CAR Standard for the performance of Musculoskeletal Ultrasound Examination

Approved: September 2005

The standards of the Canadian Association of Radiologists (CAR) are not rules, but are guidelines that attempt to define principles of practice that should generally produce radiological care. The physician and medical high-quality physicist may modify an existing standard as determined by the individual patient and available resources. Adherence to CAR standards will not assure a successful outcome in every situation. The standards should not be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed to obtaining the same results. The standards are not intended to establish a legal standard of care or conduct, and deviation from a standard does not, in and of itself, indicate or imply that such medical practice is below an acceptable level of care. The ultimate judgment regarding the propriety of any specific procedure or course of conduct must be made by the physician and medical physicist in light of all circumstances presented by the individual situation.

I. INTRODUCTION

These standards have been developed to provide assistance to practitioners performing ultrasound examinations. In some cases, additional and/or specialized examinations may be necessary. While it is not possible to detect every abnormality, adherence to the following standards will maximize the probability of detecting most of the abnormalities that occur.
Diagnostic Ultrasound is an established, effective, diagnostic imaging technique which employs the use of high frequency ultrasound waves for both Imaging and Doppler examinations.
Extensive experience has shown that ultrasound is a safe and effective diagnostic procedure. While no demonstrable harmful effects of ultrasound have been demonstrated at power levels used for diagnostic studies, quality assurance dictates it is necessary to utilize this imaging technique in the most appropriate and indicated fashion, and that studies be performed by qualified and knowledgeable physicians and/or sonographers using appropriate equipment and techniques. Diagnostic ultrasound examinations should be supervised and interpreted by trained and credentialed physician imaging specialists.

II. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A. SONOLOGIST'S CREDENTIALS CRITERIA
Physicians involved in the performance, supervision and interpretation of ultrasonography should be Diagnostic Radiologists and must have a Fellowship or Certification in Diagnostic Radiology with the Royal College of Physicians and Surgeons of Canada and/or the Collège des médecins du Québec. Also acceptable are equivalent foreign Radiologist qualifications if the Radiologist is certified by a recognized certifying body and holds a valid provincial license.
As new imaging modalities and interventional techniques are developed additional clinical training, under supervision and with proper documentation, should be obtained before radiologists interpret or perform such examinations or procedures independently. Such additional training must meet with pertinent provincial/regional regulations. Continuing professional development must meet with the requirements of the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada.

B. SONOGRAPHER'S CREDENTIALS CRITERIA
Sonographers should be graduates of an accredited School of Sonography or have obtained certification by the American Registry of Diagnostic Medical Sonographers (ARDMS) or the Canadian Association of Registered Diagnostic Ultrasound Professionals (CARDUP). They should be members of their national or provincial professional organization. Continuing medical education should be mandatory consistent with the requirements of ARDMS or CARDUP.
CARDUP will have a national exam process for sonographers in place by 2004. At that time this will become the accepted standard for sonographers. As an interim measure, individual consideration of training and qualifications by a Task Force consisting of members of relevant societies can be recommended for all those whose training does not fall within appropriate guidelines.

C. SUPERVISION AND INTERPRETATION OF ULTRASOUND EXAMINATIONS

A sonologist must be available for consultation with the sonographer on a case-by-case basis. Ideally the sonologist should be on site and available to participate actively in the ultrasound examination when required. It is recognized however that the geographic realities in Canada do not permit the presence of an on-site sonologist in all locations. Adequate documentation of each examination is critical. A videotape record may be useful as an adjunct to the hard copy images in difficult cases. Despite the geographic isolation of a community the reports must be timely. Furthermore, the sonologist must be available by telephone for consultation with the sonographer and the referring physician. The sonologist should visit the facility on a regular basis to provide on site review of ultrasound procedures and sonographer supervision.

III. TECHNICAL EQUIPMENT

High -resolution linear array transducers with a broad-bandwidth frequency 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 e.g. interphalangeal joints. Linear array transducers lack divergent beam geometry, which accentuate anisotropy. Optimal examinations require the operator to have a good understanding of the equipment and potential artifacts with the ability to change the imaging parameters appropriately e.g. depth, near field, frequency and angle of insonation. Color and power Doppler are valuable in assessing hyperemia in inflammatory or reparative tissue, vascularity of a soft tissue mass and differentiating cystic lesions from vessels and aids in ultrasound-guided biopsy and aspiration. Tissue harmonic imaging, compound imaging and extended field of view are recent advancements in the development of ultrasound. 3-D ultrasound is currently under evaluation.

While definite specifications for the ultrasound equipment are not stipulated, musculoskeletal ultrasound is a high-resolution technique that warrants up-to-date equipment.

IV. IMAGING PROTOCOLS

Depending on the clinical request and the patient's presentation, the ultrasound examination can involve a full assessment, e.g. a joint, or 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. Clinical indications for each examination will be reviewed but as these continue to expand, a comprehensive or complete list of indications is not possible.

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 employed for a complete assessment. Comparison with the contralateral asymptomatic side may be beneficial.

1. THE SHOULDER

Indications:
Rotator cuff and biceps tendon pathology (including tendonopathy, tear and impingement), arthritis, trauma, soft tissue masses, suprascapular nerve entrapment, effusion and evaluation bursae and acromioclavicular joint.

Technique:
The anatomy and pathology of the shoulder lends itself to a structured ultrasound examination. With the patient in a sitting position (preferably on a revolving chair), the examiner sits or stands in front of or behind the patient.
All tendons are assessed in their short and long axis. The biceps tendon and sheath is assessed in a neutral position with the arm resting on the ipsilateral thigh in supination with transverse and longitudinal views from the proximal aspect of the bicipital groove distally to the musculotendinous junction. A dynamic examination with external and internal rotation and abduction of the shoulder assesses the integrity of the transverse ligament and possible biceps tendon subluxation.
The subscapularis tendon is assessed with the arm in neutral and external rotation.
The supraspinatus tendon should be viewed in full internal rotation and hyperextension with forearm behind the back (Crass position), which places the tendon under stress and hence accentuates tears. Examination with the upper arm extended and the shoulder in a neutral position with the elbow flexed (palm forward against ipsilateral back pocket/modified Crass position) allows for visualization of the supraspinatus tendon immediately adjacent to the biciptal interval, an area often obscured by the acromion in the Crass position.

Where there is limited range of movement, the supraspinatus tendon is examined in as much internal rotation and hyperextension as possible. Tears of the supraspinatus are measured in transverse and long axis, distance from rotator cuff interval and the supraspinatus muscle belly assessed for atrophy/fatty infiltration.
The infraspinatus and teres minor tendons are scanned with the forearm placed across the chest with the palm of the hand placed against the contralateral shoulder or to level mid-forearm. The posterior labrum and spinoglenoid notch are also viewed in this position as well as assessment for joint effusion. The latter is assessed dynamically by maintaining the transducer in the same position while the patient alternates between abduction and adduction of the forearm. The deltoid muscle is assessed with the arm in neutral position.
The short head of the biceps and coracobrachialis tendons are assessed if clinically indicated in the same position as the long head of the biceps.
The acromioclavicular joint, with the arm in neutral position by the patient's side, is assessed in sagittal and coronal planes. If acromioclavicular separation is suspected clinically, attach weights to the patient's wrists with contralateral comparison and perform static and dynamic assessment. The anterior, posterior and axillary recesses should be assessed for joint effusion, synovitis and loose bodies. Joint bursae (subacromial-subdeltoid, subscapularis, infraspinatus, coracoclavicular, subcoracoid and supra-acromial) should be scanned for distension and synovitis. The visible articular cartilage and underlying cortical bone of the humeral head, greater and lesser tuberosities should be assessed for erosions, defects and fractures.

Impingement:
Dynamic assessment of possible subacromial impingement has become an additional component of the shoulder ultrasound examination. The shoulder is abducted in internal rotation with the medial margin transducer placed over the lateral margin of the acromion in a coronal plane. Movements of the supraspinatus tendon and subacromial-subdeltoid bursa are assessed during abduction. The transducer is then placed in a sagittal plane with its posterior margin upon the anterior aspect of the acromion and the arm is then flexed in internal rotation.

2. THE ELBOW

Indications:
Soft tissue injury, tendon pathology (including tendonopathy, enthesopathy and tear), arthritis, loose bodies, soft tissue masses, nerve entrapment, effusion, bone injury.

Technique:
Patient sits on a stool with the arm extended and the hand in supination resting on a table and the examiner sitting in front of the patient. The examination is divided into four quadrants, anterior, medial, lateral and posterior. The examination may be tailored to a specific site pending the clinical presentation.

Anterior:
The anterior joint space is assessed for effusion, synovial proliferation and loose bodies. This also applies to the other recesses of the elbow. Longitudinal and transverse assessment of the integrity visible articular cartilage and cortical bone of the anterior humeroradial, humeroulnar joints, coronoid and radial fossae. The distal biceps and site of insertion is best visualized with the forearm in external rotation and the transducer in a sagittal oblique plane. 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, adjacent radial and brachial vessels and the median and radial nerves complete the anterior scan.

Lateral:
The patient extends the arm and places both palms together. This position allows assessment of the lateral epicondyle and the attachments of the common extensor tendon and 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.

Medial:
The hand is placed in supination and the medial epicondyle common flexor tendon and ulnar collateral ligaments are scanned in both planes.

Posterior:
Palm placed down on the table with the elbow flexed to 90 degrees. The posterior joint space, triceps tendon, olecranon process and olecranon bursa are assessed. The ulnar nerve is visualized between the olecranon process and medial epicondyle. Dynamic examination with flexion and extension of the elbow is performed in the transverse plane to assess for dynamic subluxation of the ulnar nerve.

3. THE WRIST AND HAND

Indications:
Soft tissue injury, tendon pathology (tendonopathy, tenosynovitis, tear), arthritis, soft tissue masses/swelling, nerve entrapment, effusion, bone injury. This examination is usually tailored to the clinical presentation.

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

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, flexor tendons internal and external to the carpal tunnel are evaluated. These tendons can be followed to their site of insertion if clinically indicated. Assessment of the median nerve should include a cross-sectional area and longitudinal contour. Guyon's canal, containing branches of the ulnar nerve and artery with the flexor carpi ulnaris on its medial aspect, is evaluated in the same position.

Medial:
Placing the transducer transversely on the ulnar styloid and moving distally will allow visualization of the triangular fibrocartilage (TFC) in its long axis. The transducer is rotated 90 degrees to view the short axis of the TFC. The meniscus homologue lies distal to the triangular fibrocartilage and the extensor carpi ulnaris tendon and sheath superficially. This tendon should be viewed in supination and pronation to assess potential subluxation.

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 six compartments, which accommodate nine tendons. These are examined transversely initially and then longitudinally in static and dynamic mode with the latter performed with flexion and extension of the fingers. The tendons can be followed to their site of insertion where clinically indicated. Moving the transducer transversely distal to Lister's tubercle identifies the dorsal aspect of the scapholunate ligament. The remaining intercarpal ligaments are not routinely assessed.

Hands and Wrists-Arthritis

A limited study dedicated to joints suspected of involvement by clinical examination.
The joints of the wrist and hand are assessed from the volar and dorsal aspects for synovial proliferation, effusion, articular cartilage integrity, and cortical surface by aligning the transducer perpendicular to the region of interest. Overlying flexor and extensor tendons and sheaths should also be reviewed for tendonitis or tenosynovitis. Doppler interrogation may be beneficial in assessing for hyperemia.

4. THE HIP

A. Adult Hip

Indications:
Soft tissue injury, tendon pathology, arthritis, soft tissue masses/swelling, nerve entrapment, snapping hip syndrome, effusion, bone injury.

Technique:
Depending on the patient's habitus a low frequency transducer may be required to scan the hip. As the spatial resolution decreases with a decrease in the transducer frequency, the highest possible frequency is used. The patient is placed supine with the hips and knees extended. Anterior, posterior, medial and lateral approaches are performed as per clinical indication.

Anterior:
A sagittal oblique plane parallel to the long axis of the femoral neck is used for evaluation of the femoral head and neck and joint effusion. Sagittal plane is used for the labrum, iliopsoas tendon and bursa, femoral vessels

and the sartorius and rectus femoris muscles. The above structures are then scanned in the transverse plane, perpendicular to the original scan plane. When a "snapping hip" is suspected, dynamic scanning is performed over the region of interest employing the same movement that the patient describes as precipitating the complaint. The transducer is usually held in a transverse or an oblique transverse plane. The "snapping hip" is usually related to the iliopsoas tendon as it passes anteriorly over the superior pubic bone or laterally where the iliotibial band passes over the greater trochanter.

Lateral:
In the lateral decubitus position, with the symptomatic side up, axial and longitudinal scans of the greater trochanter and its bursa, the gluteus medius, minimus, maximus and the tensor fascia lata should be performed. The hamstrings are viewed, can also be assessed in the posterior position, in long and short axis from ischial tuberosity origin to site insertion as clinically indicated.

Medial:
The hip is placed in external rotation with 45 degree flexion of the knee (frog-leg position). The distal iliopsoas tendon, due to its oblique course, may be better seen in this position. Scan the adductor muscles in a sagittal oblique plane with transverse images acquired perpendicular to this plane. In addition the pubic bone and symphysis pubis and the distal rectus abdominis should be reviewed.

Posterior:
Patient prone with the legs extended. Transverse and longitudinal views of the glutei, hamstrings and sciatic nerve. The glutei are imaged obliquely from origin to greater trochanter (gluteus medius and minimus) and linea aspera (gluteus maximus). The sciatic nerve is scanned from exit greater sciatic foramen, deep to gluteus maximus and midway between ischial tuberosity and greater trochanter.

B. Prosthetic Hip:

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. Anterior and lateral approaches as described above with measurement of joint effusion at prosthesis-bone junction and assessment greater trochanteric and iliopsoas bursae.

C. Neonatal/pediatric Hip:

Indications:
Developmental dysplasia of the hip (DDH). In the first year of life, the femoral capital epiphyses and acetabulum consist of cartilage, which is readily visualized by ultrasound. Ultrasound is able to assess DDH and monitor the response to treatment. Dynamic ultrasound can also be used during provocative stress testing of the hip. Visualization of the hip is reduced once ossification of the femoral capital epiphyses commences at 6 to 12 months. The pediatric hip may also be assessed for hip pain and for assessment of the irritable hip. In these presentations, the examination is performed as per the adult hip. The following description applies to the examination for DDH only.

Technique:
The neonatal hips may be examined in the coronal and transverse views with the hips in a neutral or flexed position. At a minimum, the study should include 2 orthogonal views including a provocative stress test (coronal neutral and transverse flexed without and with stress). The morphology of the joint is best assessed at rest. Measurement of the alpha and beta angles is not regarded as mandatory but may be helpful in assuring that the appropriate landmarks are included, in classifying the DDH and in quantifying the response to treatment. The examination is usually done with the patient supine. Alternatively, the neonate can lie on their side. Restraining devices and sedation are generally not required. Parental help in distracting the neonate may be helpful in reducing movement.

The coronal view can be undertaken in neutral or flexion. In the neutral coronal view, the hip is in a relaxed position usually at about 15 degrees of flexion. The transducer is placed along the lateral side of the hip in a minimally oblique coronal plane so that the iliac bone forms a straight line superior to the mid portion of the acetabulum. In the coronal flexed view, the position of the transducer is fixed with respect to the iliac bone and acetabulum while the hip is flexed from the neutral position to 90 degrees. The transducer is then moved to optimize visualization of the hip joint. The coronal view assesses the position of the femoral capital epiphysis with respect to the acetabulum and the morphology of the acetabulum as well as the labrum. In the older neonate, the extent and symmetry or asymmetry of ossification of the femoral capital epiphyses can be determined.

The transverse view can also be undertaken with the hip in a neutral or flexed position, although generally the flexed position is preferred. The transducer is placed in the axial or transverse plane along the lateral aspect of the hip joint. The transducer is then moved so that it is centered over the hip joint and moved cephalad and caudad to assess the joint. In the coronal flexed view, a U-shaped configuration consisting of the iliac bone medially, the acetabulum posteriorly and the metaphysis of the femur laterally surrounds the femoral capital epiphysis. The relationship of the femoral capital epiphysis to the acetabulum is determined.

The provocative stress test is best undertaken with the hip in the transverse flexed position. The hip is flexed to 90 degrees and with maximum adduction applied; the hip is subjected to gentle posterior stress. This constitutes the ultrasound equivalent of the Barlow test. In the normal hip, the femoral capital epiphysis will remain normally seated within the acetabulum, while in DDH variable subluxation or dislocation will be visualized. The converse of this stress test involves abduction of the dislocated hip, which may result in reduction. This is the ultrasound equivalent of the Ortlani test. Unless specifically requested by the consultant orthopedic surgeon, stress tests are not undertaken when the patient is undergoing treatment for DDH.

5. THE KNEE

Indications:
Soft tissue injury, tendon and collateral ligament pathology, arthritis, soft tissue masses/swelling, loose intra-articular bodies, effusion, bone injury.

Technique:
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 undertaken.

Anterior:
The patient is supine with knee flexed to 30 degrees. Longitudinal and transverse scan of the quadriceps and patellar tendons, patellar retinacula and suprapatellar recess. If clinically indicated the patella is also scanned to assess for an occult injury. The distal anterior femoral articular cartilage is assessed at 90 degrees of flexion and dynamically to 30 degrees. The prepatellar, superficial and deep infrapatellar bursae are also evaluated with care not to apply excessive compression with the transducer that would compress and mask an effusion in the bursae. 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. At present, ultrasound does not provide an accurate and reliable assessment of either the anterior or posterior cruciate ligaments and MRI is advised when cruciate ligament tears or pathology are suspected.

Medial:
The patient remains supine with slight flexion of the knee and hip with external rotation of the hip or the patient may be placed in the lateral decubitus position. Both medial and lateral aspects joint can also be assessed in full extension. The medial collateral ligament, pes anserine tendons and its 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. An accurate and reliable assessment of the menisci cannot be undertaken by ultrasound at this time but meniscal cysts are often well demonstrated. If a meniscal pathology is suspected either clinically or by ultrasound, further imaging with MRI is advised. Finally the medial joint space is examined for maintenance height, articular cartilage and cortical bone.

Lateral:
Patient 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 as well as the lateral joint space. The lateral patellar retinaculum can also be assessed as well as in the anterior position and the anterior horn and body of the lateral meniscus but with the limitations as noted above for the medial meniscus.

Posterior:
The patient lies prone with the leg extended. The popliteal fossa, semimembranosis, medial and lateral gastronemius muscles, tendons and bursae are assessed. 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 but MRI is advised when cruciate ligament tears or pathology are suspected

6. THE ANKLE AND FOOT

Indications:
Soft tissue injury, tendon and ligament pathology, arthritis, soft tissue masses/swelling, loose intra-articular bodies, effusion, bone injury, Morton's neuroma (plantar foot).

Technique:
Ultrasound examination of the ankle is divided into four quadrants (anterior, medial, lateral and posterior) and is usually tailored to the clinical presentation. Examination of the foot is also limited to the clinical presentation (for example assessment of joints for synovitis, plantar fascia for fasciitis).

Anterior:
The patient lies supine with knee flexed and the plantar aspect foot flat on table. The anterior tendons are assessed in longitudinal and axial planes from musculotendinous junctions to site of insertion distally. This includes the tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius tendons from medial to lateral. The distal interosseous membrane between tibia and fibula is assessed for integrity. The anterior joint recess and capsule are scanned for effusion, loose bodies and synovial thickening. The anterior tibiofibular ligament is assessed moving the transducer in transverse plane distally over the distal tibia and fibula, superior and medial to the lateral malleolus.

Medial:
The patient maintains the same position as the anterior examination. The supra-and inframalleolar posterior tibial, flexor digitorum longus and flexor hallucis longus tendons, anterior to posterior, are first scanned transversely proximal to the medial malleolus to identify each tendon. They are assessed in longitudinal and axial planes from musculotendinous junctions to site of insertion distally. Continuous adjustment of the angulation of the transducer to remain perpendicular to the tendons as they curve under the medial malleous must be made to avoid anisotropy. The same holds true when assessing the lateral malleolus and related tendons. The tibial nerve can be scanned by identifying it between the latter two tendons at the level of the malleolus and 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 not always clearly defined, is scanned longitudinally from its attachment on the medial malleolus to the navicula, talus and calcaneus.

Lateral:
Patient supine with knee flexed and the plantar aspect foot on table with slight inversion. The peroneus brevis and longus tendons are identified proximal to the lateral malleolus on transverse scan and they can then be assessed in longitudinal and axial planes from musculotendinous junctions to site of insertion distally. The peroneus longus tendon can be followed in this manner to the cuboid groove where it courses medially along the planter aspect of the foot to insert on the base of the first metatarsal. This latter aspect of the tendon can be scanned as in the plantar position, as described in the posterior position. The peroneal tendons are also assessed for subluxation by simultaneously dorsiflexing and everting the ankle. The lateral ligament complex (anterior and posterior talofibular and calcaneofibular ligaments) are examined by placing the transducer on the tip of the lateral malleous in the following orientations: anterior and posterior horizontal oblique and posterior vertical oblique respectively. The calcaneofibular ligament can be better demonstrated with dorsal hyperextension while applying resistance with a hand on the dorsum of the foot.

Posterior:
Patient prone with feet over end of table. The Achilles tendon is scanned in longitudinal and axial planes from musculotendinous junctions (medial, lateral gastronemius and soleus muscles) to site of insertion on the posterior surface of the calcaneus, and antero-posterior diameter is assessed. Dynamic scanning with plantar and dorsiflexing may aid in the evaluation of partial tears. In cases of severe or complete tear, gentle compression of the calf muscle with one hand will generate proximal tendon motion while the site of the tear is being scanned with the other hand. The plantaris tendon lies along the medial aspect of the Achilles tendon to insert on the posteromedial calcaneus. It should be noted that this tendon may be absent as a normal variant. The retrocalcaneal bursa and Kager's fat pad are also assessed.
The plantar fascia is scanned in the same position or alternatively with the patient lying supine with toes vertical. Longitudinal and transverse assessment from its proximal origin on the medial calcaneal tubercle distally to where it divides distally and merges into the soft tissues. A measurement of antero-posterior diameter should be included. When assessing a tear, dynamic scanning of the fascia can be performed as the greater toe is being flexed dorsally as this maneuver will stretch the fascia.

Interdigital:
Patient supine with foot 90 degrees to ankle. Either 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 the examiner on the dorsal surface applies digital pressure. The transducer is moved laterally with its center at the level of the metatarsal heads. The process is repeated for the remaining interspaces and repeated transversely. When a Morton's neuroma is clinically suspected pressure can be applied to elicit the patient's

symptoms. Dynamic scanning, by squeezing the metatarsal heads together with the non-imaging hand, will bring the neuroma out of the intermetatarsal space, sometimes with a click (Mulder sign), and closer to the transducer. The intermetatarsal bursa lies on the dorsal aspect of the interdigital nerve and care must be taken to correctly identify a neuroma.

7. PERIPHERAL NERVES

Nerves have a fascicular pattern with hypoechoic longitudinal neuronal fascicles interspersed with hyperechoic interfascicular epineurium. In addition they have a hyperechoic superficial epineurium. As a nerve bifurcates each fascicle enters only one of the subdivisions without splitting. They course adjacent to vessels and are readily distinguished from the surrounding tendons on dynamic examination where the nerve demonstrates little movement and is less prone to anisotropy artifact. They may become more hypoechoic as they pass through fibro-osseous tunnels as the fascicles become more compact. Examination in the transverse plane is usually preferred to assess the course of the nerve, as it may be difficult to separate from the surrounding tendons and muscles on longitudinal scan. Assessment at the level of fibro-osseous tunnels requires dynamic examination. A dislocated nerve is readily identifiable on ultrasound but an intermittently subluxing nerve requires dynamic examination e.g. ulnar nerve within the cubital tunnel (see posterior elbow examination). Entrapment neuropathies also typically occur within fibro-osseous tunnels e.g. cubital and Guyon tunnels for the ulnar nerve, the common peroneal nerve at the fibular neck and the tarsal tunnel for the tibial nerve. In addition congenital abnormalities, e.g. accessory muscles or vessels, size of tunnel can be assessed. Adjacent pathology of tendons, soft tissues and bone can be readily evaluated on ultrasound. The nerve is assessed for focal or diffuse swelling or attenuation. Measurements should include diameter, cross-sectional area and AP/Width ratio.

8. SOFT TISSUE MASS

The mass should be scanned in both longitudinal and transverse planes. Ultrasound is an excellent method for differentiating solid from cystic masses. Measurement of its size and relationship to surrounding structures, particularly joints, neurovascular bundles and tendons, should be assessed as well as compressibility of the lesion. Color or Power Doppler evaluation is undertaken to delineate intra- and extralesional vessels and vascularity of the mass. Refer to interventional section in cases requiring biopsy.

9. INTERVENTIONAL MUSCULOSKELETAL ULTRASOUND

Indications:
Aspiration of cysts, fluid collections and abscesses, arthrocentesis, insertion of drainage catheters, ultrasound guided biopsy, medicinal injections, intra-articular injection of contrast (prior to CT or MRI), treatment of tendon calcifications and foreign body retrieval.
Ultrasound is an ideal modality for image guidance of interventional procedures within the musculoskeletal system. The usual standards for interventional procedures apply i.e. review prior imaging, written consent, local anaesthetic, sterile conditions, and avoidance of relative and absolute contra-indications. Ultrasound provides direct visualisation of the needle, monitors the pathway and shows the position of the needle within the target area, avoiding significant intra and extra-lesional vessels. Prior to any procedure a thorough ultrasound examination to characterise the target area and its relationship to surrounding structures is performed. Colour or Power Doppler is required to delineate any vessels within the target zone. The needle can be attached directly to the transducer or held freehand and should be visualised throughout the procedure. The transducer is aligned in the same longitudinal plane as the needle. Slight to and fro movement or injection of a small amount of sterile saline or air may be beneficial in visualizing the needle. Power Doppler may improve visualistion of the needle.

In cases of biopsy focal areas of vascularity indicate viable tissue for pathological examination. The shortest pathway to the region of interest is then selected. Biopsy of any soft tissue masses, which may be malignant, should not be biopsied without prior oncological surgical review. In addition further imaging with MRI is usually required. Biopsy should then be completed within the surgical area of resection, through the shortest path and number of tissues. Discussion with the local pathologist and oncological surgeon is beneficial in deciding to perform fine needle aspiration or core needle biopsy.

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