Perspective
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Musculoskeletal ultrasound a practical perspective

Abstract

This article is designed for the busy medical practitioner and will provide a new perspective for the utilization of Musculoskeletal (MSK) ultrasound. This article is not another MSK Ultrasound vs. MRI comparison. Both MRI and MSK Ultrasound are important diagnostic tools with each having its own distinct and individual value. Comparing the two technologies is like comparing a knife to a fork. They both have a place in the kitchen but are clearly used for different purposes. This article will provide as an overview, the practical applications of MSK Ultrasound from our first-hand perspective as clinicians who use and depend on MSK Ultrasound every day in a busy pain management clinic.

A detailed explanation of each diagnostic application is beyond the scope of this article. However, you will very quickly see that MSK Ultrasound has the capacity of providing clear, concise and conclusive diagnostic information, with no contraindications and at a low cost. Having this level of diagnostic clarity early in your treatment enables you to streamline your options and keep more of your patient care "in-house". Also, in addition to improved diagnostic efficiency, MSK Ultrasound Is easy to cost justify because the procedures are covered by 3rd party insurance companies.

Let's begin exploring MSK Ultrasound.

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What is diagnostic ultrasound?

Ultrasound (US) or Sonography involves the sending of sound waves into the body that are reflected off of internal organs and tissue structures. The sound waves are transmitted and received by a "transducer" or "probe". The returning reflections are converted into images that are visualized on a monitor through advanced computer automation. A standard two-dimensional (2D), B mode, linear array ultrasound probe is used for musculoskeletal ultrasound testing. The probe operates at frequencies high above the hearing capability or heat creation range. The common frequency range for MSK Ultrasound is generally between 5-15MHz (a hertz* represents 1 million cycles per second, so when we say working within a frequency range of 5-15megahertz we are using shorthand meaning that it operates at 5-15million cycles per second). The lower frequency numbers (2-7 MHz) are used for deeper structures and higher frequency numbers (8-15 MHz) are for more superficial structure observation.

*This term honors the famous German physicist named "Hertz"

A brief history of ultrasound and MSK ultrasound

The history of ultrasound technology dates back to 1912 when Lewis Fry Richardson in England patented two mechanisms for obstacle avoidance as a response to the sinking of the Titanic. With the outbreak of World War 1 in 1914 and the menace of the submarine new attention was focused on ultrasound as a way to detect objects underwater.

Ultrasound's value in medicine was first realized in the late 1940's. Since that time there has been a steady advancement in its use. Over the years the process has been spurred by improvements in technology that have enabled ultrasound systems to obtain increasingly clear and now exquisite anatomical detail and images displayed in 3 or 4 Dimension.

The use of ultrasound for musculoskeletal diagnosis dates back to the very inception of ultrasound use in medicine. MSK Ultrasound technology was first commercially introduced in the United States in 1977 where Dr. Jon Jacobson[1] showed rotator cuff abnormalities with ultrasound at an exhibit at the annual convention of the American Institute of Ultrasound in Medicine (AIUM) in Dallas, Texas. Over the past 40 year's instrumentation, probe technology and computer science has advanced to the point where muscles, tendons, ligaments, fluids and nerves can be clearly visualized.[2]

It is important to note early on that the major "caveat" of MSK Ultrasound, is its high operator dependence. In learning to be proficient in performing MSK Ultrasound, the more one knows about anatomy and physiology the shorter the learning cycle.

Benefits of MSK ultrasound testing

MSK ultrasonography is non-invasive, does not use ionizing radiation (X-Ray) and has no known or reported risk. It can be done quickly, with little discomfort to the patient, and has the capacity for bi-lateral imaging making comparison with the asymptomatic, contralateral limb possible. In most cases it is much less expensive than other imaging studies.[3] MSK ultrasonography is the ideal modality for the examination of soft tissue because of its multiplanar and real-time capabilities. MSK Sonography yields anatomic information during active and passive mobilization (motion) that is unattainable with other modalities. In addition, synovial and cartilage thickness can be accurately quantitated, providing an objective means of following patients with inflammatory arthritides. Ultrasound examination of deep-seated joints such as the hip and shoulder is especially valuable. Joint effusions, loose bodies, tendonitis, tendon and muscle ruptures

can all be demonstrated with MSK Ultrasound. The non-invasive nature of the examination and lack of ionizing radiation make it very well accepted by patients, especially children.[4]

Important considerations

Because MSK Ultrasound works in real time, traditional "needle procedures" such as joint aspiration, infiltration and biopsy can be guided with sonography once an abnormality is detected. Because sonography measures motion, a dynamic examination may detect abnormalities that are present only with joint positioning. For example, when evaluating the biceps brachii long head tendon for subluxation MSK Ultrasound allows for evaluation in the neutral position and during external rotation. This view is important as transient medial subluxation of the long head of the biceps brachii tendon may occur only in this position.[5] Imagine a patient who presents with transient shoulder pain. Your clinical examination reveals nothing obvious in a neutral position; however, upon external rotation with MSK Ultrasound you will watch the tendon sublux from its position in the bicipital groove.

Another abnormality that may be better identified by MSK Ultrasound than by other imaging options is calcium hydroxyapatite crystal deposition or calcific tendonitis. Because calcifications, like tendons, appear as a low signal on MRI images, their intratendinous presence may go unrecognized.[6]

The aging population

It is our experience, having many "seasoned citizens" as patients that a different set of circumstances exist for the physician treating that category of patient. Many older patients have never been to a doctor for anything more than cold or flu symptoms. Now as they age, things start to hurt. How about the aching shoulder from a football injury that occurred more than forty years ago? Or the knees or elbows that hurt and is swollen? Hand and wrist pain because of hours spent on the home computer or from job related stress over many years. On the other side of the coin, the older patient may have a history, because of bad genetic luck, of extensive medical treatment for complications of diabetes, heart and lung diseases, joint replacements, surgical procedures, etc. As a result many of these patients have been exposed to large amounts of ionizing radiation from x-rays. Possibly their spines are rigid and they cannot remain in a supine position for any long period of time. How about implanted devices such as pacemakers, defibrillators or other life saving devices? What about total joint replacements or patients that are simply claustrophobic?

The good news is that for all of those special patients MSK Ultrasound is the perfect diagnostic tool as it has no contraindications to its use, does not use Ionizing radiation and can be performed with a patient sitting comfortably in a chair. Probably the best part from your patient's perspective is that they don't have to make appointments to get a diagnostic study and again with your office to learn the results. Everything is performed in your office. Establishing a treatment program for a now clearly identified condition can begin immediately.

Important numbers that should guide your thinking

It is important to note that as the population ages there will be increasing numbers of patients who will present with joint pain symptoms. Many of these patients may not have had any significant past joint pain problems. Statistically, 80% of healthcare is consumed in the last 20% of life. It is estimated that 30% of the population (almost 100 million people) will be over the age of 65 in the next few years. Forward thinking doctors are accepting the reality of those numbers and adjusting their practices to care for those patients. Having MSK Ultrasound in your practice for that group is essential for all of the previously stated reasons.

MSK ultrasound evaluation of the major joints—basic introduction

Shoulder

MSK Ultrasound of the shoulder, particularly of the rotator cuff is one of the most common examinations performed today. Third only to low back pain and carpal tunnel syndrome, shoulder pain is extremely common, especially in patients over the age of 40. Ease of access to the shoulder joint allows for the investigation of many disorders and specific applications, including:

A. Rotator cuff tears (both partial and full thickness)
B. Calcific Tendinitis
C. Joint effusions
D. Biceps tendonitis or tenosynovitis
E. Biceps Tendon Tears and/or Ruptures
F. Arthritis/bursitis
G. Fracture/labral tear
H. Dislocation (Subluxation) of the Biceps Tendon
I. Subdeltoid-subacromial bursitis
J. Gleno-humeral joint effusion
K. Impingement Syndrome
L. Fractures (Hill-Sachs Deformity)
M. Needle Guidance

Patients suffering from rotator cuff disease typically complain of a dull, chronic ache in their shoulder, which prevents them from raising their arm (i.e. performing actions like combing their hair), or an inability to raise their arm above their shoulder. Many patients have difficulty sleeping on the affected side. While relatively uncommon before the age of 30, rotator cuff tears become increasingly common with age and are present in the majority of the population over the age of 70.

Elbow

MSK Ultrasound examination of the elbow is often directed more by patient symptoms (i.e. persistent pain and swelling) than by scanning normal structures from a routine scanning approach, however, a sequential scanning procedure minimizes the chance of missing any significant pathology. The following are the most common general applications for MSK Ultrasound of the elbow:

A. Medial-Lateral Epicondylitis
B. Triceps Tendon-Olecranon Fossa
C. Joint Effusions-Loose Bodies

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D. Arthritis-Erosion

E. Ulna-Collateral Ligament Tears

F. Bursitis

G. Distal Biceps Tendon Rupture

H. Needle Guidance

Technical information

Normal anatomy of the elbow as visualized by MSK Ultrasound was described by *Barr and Babcock ( ) Resnick* ( ). In seven views, they were able to image the structures of the elbow in patients over a wide range of ages, from several months to 45 years. Because MSK Ultrasound allows visualization of cartilage that may not be visible with radiography, it has been found particularly helpful in the examination of infants and children.[7] The sonographic findings in transphyseal fractures, other occult fractures, joint effusions, and cellulitis have been described. Characteristic findings in tennis elbow (see following discussion) have been reported, consisting of hypoechoic extratendinous collections in muscle tears, fluid collections adjacent to the extensor carpi radialis brevis in bursitis, and alterations of tendon echogenicity and size in enthesopathy and tendinosis.[8]

Lateral epicondylitis ("tennis elbow") is accompanied by mucoid degeneration of the extensor tendons, especially the extensor carpi radialis brevis. Such tendinosis is characterized by thickening and a diffuse decrease in echogenicity of the tendon. Frank tears can also be identified. Acute exacerbations of lateral (or medial) epicondylitis or tendon tears are associated with increased vascularity when power Doppler methods are used. Tears of the biceps tendon can also be recognized, and the degree of tendon retraction in cases of complete disruption can be documented[8] Resnick.

Neurovascular structures, especially the ulnar nerve, can also be assessed with MSK Ultrasound. Normally, the ulnar nerve is located in the cubital tunnel and, in the longitudinal plane, contains linear hyperechoic strands[9] *Resnick*. Focal enlargement of the nerve and decreased echogenicity are typical of neuritis, and subluxation of the ulnar nerve can be promoted when provocative positions of the elbow are employed.

Hand/Wrist

Patients usually require a MSK Ultrasound examination of the hand and wrist to evaluate the origin of localized swelling or to diagnose tendon pathology. The most common cause of localized swelling within the hand is a ganglion (or synovial cyst), making up approximately 70% of all soft tissue masses involving the hand and/or wrist. Other soft tissue masses, listed in order of frequency, include:

A. Giant cell tumor of the tendon sheath

B. Hemangiomas

C. Glomus Tumor

D. Nerve Tumor

The following are common diagnostic and general indications for MSK Ultrasound testing of the hand and wrist:

A. Carpal Tunnel Syndrome

B. Tenosynovitis-Tendon Tears

C. De Quervains Disease

D. Ganglion Cyst

E. Synovial Cysts

F. Arthritis-Rheumatoid Disease

G. Loose Bodies

H. Calcification

I. Stress Fractures

J. Needle Guidance

Technical information ( ) resnick

Fornage and associates demonstrated that the normal tendons of the hand can be visualized by MSK Ultrasound *( ) Fornage*. Inflammatory abnormalities, including foreign bodies and tenosynovitis, can also be visualized with MSK Ultrasound. Jeffrey and associates reported on eight patients with acute suppurative tenosynovitis. The affected tendons were 25 percent larger than contralateral structures. In five of six cases, hypoechoic areas adjacent to symptomatic tendons contained purulent material. Ganglion cysts of the wrist are seen as well-marginated, multilobulated, hypoechoic masses that are easily differentiated from other abnormalities such as lipomas or aneurysms.

Within the carpal tunnel, the normal median nerve reveals multiple hypoechoic nerve fascicles surrounded by the hyperechoic perineurial structures. In general, if the nerve measures 0.9 to 1.0 cm in the long axis, or if its area is greater than 10 mm (in cross section, it is abnormal). Dynamic (motion) MSK Ultrasound (accomplished as the patient flexes the fingers) can contribute to the accurate diagnosis. Tenosynovitis and ganglion cysts are among the causes of carpal tunnel syndrome that can be evaluated with MSK Ultrasound.

With regard to the tendons about the wrist, disruption of either the flexor or extensor tendons is displayed ultrasonographically as a focal disruption of the normal hyperechoic tendinous structure, often with interposed granulation tissue or blood. With regard to tenosynovitis, bland tenosynovial fluid is not accompanied by increased blood flow when investigated with power Doppler sonography, whereas a marked increase in peritendinous blood flow suggests tenosynovitis.

Ganglion cysts, a common cause of masses about the wrist and are identifiable by MSK Ultrasound, and their site of origin and differentiation from vascular lesions are discernible with this method.[10]

Hip

The following are common diagnostic and general indications for Hip MSK Ultrasound;

A. Adductor Tendon Disorders

B. Hip Flexor

C. Bursitis

D. Effusions

E. IT Band/Tensor Fascia Latae

F. ASIS Tendon Insertion Pathology

G. Ortolani's click

We will discuss the hip in two sections, the adult hip and the pediatric hip. MSK Ultrasound has been found to be quite useful in several scenarios, including: Assessment of intra and/extra-articular fluid collections. Assessment of muscle and/or tendon injuries and/or pathology. Guidance of aspiration and/or biopsy needles

The dynamic scanning capability of MSK Ultrasound allows assessment of the hip joint in real time, with the leg in any position as well as rapid comparison with the normal hip. Add to this the much lower cost of an ultrasound examination and its portability and you can see the potential for increasing utilization of hip ultrasound.[11]

Indications for adult hip ultrasound

MSK Ultrasound examination of the hip is most often requested in patients suffering from pain. The cause of hip pain varies greatly, ranging from joint effusions in the normal population to stress related hip injuries in the athlete. Other indications for hip ultrasound include;

1. Hip pain in the athlete and/or non-athlete
2. Evaluation of the "clicking" or locking hip (i.e. "snapping hip syndrome)
3. Evaluation of suspected developmental dysplasia of the hip (DDH) formerly known as congenital dislocation of the hip (CDH).

Patients presenting with hip pain may do so for many reasons, including arthritis, infection, trauma or even neoplasm. Frequently a joint effusion is associated with the underlying disease process, and fortunately MSK Ultrasound is sensitive to the presence of fluid either in or around the hip joint. Once identified, MSK Ultrasound may be of further value with its ability to guide a needle into the fluid collection for cytological or other analysis.

Indications for infant hip ultrasound

Evaluation of the infant hip for congenital dislocation has been performed using ultrasound since the late 1980's because of ultrasound's ability to image the soft tissue and cartilaginous structures not seen on conventional radiographs. Formerly known as CHD or congenital dislocation of the hip, current imaging experts have replaced that term with DDH or developmental dysplasia of the hip as the latter term more fully describes the wide range of developmental hip abnormalities that may occur, as opposed to dislocation alone.

Amongst other factors, it is thought that persistent, gentle force upon the leg(s) while the fetus is in the uterus, such as that caused by oligohydramnios (abnormally low amniotic fluid levels), breech presentation of the fetus and even a first pregnancy, with very tight uterine and maternal anterior abdominal wall muscles, may be responsible for newborn hip dysplasia. The first six weeks of a newborn infant's life are critical to healthy hip joint formation as DDH is the result of a disruption in the normal relationship between the acetabulum and the femoral head. Without adequate contact between them, neither develops normally. At birth, the acetabulum has a small bony and large cartilaginous component and the percentage of the femoral head covered by the acetabulum is less than that at any other time in development.

Knee (MJ)

MSK Ultrasound of the knee is a commonly requested study of the lower extremities. The knee is a bicondylar joint stabilized by soft tissue structures; ligaments, tendons, menisci, and the joint capsule. These structures are all easily injured by trauma, particularly sports-related trauma. MSK Ultrasound is the only readily available non-surgical technique for the examination of soft tissue injuries at the time the patient presents for clinical evaluation.

The following are common diagnostic and general indications for Knee MSK Ultrasound;

A. Meniscal tears
B. Internal derangement
C. Ligament tears
D. Sprains/strains
E. Chondral defects
F. Arthritis
G. Joint effusions
H. Loose bodies
I. Calcification
J. Baker's cyst
K. Popliteal masses
L. Patella tendinitis
M. Osgood-Schlatter's disease
N. Bursitis
O. Needle guidance

Intra-articular and extra-articular pathology are equally common causes of knee pain. Pain and swelling of the knee accompanied by a normal radiographic examination are a clear indication for a MSK Ultrasound examination. Sonography has the capability to demonstrate non-invasively, both intra-articular and extra-articular pathologies. No other diagnostic imaging modality has this capability. In addition, there is no risk, discomfort, high cost and delay that might be expected with other diagnostic procedures.

Tendonitis is a common cause of knee pain. Most frequently involved are the quadriceps, biceps and patellar tendons. Increased edema and decreased acoustic signal within the involved tendon is visualized. Calcifications are often seen in cases with chronic tendonitis.

Bursitis may also be the cause of knee pain. Traumatic, septic and hemorrhagic etiologies may be the cause of bursitis. Rupture of Baker's cyst is almost always associated with pain and swelling of the knee, which may extend to involve the entire lower extremity. MSK Ultrasound is also valuable in evaluating ligamentous injuries, synovial cysts, ganglia, muscle tears, aneurysm, and venous thrombosis.

Examination of intra-articular pathology can demonstrate synovial thickening, meniscal tears, articular cartilage defects, loose bodies, and cruciate ligament tears.

A normal sonographic examination demonstrating no effusion indicates that the source of pain lies outside of the joint.

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Foot and ankle

The most common indication for high resolution MSK Ultrasound of the foot and ankle is to investigate persistent pain after a period of four to six weeks following an acute injury. MSK Ultrasound is very capable of imaging the various tendons and tendon sheaths (of which there are many) within and surrounding the ankle joint and foot. The dynamic (motion) nature of ultrasound scanning makes it a particularly valuable imaging tool when compared with other radiological procedures.

The following are common diagnostic and general indications for foot and ankle MSK Ultrasound;

A. Ligament tears/sprains and strains
B. Tendon tears/tenosynovitis
C. Cysts/loose bodies
D. Achilles tendon rupture/tendinitis
E. Bursitis/effusion/synovitis
F. Stress fractures
G. Arthritis/rheumatoid disease/articular erosion
H. Osteochondral defects
I. Neuromas
J. Plantar fasciitis
K. Tarsal tunnel syndrome
L. Plantar fibroma
M. Post-operative evaluation
N. Needle guidance

Achilles tendon

The Achilles tendon can be quickly and accurately evaluated. Sonography is useful in demonstrating full-thickness tendon tears, partial-thickness tears and tendonitis. High resolution sonography allows detection of an intact plantaris tendon. When a full-thickness Achilles tendon tear is identified by sonography, passive plantar flexion is used to determine if the torn tendon ends become approximated. An added benefit of sonography is that accurate information regarding plantaris tendon and the torn. Achilles tendon approximation can assist the surgeon in deciding between surgical and conservative treatment.[12]

Conclusion

The addition of MSK Ultrasound will significantly change the dynamics of a busy practice that regularly treats orthopedic problems, musculoskeletal pain and soft tissue injury. Because of its relatively low cost of acquisition, utilization versatility, dynamic (motion) patient evaluation and no contraindications to its use, MSK Ultrasound is an important, practice changing diagnostic tool. Also, it has been documented that the addition of MSK Ultrasound improves the outcome of "Needle Guided" procedures (infiltration, aspiration, and biopsy) by a factor of 40%, or more.

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Conflict of interest

Authors declare there is on conflicts in publishing the article.

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