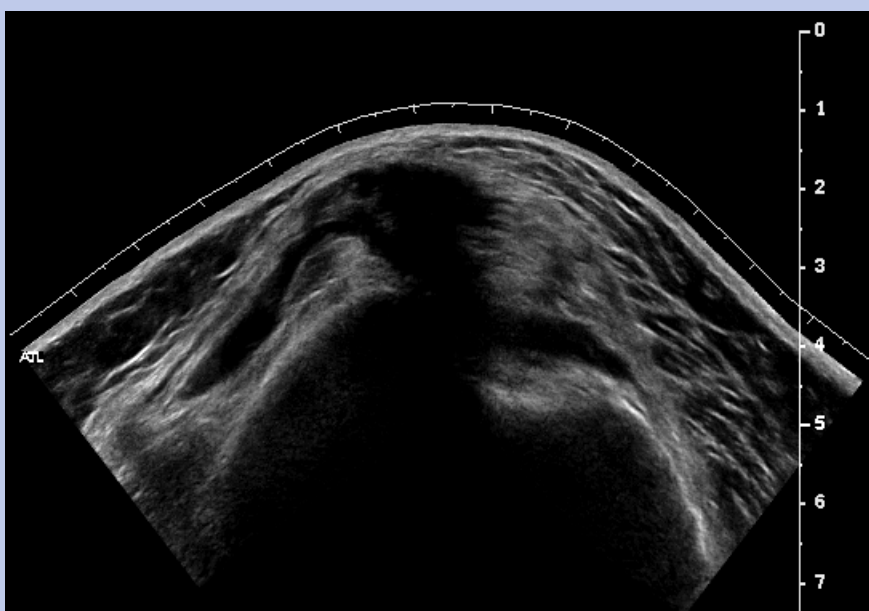


AIUM Practice Guideline for the Performance of the Musculoskeletal Ultrasound Examination



The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary association dedicated to advancing the safe and effective use of ultrasound in medicine through professional and public education, research, development of guidelines, and accreditation. To promote this mission, the AIUM is pleased to publish, in conjunction with the American College of Radiology (ACR), this *AIUM Practice Guideline for the Performance of the Musculoskeletal Ultrasound Examination*. We are indebted to the many volunteers who contributed their time, knowledge, and energy to bringing this document to completion.

The AIUM represents the entire range of clinical and basic science interests in medical diagnostic ultrasound, and, with hundreds of volunteers, the AIUM has promoted the safe and effective use of ultrasound in clinical medicine for more than 50 years. This document and others like it will continue to advance this mission.

Practice guidelines of the AIUM are intended to provide the medical ultrasound community with guidelines for the performance and recording of high-quality ultrasound examinations. The guidelines reflect what the AIUM considers the minimum criteria for a complete examination in each area but are not intended to establish a legal standard of care. AIUM-accredited practices are expected to generally follow the guidelines with recognition that deviations from these guidelines will be needed in some cases, depending on patient needs and available equipment. Practices are encouraged to go beyond the guidelines to provide additional service and information as needed.



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I. Introduction

The clinical aspects of this guideline (Introduction, Specifications for Individual Examinations, and Equipment Specifications) were developed collaboratively by the American Institute of Ultrasound in Medicine (AIUM) and the American College of Radiology (ACR). Several sections of this guideline (Qualifications and Responsibilities of Personnel, Documentation, Written Request, and Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns) vary between the organizations and are addressed by each separately.

This guideline has been developed to assist practitioners performing a musculoskeletal ultrasound examination. While it is not possible to detect every abnormality, adherence to the following guidelines will maximize the probability of detecting most abnormalities that occur.

II. Qualifications and Responsibilities of Personnel

See the AIUM Official Statement *Training Guidelines for Physicians Who Evaluate and Interpret Diagnostic Ultrasound Examinations* and the *AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices*.

III. Written Request for the Examination

The written or electronic request for an ultrasound examination should provide sufficient information to allow for the appropriate performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider or under their direction. The accompanying clinical information should be provided by a physician or other appropriate health care provider familiar with the patient's clinical situation and should be consistent with relevant legal and local health care facility requirements.

IV. Supervision and Interpretation of Ultrasound Examinations

A physician must be available for consultation with the sonographer on a case-by-case basis. Ideally, the physician should be on-site and available to participate actively in the ultrasound examination when required. It is recognized, however, that geographic realities may not permit the presence of an on-site physician in all locations. In this case, the physician should visit the facility on a regular basis to provide on-site review of ultrasound procedures and sonographer supervision.

V. Specifications for Individual Examinations

Depending on the clinical request and the patient's presentation, the ultrasound examination can involve a full assessment of a joint, or it can be tailored to a specific region of interest. If a limited study is performed, it is essential to have a full understanding of the relevant abnormalities, including those that may mimic the patient's symptoms.

General ultrasound scanning principles apply. Axial and longitudinal views should always be obtained with the transducer perpendicular to the axis of the region of interest to minimize artifact. Abnormalities should be measured in both planes. Graded compression of soft tissues should be used for a complete assessment.

A. The Shoulder

1. Indications for a Shoulder Ultrasound Examination

The indications for ultrasound of the shoulder include, but are not limited to, evaluation of shoulder pain or dysfunction.

2. Specifications of the Shoulder Examination

Patients should be examined in the sitting position, preferably on a rotating seat. Examination of the shoulder should be tailored to the patient's clinical circumstances and range of motion.

The biceps tendon should be examined with the forearm in supination and resting on the thigh or with the arm in slight external rotation. The tendon is examined in a transverse plane (short axis), where it emerges from under the acromion, to the musculotendinous junction distally. Longitudinal views (long axis) should also be obtained. These views should be used to determine if the tendon is properly positioned within the bicipital groove, subluxated, dislocated, or torn.

To examine the subscapularis tendon, the elbow remains at the side while the arm is placed in external rotation. Both transverse (long axis) and sagittal (short axis) views should be obtained. Dynamic evaluation as the patient moves from internal to external rotation may be helpful.

To examine the supraspinatus tendon, the arm can be extended posteriorly, and the palmar aspect of the hand can be placed against the superior aspect of the iliac wing with the elbow flexed and directed toward midline (instruct patient to place the hand in the back pocket). Other positioning techniques also may be helpful.

To scan the supraspinatus and infraspinatus tendons along their long axis, it is important to orient the transducer approximately 45° between the sagittal and coronal planes to obtain a longitudinal view. The transducer then should be moved anteriorly and posteriorly to completely visualize the tendons.

Transverse views of the tendons should be obtained by rotating the probe 90° to the long axis. The tendons are visualized by sweeping medially to the acromion and laterally to their insertions on the greater tuberosity. The more posterior aspect of the infraspinatus and teres minor tendons should be examined by placing the transducer at the level of the glenohumeral joint below the scapular spine while the forearm rests on the thigh with the hand supinated. Internal and external rotation of the arm is helpful in identifying the infraspinatus muscle and its tendon and in detecting small joint effusions.

To visualize the teres minor tendon, the probe should be angled slightly inferiorly. Throughout the examination of the rotator cuff, the cuff should be compressed to detect nonretracted tears. In the evaluation of rotator cuff tears, comparison with the contralateral side may be useful.

While examining the rotator cuff, it is also important to evaluate for bursal thickening, effusion, loose bodies, tendon calcification, and muscle and bony abnormalities. If symptoms warrant, the acromioclavicular joint, the supraspinatus notch, and the spinoglenoid notch also may be evaluated. Dynamic evaluation of the rotator cuff also is useful, for example, to evaluate the rotator cuff for impingement or assess cuff tear extent.

B. The Elbow

1. Indications for an Elbow Examination

The indications for ultrasound of the elbow include but are not limited to soft tissue injury, tendon pathology (including tendinopathy, enthesopathy, and tears), ligament pathology, arthritis, loose bodies, soft tissue masses, nerve entrapment, effusion, and bone injury.

2. Specifications of the Elbow Examination

The patient is seated with the arm extended and the hand in supination, resting on a table, and the examiner sitting in front of the patient. The elbow may also be examined with the patient supine and the examiner on the same side as the elbow of interest. The examination is divided into 4 quadrants: anterior, medial, lateral, and posterior. The examination may be tailored to a specific site depending on the clinical presentation.

a. Anterior

The anterior joint space and other recesses of the elbow are assessed for effusion, synovial proliferation, and loose bodies. Longitudinal and

axial scanning of the anterior humeroradial and humeroulnar joints and coronoid and radial fossae is performed to assess the articular cartilage and cortical bone. The annular recess of the neck of the radius is scanned dynamically with the patient alternatively supinating and pronating the forearm. The same dynamic assessment can be made for the biceps tendon and its attachment to the radial bicipital tuberosity. The brachialis muscle, the adjacent radial and brachial vessels, and the median and radial nerves complete the anterior scan.

b. Lateral

The patient extends the arm and places both palms together, or if the patient is supine, the forearm is placed across the abdomen. This position allows assessment of the lateral epicondyle and the attachments of the common extensor tendon, as well as the more proximal attachments of the extensor carpi radialis longus and brachioradialis. The hand is then pronated with the transducer on the posterolateral aspect of the elbow to scan the radial collateral ligament.

c. Medial

The hand is placed in supination, and the medial epicondyle, common flexor tendon, and ulnar collateral ligament are scanned in both planes. The ulnar nerve is visualized in the cubital tunnel between the olecranon process and medial epicondyle. Dynamic examination with flexion and extension of the elbow is performed to assess dynamic subluxation of the ulnar nerve. Dynamic examination with valgus stress is performed to assess

integrity of the ulnar collateral ligament. During stress testing, the elbow must be slightly flexed to disengage the olecranon from the olecranon fossa.

d. Posterior

The palm is placed down on the table, or if the patient is supine, the forearm is placed across the abdomen, with the elbow flexed to 90°. The posterior joint space, triceps tendon, olecranon process, and olecranon bursa are assessed.

C. The Wrist and Hand

1. Indications for a Wrist and Hand Examination

The indications for ultrasound of the wrist and hand include but are not limited to soft tissue injury, tendon pathology (tendinopathy, tenosynovitis, and tears), arthritis, soft tissue masses or swelling (including ganglion cysts), nerve entrapment, effusion, foreign bodies, and bone injury. This examination is usually tailored to the clinical presentation.

2. Specifications of the Wrist and Hand Examination

The patient sits with hands resting on a table placed anteriorly or on a pillow placed on the patient's thighs. The volar examination requires the wrists to be placed flat or in mild dorsiflexion with palm up and during both ulnar and radial deviation to delineate all the necessary anatomy. The dorsal scan requires the wrist to be placed palm down with mild volar flexion.

a. Volar

Axial and longitudinal images should be obtained from the volar wrist crease to the thenar muscles. The transducer will require angulation to

compensate for the normal contour of the wrist. The flexor retinaculum, the flexor digitorum profundus and superficialis tendons, and the adjacent flexor pollicis longus tendon are identified within the carpal tunnel. Dynamic imaging with flexion and extension of the fingers will demonstrate normal motion of these tendons. The median nerve lies superficial to these tendons and deep to the flexor retinaculum, and it moves with the tendons but with less amplitude on dynamic imaging. The distal end of the median nerve is tapered and divides into the distal divisions for the hand. The palmaris longus tendon lies superficial to the retinaculum. On the radial side of the wrist, the flexor carpi radialis longus tendon lies within its own canal. It is important to evaluate the region of the flexor carpi radialis and the radial artery for occult ganglion cysts, which typically originate from the radiocarpal joint capsule. On the ulnar side, branches of the ulnar nerve and artery lie within Guyon's canal. The flexor carpi ulnaris tendon borders the ulnar aspect of Guyon's canal. All the tendons can be followed to their sites of insertion if clinically indicated.

b. Ulnar

Placing the transducer axially on the ulnar styloid and moving distally will allow visualization of the triangular fibrocartilage in its long axis. The transducer is then moved 90° to view the short axis of the triangular fibrocartilage. The meniscus homologue lies distal to the triangular fibrocartilage and deep to the extensor carpi ulnaris tendon. This tendon should be viewed in supination and pronation to assess subluxation.

c. Dorsal

Structures are very superficial on the dorsal surface, and a high-frequency transducer is required with or without the use of a standoff pad. The extensor retinaculum divides the dorsal aspect of the wrist into 6 compartments, which accommodate 9 tendons. These are examined axially initially and then longitudinally in static and dynamic modes, the latter being performed with flexion and extension of the fingers. The tendons can be followed to their sites of insertion where clinically indicated. Moving the transducer axially distal to Lister's tubercle identifies the dorsal aspect of the scapholunate ligament, a site of symptomatic ligament tears and ganglion cysts. The remaining intercarpal ligaments are not routinely assessed. In patients with suspected inflammatory arthritis, the metacarpophalangeal joints and, if symptomatic, the proximal interphalangeal joints are evaluated from the volar and dorsal aspects in both the longitudinal and axial planes for effusion, synovial hypertrophy, and bony erosions. Color and power Doppler evaluation may be useful in detecting synovial hyperemia. Other joints of the wrist and hand are similarly evaluated as clinically indicated.

D. The Hip

1. Adult Hip

a. Indications for a Hip Examination

The indications for ultrasound of the adult hip include but are not limited to soft tissue injury, tendon pathology, arthritis, soft tissue masses or swelling, nerve entrapment, effusion, and bone injury.

b. Specifications of the Hip Examination

Depending on the patient's habitus, a lower-frequency transducer may be required to scan the hip. Because the spatial resolution decreases with a decrease in the transducer frequency, the operator should use the highest possible frequency that provides adequate penetration. The patient is placed supine with the hip in mild external rotation. Anterior, posterior, medial, and lateral approaches are performed. The examination may be tailored to a specific site depending on the clinical presentation.

i. Anterior

A sagittal oblique plane parallel to the long axis of the femoral neck is used for evaluation of the femoral head, neck, and joint effusion. The sagittal plane is used for the labrum, the iliopsoas tendon and bursa, the femoral vessels, and the sartorius and rectus femoris muscles. The above structures are then scanned in the axial plane, perpendicular to the original scan plane. When a "snapping hip" is suspected, dynamic scanning is performed over the region of interest using the same movement that the patient describes as precipitating the complaint. The "snapping hip" is usually related to the iliopsoas tendon as it passes anteriorly over the superior pubic bone or laterally where the iliotibial tract crosses the greater trochanter.

ii. Lateral

In the lateral decubitus position, with the symptomatic side up, axial and longitudinal scans of the greater trochanter, greater trochanteric bursa, gluteus medius, gluteus maximus, gluteus minimus, and tensor fascia lata should be performed. An iliotibial tract that snaps over the greater trochanter can be assessed in this position using dynamic flexion-extension.

iii. Medial

The hip is placed in external rotation with 45° of knee flexion (frog-leg position). The distal iliopsoas tendon, because of its oblique course, may be better seen in this position. The adductor muscles are imaged in the sagittal oblique orientation, with axial images obtained perpendicular to this plane. In addition, the pubic bone and symphysis and the distal rectus abdominis insertion should be evaluated.

iv. Posterior

The patient is prone with the legs extended. Axial and longitudinal views of the glutei, hamstrings, and sciatic nerve are obtained. The glutei are imaged obliquely from origin to greater trochanter (gluteus medius and minimus) and linea aspera (gluteus maximus). The sciatic nerve is scanned axially from its exit at the greater sciatic foramen deep to the gluteus maximus. It can be followed distally, midway between the ischial tuberosity and greater trochanter, lying superficial to the quadratus femoris muscle.

2. Prosthetic Hip

a. Indications for a Prosthetic Hip Examination

Assess for joint effusions and extra-articular fluid collections, often as part of an ultrasound-guided procedure for fluid aspiration in the clinical scenario of prosthetic joint infection.

b. Specifications of the Prosthetic Hip Examination

Anterior and lateral approaches, as described above, can be used to measure joint effusion at prosthesis-bone junction and detect fluid in the greater trochanteric and iliopsoas bursae.

3. Neonatal or Pediatric Hip

See the *AIUM Practice Guideline for the Performance of the Ultrasound Examination for Detection of Developmental Dysplasia of the Hip*.

E. The Knee

1. Indications for a Knee Examination

The indications for ultrasound of the knee include but are not limited to soft tissue injury, tendon and collateral ligament pathology, arthritis, soft tissue masses or swelling, loose intra-articular bodies, effusion, and bone injury.

2. Specifications of the Knee Examination

The examination is divided into 4 quadrants. Either a comprehensive structured examination of the whole knee or, alternatively, a limited study tailored to the clinical presentation is performed.

a. Anterior

The patient is supine with the knee flexed to 30°. Longitudinal and axial scans of the quadriceps and patellar tendons, patellar retinacula, and suprapatellar recess are obtained.

If clinically indicated, the patella is also scanned to assess for an occult injury. The distal femoral cartilage can be assessed with the probe placed in the suprapatellar space in the axial plane with the knee in maximal flexion. Longitudinal views of the cartilage over the medial and lateral femoral condyles are added as indicated. The prepatellar, superficial, and deep infrapatellar bursae are also evaluated. The distal or tibial aspect of the anterior cruciate ligament may be visualized inserting into the anteromedial tibial plateau with the knee in maximum flexion and the transducer in the longitudinal plane of the ligament.

b. Medial

The patient remains supine with slight flexion of the knee and hip with slight external rotation of the hip. Alternatively, the patient may be placed in the lateral decubitus position. The medial joint space is examined. The medial collateral ligament, the pes anserine tendons and bursa, and the medial patellar retinaculum are scanned in both planes. The anterior horn and body of the medial meniscus may be identified in this position, particularly with valgus stress. If meniscal pathology is suspected either clinically or by ultrasound, further examination with magnetic resonance imaging is advised.

c. Lateral

The patient remains supine with the ipsilateral leg internally rotated or in a lateral decubitus position. A pillow may be placed between the knees for comfort. From posterior to anterior, the popliteus tendon, biceps femoris tendon, fibular collateral ligament, and iliotibial band and bursa are

scanned. The lateral patellar retinaculum can also be assessed in this position (as well as in the anterior position). The joint line is scanned for meniscal pathology or cysts.

d. Posterior

The patient lies prone with the leg extended. The popliteal fossa, semimembranosus, medial and lateral gastrocnemius muscles, tendons, and bursae are assessed. To confirm the diagnosis of a popliteal cyst, the comma-shaped extension toward the posterior joint has to be visualized sonographically in the posterior axial scan between the medial head of gastrocnemius and semimembranosus tendon. In addition, the posterior horns of both menisci can be evaluated. The posterior cruciate ligament may be identifiable in a sagittal oblique plane in this position. Examination of the intercondylar region of the femur in the transverse plane can evaluate for injury to the anterior cruciate ligament, although magnetic resonance imaging should be considered for this indication.

F The Ankle and Foot

1. Indications for an Ankle and Foot Examination

The indications for ultrasound of the ankle and foot include but are not limited to soft tissue, tendon, and ligament injury, arthritis, soft tissue masses or swelling, intra-articular loose bodies, effusion, bone injury, Morton's neuroma, plantar fasciitis, and foreign bodies.

2. Specifications of the Ankle and Foot Examination

Ultrasound examination of the ankle is divided into 4 quadrants (anterior, medial, lateral, and posterior) and is usually

tailored to the clinical presentation.

Examination of the foot is also tailored to the clinical presentation (eg, assessment of joints for synovitis, the plantar fascia for fasciitis, or a mass for Morton's neuroma or a ganglion cyst).

a. Anterior

The patient lies supine with the knee flexed and the plantar aspect of the foot flat on the table. The anterior tendons are assessed in longitudinal and axial planes from their musculotendinous junctions to their distal insertions. From medial to lateral, this tendon group includes the tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius tendons (the latter being congenitally absent in some patients). The anterior joint recess is scanned for effusion, loose bodies, and synovial thickening. The anterior joint capsule is attached to the anterior tibial margin and the neck of the talus, and the hyaline cartilage of the talus appears as a thin hypoechoic line. The anterior tibiofibular ligament is assessed by moving the transducer proximally over the distal tibia and fibula, superior and medial to the lateral malleolus, and scanning in an oblique axial plane.

b. Medial

The patient maintains the same position as in the anterior examination. The posterior tibial, flexor digitorum longus, and flexor hallucis longus tendons (located in this order from anterior to posterior) are initially scanned axially proximal to the medial malleolus to identify each tendon. They are assessed in longitudinal and axial planes from their proximal musculotendinous junctions in the

supramalleolar region to their distal insertions. Continuous adjustment of the angulation of the transducer to remain perpendicular to the tendons as they curve under the medial malleolus must be made to avoid anisotropy. The same holds true when assessing the lateral aspect of the ankle, as described below. The tibial nerve can be scanned by identifying it between the flexor digitorum tendon anteriorly and the flexor hallucis longus tendon posteriorly, at the level of the malleolus. The nerve can then be followed proximally and distally. The flexor hallucis longus may also be scanned in the posterior position, medial to the Achilles tendon. The deltoid ligament is scanned longitudinally from its attachment to the medial malleolus to the navicular, talus, and calcaneus.

c. Lateral

The patient is supine with the knee flexed and the plantar aspect of the foot on the table with slight inversion. The peroneus brevis and longus tendons are identified proximal to the lateral malleolus on an axial scan, and they can then be assessed in longitudinal and axial planes from their proximal (supramalleolar) musculotendinous junctions to their distal insertions. The peroneus longus can be followed in this manner to the cuboid groove, where it turns to course medially along the planter aspect of the foot to insert on the base of the first metatarsal and medial cuneiform. This latter aspect of the tendon can be scanned in the prone position, as described below. The peroneus brevis tendon is followed to its insertion on the base of the fifth metatarsal. The peroneus brevis and longus tendons are

assessed for subluxation using real-time images with dorsiflexion and eversion. The lateral ligament complex is examined by placing the transducer on the tip of the lateral malleolus in the following orientations: anterior and posterior horizontal oblique for the anterior and posterior talofibular ligaments and posterior vertical oblique for the calcaneofibular ligament.

d. Posterior

The patient is prone with feet extending over the end of the table. The Achilles tendon is scanned in the longitudinal and axial planes from the musculotendinous junctions (medial and lateral heads of the gastrocnemius and soleus muscles) to the site of insertion on the posterior surface of the calcaneus. Dynamic scanning with plantar and dorsiflexing may aid in the evaluation of tears. The plantaris tendon lies along the medial aspect of the Achilles tendon and inserts on the posteromedial calcaneus. It should be noted that this tendon may be absent as a normal variant but is often intact in the setting of a full-thickness Achilles tendon tear. The retrocalcaneal bursa, between the Achilles and superior calcaneus, is also assessed. The plantar fascia is scanned in both planes from its proximal origin on the medial calcaneal tubercle distally where it divides and merges into the soft tissues.

e. Digital

In patients with suspected inflammatory arthritis, the metatarsophalangeal joints and, if symptomatic, the proximal interphalangeal joints are evaluated from the plantar and dorsal aspects in both the longitudinal and axial planes for effusion,

synovial hypertrophy, synovial hyperemia, and bony erosions. Other joints of the foot are similarly evaluated as clinically indicated.

f. Interdigital

The patient is supine with the foot dorsiflexed 90° to the ankle. Either a dorsal or plantar approach can be used. The latter will be described here. The transducer is placed longitudinally on the plantar aspect of the first interdigital space, and digital pressure is applied by the examiner on the dorsal surface. The transducer is moved laterally with its center at the level of the metatarsal heads. The process is repeated for the remaining interspaces and then repeated axially. When Morton's neuroma is clinically suspected, pressure can be applied to reproduce the patient's symptoms. The intermetatarsal bursa lies on the dorsal aspect of the interdigital nerve, and care must be taken to correctly identify a neuroma and differentiate it from the bursa.

G. Peripheral Nerves

1. Indications for a Peripheral Nerve Examination

The indications for a peripheral nerve examination include but are not limited to compression neuropathies, neuritis, nerve masses, nerve trauma, and nerve subluxation.

2. Specifications of the Peripheral Nerve Examination

Nerves have a fascicular pattern with hypoechoic longitudinal neuronal fascicles interspersed with hyperechoic interfascicular endoneurium. In addition, they have a hyperechoic superficial epineurium. As a nerve bifurcates, each fascicle enters only one of the subdivisions without splitting.

Nerves course adjacent to vessels and are readily distinguished from the surrounding tendons with a dynamic examination, during which the nerve demonstrates relatively little movement compared to the adjacent tendons. Nerves may become more hypoechoic as they pass through fibro-osseous tunnels, as the fascicles become more compact. Examination in the axial plane is usually preferred to assess the course of the nerve, as it may be difficult to separate the nerve itself from the surrounding tendons and muscles on a longitudinal scan. Assessment at the level of fibro-osseous tunnels requires dynamic examination. A statically dislocated nerve is readily identifiable on ultrasound images, but an intermittently subluxating nerve requires dynamic examination. Perhaps the most commonly subluxating nerve is the ulnar nerve within the cubital tunnel (see posterior elbow examination). Entrapment neuropathies also typically occur within fibro-osseous tunnels (eg, cubital and Guyon's tunnels for the ulnar nerve, carpal tunnel for the median nerve, fibular neck for the common peroneal nerve, and tarsal tunnel for the tibial nerve). Adjacent pathology of tendons, soft tissues, and bone can be readily evaluated to determine the potential underlying cause of the nerve dysfunction. In addition, congenital abnormalities (eg, accessory muscles or vessels) can be assessed.

H. Soft Tissue Mass

1. Indications for a Soft Tissue Mass Examination

The indications for a soft tissue mass examination include but are not limited to determining the cystic or solid nature of a mass as well as its size, vascularity, margins, and relationship to adjacent structures.

2. Specifications of the Soft Tissue Mass Examination

The mass should be scanned in both longitudinal and axial planes. Ultrasound is an excellent method for differentiating solid from cystic masses. The mass should be measured in 3 orthogonal planes, and its relationship to surrounding structures should be determined, particularly to joints, neurovascular bundles, and tendons. Compressibility of the lesion should be evaluated. Color or power Doppler evaluation may help to delineate intralesional and extralesional vessels and vascularity of the mass.

I. Interventional Musculoskeletal Ultrasound

1. Indications for Interventional Musculoskeletal Ultrasound

The indications for interventional musculoskeletal ultrasound include but are not limited to aspiration of cysts, fluid collections and abscesses, arthrocentesis, insertion of drainage catheters, ultrasound-guided biopsy, medicinal injections, intra-articular injection of contrast agents (before computed tomography or magnetic resonance imaging), lavage and aspiration of tendon calcifications, and foreign body retrieval.

2. Specifications of Interventional Musculoskeletal Ultrasound

Ultrasound is an ideal imaging modality for image guidance of interventional procedures within the musculoskeletal system. The usual standards for interventional procedures apply (ie, review of prior imaging, appropriate consent, use of a local anesthetic, and sterile conditions). The use of a sterile drape that surrounds the prepared site, a sterile ultrasound probe cover, and sterile gloves will lower risk of contamination and infection.

Ultrasound provides direct visualization of the needle, monitors the needle pathway, and shows the position of the needle within the target area. Direct visualization of the needle allows the practitioner to avoid significant intralesional and extralesional vessels, adjacent nerves, and other structures at risk.

Before any procedure, a thorough ultrasound examination to characterize the target area and its relationship to surrounding structures is performed. Color or power Doppler evaluation is useful to delineate any vessels within the target zone. The shortest pathway to the region of interest should ideally be selected, with consideration given to regional neurovascular structures. The transducer is aligned in the same longitudinal plane as the needle. The needle can be attached directly to the transducer or held freehand. Either way, the needle is visualized throughout the procedure. Slight to-and-fro movement or injection of a small amount of sterile saline or air may be beneficial in visualizing the needle. In cases of biopsy, focal areas of vascularity indicate viable tissue for pathologic examination.

J. Ultrasound of Foreign Bodies in Superficial Soft Tissue

1. Indications for Detection of Foreign Bodies in Superficial Soft Tissues by Ultrasound

Ultrasound is helpful for detection and localization of foreign bodies, especially nonradiopaque foreign bodies such as wood, plastic, and certain types of glass.

2. Specifications of the Ultrasound Examination for Detection of Foreign Bodies

Most foreign bodies are associated within an acoustic shadow or a comet tail artifact. Once a foreign body is detected,

ultrasound can be used to demonstrate its relationship to adjacent structures. In addition to a high-frequency linear array transducer, detection of foreign bodies in superficial subcutaneous tissues requires a standoff pad.

VI. Documentation

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should be accompanied by measurements. Images should be labeled with the patient identification, facility identification, examination date, and side (right or left) of the anatomic site imaged. An official interpretation (final report) of the ultrasound findings should be included in the patient's medical record. Retention of the ultrasound examination should be consistent both with clinical needs and with relevant legal and local health care facility requirements.

Reporting should be in accordance with the *AIUM Practice Guideline for Documentation of an Ultrasound Examination*.

VII. Equipment Specifications

Musculoskeletal ultrasound should be performed with high-resolution linear array transducers with a broad bandwidth. Frequencies between 7.5 and 12 MHz are generally preferred, with frequencies lower and higher required for deep and very superficial structures, respectively. Transducers with a small footprint should be used in assessment of smaller structures, (eg, interphalangeal joints). Linear array transducers accentuate anisotropy because of the lack of divergent beam geometry. Color and power Doppler imaging are valuable in assessing hyperemia in inflammatory or reparative tissue, determining the vascularity of a soft tissue mass, differentiating cystic lesions from

vessels, and assisting in ultrasound-guided biopsy and aspiration. Doppler frequencies should be set to optimize flow detection. Tissue harmonic imaging, compound imaging, and extended field-of-view imaging are recent advancements that may be useful in musculoskeletal ultrasound.

VIII. Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns

Policies and procedures related to quality control, patient education, infection control, and safety should be developed and implemented in accordance with the *AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices*.

Equipment performance monitoring should be in accordance with the *AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices*.

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This guideline was developed by the American Institute of Ultrasound in Medicine (AIUM) in collaboration with the American College of Radiology (ACR), according to the process described in the *ACR Practice Guidelines and Technical Standards Book*.

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