Musculoskeletal Mimickers of entrapment neuropathies: an integrated clinical, electromyographic, and sonographic approach to the correct diagnosis

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Key Practice Points:
• Upper limb entrapment neuropathies can present clinically similar to various musculoskeletal conditions.
• History, physical examination, and electrodiagnostic studies alone do not always accurately identify the correct diagnosis.
• The practitioner’s ability to employ a combination of neuromuscular and musculoskeletal ultrasound can be a powerful adjuvant to clinical and electrodiagnostic data in attaining the correct diagnosis and identifying extrinsic causes of entrapment or completely separate pathology.

Introduction
Musculoskeletal Ultrasound (MSK US) and Neuromuscular Ultrasound (NM US) are emerging fields based upon the use of high frequency sound waves to image musculoskeletal and neuromuscular structures. Ultrasound is superior at providing high resolution images of muscles, joints, ligaments, tendons and even nerves when compared to other imaging modalities, however, the field of image is small. This makes it an ideal imaging modality for characterizing entrapment neuropathies in osteofibrous tunnels. However, a disservice to the patient could be done when performing a sonographic evaluation of entrapment neuropathies without including a patient’s muscle, tendon, and bone “neighbors.” Thus, it is important to follow a systematic scanning protocol that fully evaluates surrounding structures. Such a protocol is beyond the scope of the text, but available in several print and online resources for the novice sonographer.

General Pathological Concepts
Several pathologies can be identified via ultrasound, which are summarized elsewhere. Most prominent are tendon tears and tendonosis. Other pathologies such as arthritis, ligamentous tears, and bursitis are also amenable to diagnosis via musculoskeletal ultrasound. While generally ultrasound is not a good modality for imaging of bones and the interior of joints, occasionally boney defects can be imaged such as the stress fracture visualized in a runner below.
Sonographic Differential of Median Neuropathy at the Wrist

Median neuropathy at the wrist is the most common entrapment neuropathy in the upper limb and is almost always secondary to compression in the carpal tunnel. The clinical manifestation of median neuropathy is known as Carpal Tunnel Syndrome (CTS). The syndrome almost always includes pain and is associated with parasthesias. There is often numbness in a median nerve distribution including the first, second, and third digits along with the radial half of the fourth digit with sparing of the thenar eminence. There may be weakness with thumb opposition and abduction. If severe enough, there will be atrophy of the thenar eminence.

Sonographic findings seen with carpal tunnel syndrome include decreased nerve movement in the sagittal and transverse view, decreased nerve echogenicity, increased nerve vascularity, increased nerve cross-sectional area, and bowing of the flexor retinaculum with pinching of the median nerve.

Musculoskeletal conditions involving the wrist or thumb can mimic median neuropathy at the wrist and can also be a specific cause of it. In the setting of acute CTS symptoms, consideration for a scaphoid fracture should be given with trauma and tenderness in the anatomic snuff box. If a fracture is present and extends to the bony cortex, it can be visualized as a focal, step-off deformity. Other associated findings include hyperemia, adjacent hypoechoic soft tissue swelling and point tenderness with transducer pressure.

Another musculoskeletal mimicker in the setting of trauma is scapholunate dissociation since the scaphoid and lunate bones form the posterior portion of the carpal tunnel. This presents with wrist pain and symptoms of instability such as slipping and snapping. Sonographic evaluation is performed in the transverse position and has been previously described. The scapholunate ligament is located by scanning between the scaphoid and lunate and moving the probe transversely toward the triquetrum. It is normally hyperechoic with a fibrillar echotexture. The scapholunate ligament will appear hypoechoic and thickened if partially torn and will be replaced by anechoic fluid and hypoechoic synovitis if completely torn. Dynamic ultrasound is utilized in this setting by having the patient make a clenched fist which may reveal abnormal widening of the scapholunate space.
Common tendon overuse syndromes that should be considered in the differential of CTS include de Quervain's tenosynovitis, intersection syndrome, and flexor carpi radialis (FCR) tenosynovitis. Sonographic evaluation of tendons should be conducted in transverse and longitudinal planes and by scanning from proximal to distal. De Quervain's involves inflammatory thickening of the sheath surrounding the first compartment extensor tendons at the wrist, the abductor pollicus longus, and extensor pollicus brevis. It presents with pain and swelling over the radial styloid. This can be provoked with the Finkelstein test by having the patient make a fist with the thumb inside the fingers and pushing the fist into ulnar deviation. The tendons are located over the lateral surface of the distal radius tip. On sonographic evaluation there will be anechoic thickening of the sheath around the tendons that is non-compressible. There may also be hyperemia, tendinosis, and cortical irregularity of the radius. Intersection syndrome is a tenosynovitis of the second compartment extensor tendons, extensor carpi radialis brevis, and longus. Pain will be more dorsal and slightly more proximal than with de Quervain's and can be provoked by resisted wrist extension in a radial direction. The second compartment tendons can be located ulnar to the first compartment extensor tendons and radial to Lister's tubercle. Sonographic findings will be the same as those seen with de Quervain's tenosynovitis. Flexor carpi radialis tenosynovitis will present with pain on the radial aspect of the volar wrist and this can be provoked with resisted wrist flexion in the radial direction. This is a large tendon that is positioned just radial to the median nerve but is outside the carpal tunnel. The radial artery and veins are just radial to the FCR tendon. Sonographic findings will be those of tenosynovitis as listed previously. Typical appearance of tenosynovitis shown below. On the left image is the pronounced Doppler flow associated with first compartment tenosynovitis. On the right image, the fluid filled tendon sheath is visualized. To the right of the tendon is the hypoechoic radial artery and to the left is a needle tip. The patient had an excellent response to this corticosteroid injection.

Arthritic conditions should be considered in the older population and those with history of remote trauma to the wrist. Carpal metacarpal (CMC) joint arthritis is fairly common and presents as pain at the base of thumb. The CMC grind test can be performed by grasping the metacarpal base and rotating the CMC joint which will reproduce the patient's typical pain. The CMC joint relocation test can be performed by placing dorsal pressure on the thumb metacarpal and relocating the joint which will also reproduce pain. The joint is evaluated in the longitudinal view. The joint may be distended with anechoic fluid. It is important to characterize the fluid since synovitis represents an inflammatory condition that requires further diagnostic
workup to prevent poor outcomes. If the fluid is not anechoic then it should be evaluate for synovitis which is non-compressible and will have flow on color Doppler imaging. One may also find irregularity of the bone cortex under cartilage surfaces which represents erosions. There are multiple synovial joints in the wrist and hand. The distal radioulnar joint can be assessed in the transverse plane and the digit joints and the radiocarpal joints in the longitudinal pain.

**Sonographic Differential of Ulnar Neuropathy at the Wrist**

Ulnar neuropathy at the wrist (UNW) typically occurs at Guyon’s canal. Nerve compression is usually caused by a space-occupying lesion such as a lipoma, ganglion, ulnar artery aneurysm, muscle anomaly, or is from repetitive trauma to the base of the wrist such as occurs from prolonged cycling.

UNW is typically a painless syndrome so the sonographic musculoskeletal differential is narrow. If ulnar-sided wrist pain is present, it is important to evaluate for flexor carpi ulnaris tenosynovitis. Pain can be provoked with resisted wrist flexion in ulnar deviation. The tendon can be identified by scanning proximal to the pisiform bone and evaluating for signs of tenosynovitis. The ulnar-sided carpal joints should be evaluated for arthritis. A large part of the differential for UNW is other neurologic lesions and includes radiculopathy, polyneuropathy, ulnar nerve entrapment at the elbow, motor neuron disease and thoracic outlet syndrome and is best evaluated always in conjunction with electodiagnostics. For the advanced sonographer, the triangular fiburocartilidginous complex can be evaluated.

**Sonographic Differential of Median Neuropathy Proximal to the Wrist**

Median neuropathy proximal to the carpal tunnel is rare in the general population and is not straightforward since multiple sites of entrapment have been described. The most common syndrome encountered is the pronator syndrome. It presents as insidious onset of volar forearm pain that is related to repetitive arm pronation and wrist flexion.

The approach to median neuropathy at the elbow used in our laboratory is to follow the median nerve from the antecubital fossa where it lies medial to the biceps tendon throughout its course distally to the carpal tunnel. The nerve is evaluated in transverse and longitudinal views while searching for decreased nerve echogenicity and enlargement which would suggest a focal entrapment.

The most proximal site is known as the ligament of Struthers. In a small number of individuals, there is a bony spur on the shaft of the humerus that is just proximal to the medial epicondyle. The ligament stretches from the spur to the epicondyle and the median nerve can become entrapped underneath. Entrapment at this site does not produce pronator syndrome, rather it involves all median innervated muscle. Among many entrapment syndromes, a musculoskeletal etiology includes pronator hypertrophy, fibrous bands within the muscle or an anomalous course of the nerve such a piercing the humeral head of the muscle.

It is important to evaluate anterior elbow structures with MSK US to rule out musculoskeletal mimickers. Distal biceps tear or partial tear should be ruled out. The biceps tendon lies superficial to the brachialis muscle and dives deep in an oblique course to insert on the radial tuberosity. The biceps tendon presents technical challenges for imaging which require creative ultrasound windows to avoid false positive results. A partial tear will appear as an anechoic focal region with loss of the normal tendon fibrillar
pattern. Dynamic ultrasound can be employed to increase the gapping of a tear by having the patient flex the elbow or by the operant passively extending the elbow.

**Sonographic Differential of Ulnar Neuropathy Proximal to the Wrist**

Ulnar neuropathy at the elbow (UNE) is the second most common entrapment neuropathy in the upper extremity. The clinical presentation is similar to that as UNW except that there will also be sensory disturbance of the medial hand and pain may localize to the medial elbow and radiate down. Occasionally ganglia or osteophytes can be discovered as causes of entrapment. Below is a patient who had a UNE caused by an osteophyte at the elbow. Swelling of the nerve is noted in the regions adjacent to the spur.

![Ulnar Neuropathy Image](image)

Dynamic ultrasound can be used during elbow flexion to demonstrate ulnar nerve subluxation out of the ulnar groove.

There are two major musculoskeletal conditions that present similar to UNE or occur in conjunction with it. Medial epicondylitis, also known as golfer’s elbow, presents with medial elbow pain which is provoked with activities that require repeated wrist flexion (tendonosis). This can be evaluated by placing the transducer longitudinally over the medial epicondyle of the humerus and evaluate the insertion of the common flexor tendon for findings of tendonitis. Slightly distal to this is the trochlea of the humerus which articulates with the ulna. Here, the ulnar collateral ligament can be evaluated which is another important mimicker. It lies deep to the flexor tendon and musculature and extends from the epicondyle, over the joint space and inserts onto the ulna. It should be evaluated for a partial or complete tear. The transducer must stay perpendicular to the ligament to avoid the effects of anisotropy which will appear like a hypoechoic tear. Olecranon bursitis is another musculoskeletal condition in the differential for UNE. As with all bursa pathology, a compressible fluid collection is noted which is tender to sonopalpation. Below is the sonographic appearance of an olecranon bursitis with the hypoechoic “sliver” overlaying the hyperechoic tendon.
Dynamic varus elbow stress can be applied to further evaluate for medial collateral ligament injury and to evaluate for abnormal widening of the joint space. Normal values for major league pitchers have been evaluated in the Philadelphia Phillies. In the first author’s opinion, this pioneering research opened the door for superlative performed in this major league team (as well as the riots that followed the championship).

Sonographic Differential of Radial Neuropathy

There are a few known radial nerve entrapment and compression sites but the one most commonly confused with a musculoskeletal condition is posterior interosseous neuropathy (PIN). The patient will present with some weakness of wrist extension with the wrist in a radial-deviation because of involvement of the extensor carpi ulnaris muscle and sparing of the extensor carpi radialis. There will also be weakness of finger extension. There may be pain in the forearm because the posterior interosseous nerve supplies the forearm interosseous membrane and joint capsules. If there is sensory loss in a radial distribution or weakness of elbow extension or elbow flexion, then a more proximal radial nerve lesion should be considered. Comparison of muscle bulk with the contralateral side will demonstrate atrophy of the muscle. Sonographic evaluation will often demonstrate pain with transducer pressure.

The PIN syndrome is most commonly misdiagnosed as lateral epicondylitis, also known as tennis elbow, which is exceedingly more common. This is typically an overuse condition consisting of tendinosis and possible tendon tears of the wrist extensor tendons which insert into the lateral epicondyle. The extensor carpi radialis brevis component is the most commonly affected. The transducer is placed in a longitudinal view over the lateral elbow. The radial head can be identified by seeing hyperechoic shadowing. As the transducer is moved proximally, the radial head’s articulation with the capitellum of the humerus can be seen. Slightly proximal to the capitellum is a flattened contour which is the lateral epicondyle which is where the common extensor tendon inserts. Tendinosis will appear as hypoechoic swelling of the tendon with adjacent bone irregularity. Calcifications may be seen within the tendon and it may be hyperemic on color Doppler imaging. A tendon tear will be visualized as anechoic clefts within the tendon that may increase in size during dynamic imaging of resisted wrist extension. Below is a patient who presented to our electrodiagnostic laboratory with arm pain and was found to have a tendon tear which is displayed below in both short and long axis.
Sonographic Differential of Suprascapular Neuropathy

The suprascapular nerve branches directly off the upper trunk of the brachial plexus and has contributions from the C5 and C6 nerve roots. It innervates the supraspinatus and infraspinatus muscles in that order and carries pain sensation from the glenohumeral and acromioclavicular joint. Suprascapular neuropathy presents as a deep achy pain along the superior aspect of the scapula radiating to the shoulder. The pain is exacerbated with shoulder movements such as arm extension and adduction which increases tethering of the nerve. There will be weakness of the supraspinatus muscle which is a shoulder abductor and of the infraspinatus muscle which is a shoulder external rotator. There may be frank atrophy of these muscles as seen over the supraspinatus and infraspinatus fossa, respectively. The fossa are separated by the spine of the scapula. There is no numbness associated with this neuropathy because the nerve carries no cutaneous sensory nerve fibers.

Ultrasonographic evaluation of the nerve has been described. It enters the supraspinatus fossa by passing through the suprascapular notch on the superior lateral portion of the scapula which is formed by the bridging transverse scapular ligament. The nerve can be identified with the transducer in a longitudinal view of the supraspinatous muscle. A cross-sectional view of the nerve will be visualized lying deep to the muscle. A mean cross-sectional area of the supraspinatous nerve has not been reported, Doppler can identify the suprascapular artery which is adjacent to it. The nerve can then be followed to the spinoglenoid notch in the spine of the scapula, where it passes to innervate the infraspinatus muscle. It is important to evaluate for a ganglion cyst or space occupying mass in this location. If on clinical exam there is only weakness and atrophy of the infraspinatus with sparing of the supraspinatus, then the nerve lesion is likely occurring at the spinoglenoid notch.

Suprascapular neuropathy is exceedingly rare and is most likely to be clinically misdiagnosed as a rotator cuff tear (RTC) or tendinosis. In clinical practice, tendon tears and tendonopathies exist on a continuum from mild tendonotic changes to complete tendon tear and can have very similar appearances. One example is shown below. Note the cortical irregularity seen on the left shoulder compared to the right.
The supraspinatus tendon is most commonly involved but the infraspinatus can be as well. With complete tears there will be weakness, pain and muscle atrophy presenting very clinically to suprascapular neuropathy. However, the patient may report a history of pain and catching with overhead activities. The suprascapular tendon pathology is typically seen proximal to its insertion into the anterior and middle facets of the greater tuberosity of the humerus. The tendon is best visualized with the patient in the modified Crass position which is with the arm extended, elbow flexed and the subject's hand in their back pocket. Partial thickness tears of the tendon may be seen as hypoechoic clefts along the articular surface or they may be seen superiorly along the bursal surface of the tendon. There may be cortical irregularity over the greater tuberosity. A complete tear will be visualized as an anechoic area with retraction of the tendon. Tendinosis will be visualized as tendon swelling and the tendon may appear hypoechoic. There may be intrasubstance heterogeneous abnormality of the tendon which may represent a precursor to a tear. The infraspinatus tendon should also be evaluated for tendinosis or tendon tear. The subject should have the affected arm placed across their chest with their hand over the contralateral shoulder. The infraspinatus lies on the inferior side of the spine of the scapula and inserts into the middle facet of the greater tuberosity of the humerus.

Radiculopathy
A limitation to ultrasound is the evaluation of radiculopathy. Various musculoskeletal disorders and peripheral nerve entrapments syndromes in the upper extremities can clinically present similar to cervical radiculopathy. In the case of radiculopathy, one will almost always have associated neck pain that radiates down the arm. The Spurling’s maneuver may be helpful in provoking the radicular pain in the arm. Diminished reflex representing the nerve root involved can help differentiate radiculopathy from a musculoskeletal disorder but may not be helpful in distinguishing it from a peripheral neuropathy. Paresthesias are less helpful on clinical grounds because they are known to occur with various myofascial syndromes. A well-demarcated distribution of sensory loss will most likely be the result of a peripheral
neuropathy. It takes a very knowledgeable practitioner to decipher if a vague distribution of sensory loss is in the distribution of a peripheral nerve or represents a single nerve root dermatome.

Further complicating the picture is that the "sclerotomes" of joints can also refer pain to their distribution. In one interesting study, treatment of shoulder pathology actually improved sensory function in the arm and hand in patients with shoulder pathology and “radicular” neurological deficits.12

Summary

In closing, ultrasound is a strong complement to clinical findings and electrodiagnostic studies in order to localize etiologies of pain and weakness whether they are problems with joint, muscle, tendon, or nerve. However, it is important to keep in mind that ultrasound is very operator dependent and a significant investment of time and training is needed for a provider to achieve the diagnostic potential of this tool.


7. ESSR European Society of Musculoskeletal Radiology. 


