Joint Region	Reading	Anatomic Structures
		• Longitudinal and transverse needle imaging • Needle imaging, guidance, injection, and aspiration techniques in various models including phantom blocks, chicken legs, and water-filled latex gloves

DIP indicates distal Interphalangeal joint; PIP, proximal interphalangeal joint; ASIS, anterior superior iliac spine; MCL, medial collateral ligament; LCL, lateral collateral ligament; ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; PTFL, posterior talofibular ligament.

TABLE 2

Resident survey results

	Likert Mean (SD) Score
What was your amount of pre-MSUS knowledge before the first session of our MSUS course?	1.7 (0.6)
What do you think is your current level of basic MSUS anatomy knowledge?	2.6 (0.7)
What do you think is your current level of MSUS ability to optimally image structures?	2.5 (0.7)
What do you think is your current level of MSUS procedural competency?	2.2 (0.8)
How beneficial has the independent study approach (i.e., self-guided scanning practice and reading the ESSR guidelines and Fundamentals of Musculoskeletal Ultrasound) allowed you to maximally improve your skills?	3.0 (0.7)
Do you feel using residents as group teachers during the course have been beneficial to your learning?	3.9 (1.0)
How confident would you feel performing diagnostic MSUS now, independently?	1.7 (0.7)
How confident would you feel performing MSUS-guided procedures now, independently?	1.7 (0.8)
What is your overall rating of the MSUS course, including didactic sessions, hands-on practice sessions, self-directed learning, and reading?	4.0 (0.7)
How many US courses have you attended, if any, outside of the SRH curriculum?	2.1 (0.6)
If you have attended them, have the optional hands-on MSUS sessions with the rheumatology department been beneficial to your learning?	3.3 (0.6)
If you have attended it, has the new rheumatology clinical rotation been beneficial to your learning?	4.0 (1.1)
What is your overall rating of the MSUS course extracurricular opportunities including clinical rotations, voluntary practice sessions with the rheumatology department and Harvard Medical School teaching sessions?	3.6 (0.9)
	Yes/No (%)
Have you participated as a resident table trainer for any of the MSUS training sessions?	Yes = 8 (36) No = 14 (64)
Have you participated as a teacher in the medical student US course at Harvard Medical School?	Yes = 7 (32) No = 15 (68)
If you have participated in teaching at Harvard Medical School, did you spend extra time preparing to teach before the session?	Yes = 6 (86) No = 1 (14)
	Likert Item (%)
In the last year, how often have you practiced US outside of scheduled training sessions and clinic?	None = 2 (9) A few times = 16 (73) Every 2–3 mos = 1(5) Monthly = 4 (18)
In the last year, approximately how many diagnostic US examinations have you participated in (performed some aspect) during clinical rotations?	None = 7 (32) 1–10 = 11 (50) 21–30 = 2 (9) 30+ = 3 (14)
In the last year, approximately how many US-guided procedures have you participated in (performed some aspect) during clinical rotations?	None = 5 (23) 1–10 = 8 (36) 11–20 = 5 (23) 21–30 = 3 (14) 30+ = 2 (9)