INTEGRATIVE DRY NEEDLING

Diagnostic Ultrasound for The Assessment & Dry Needling Treatment of Tendinopathy

Pre-reading Manual

The information contained in this pre-reading manual is not comprehensive nor exhaustive. The goal of the pre-reading, and the associated course is to quicken the learning curve of musculoskeletal healthcare providers to be able to obtain proper images of selected joints and associated structures such as tendons, ligaments, nerves, fibrocartilage, and arteries/veins. We will touch on some terminology, parameters, and techniques that providers will likely use for musculoskeletal (*MSK) ultrasound. This will only be a cursory overview of the physics and the ultrasound controls. Please take the time to take a deep dive into this information because this background information will culminate into a huge light bulb weekend for you and at the end of the two-days you will say, "I get it!!"*

Diagnostic Ultrasound is a great way to image inside the body non-invasively and without side effects. Diagnostic Ultrasound is a powerful point-of-care tool for musculoskeletal healthcare providers because it fits perfectly into their knowledge and treatment paradigm. Currently, many schools that teach certified ultrasound technologists either do not learn MSK Diagnostic Ultrasound in their program or they only learn how to obtain certain images but do not have the advanced anatomical background required to interpret images. The images are sent to a radiologist or an orthopedic surgeon for reading, and then later the results are provided to the patient. As musculoskeletal healthcare providers we can use diagnostic ultrasound to provide point of care service to immediately obtain images, evaluate the anatomical structures, create our plan of care, and provide ultrasound guided dry needling treatment. Another clinical benefit is visualizing movement of joints and soft tissue structures in real time by having the patient move the body part while holding the tranducer over the area. Currently, there are many states do not permit therapists, Athletic Trainers and other allied health providers to order diagnostic testing forcing them to rely solely on history, and bedside clinical testing. Diagnostic ultrasound is becoming more main stream and accepted by professional organizations like the American Physical Therapy Association.

Knobology is the term used for the knobs and system controls of the ultrasound machine. Although we will not be going deep into all the controls some of them are important to help get the best possible image for accurate evaluation of MSK imaging.

There is a transducer head, also known as a probe, that is used with gel for conductivity similar to our traditional therapeutic ultrasounds that Therapists, Trainers and Chiropractors use clinically. However, in Diagnostic Ultrasound the transducer head emits ultrasonic waves, the waves bounce off different body structures and send back electrical signals that are received back by the transducer producing two-dimensional screen images in shades of gray. The denser structures (i.e. tendons, outer cortical margin of bones) return a whiter image, and the more fluid filled structures (bursa, muscles-) have a darker gray or even black image. The various gray scale information that comes back to the transducer creates an image on the screen representing the different structures that are in the view of, and deep to the transducer. A feature of diagnostic ultrasound compared to therapeutic ultrasound is that it does always not need to be in contact with the skin while being used.

There are different size and frequency transducers. For MSK Ultrasound we primarily use two types. The linear head transducer (picture #1) is a higher frequency probe, which commonly gives a better quality image but is limited in the depth of penetration. The frequency usually ranges from 6-13 or even as high as 15 MHZ. It is called a linear transducer because the part that touches the patient is a straight linear line. This linear transducer is used for most of the MSK structures around the joints of shoulder, elbow, hand, wrist, knee, foot, and ankle. The other transducer that is used is called curvilinear (picture #2). Much like its name, the part that contacts the patient is not linear but in fact curved. It has a lower frequency than the linear transducer; most are between 2-6 MHZ. The lower the frequency the deeper the penetration to reach deeper structures and optimize visualization, albeit a grainy image. The quality of the image degrades with the lower frequency transducer. It is commonly used in MSK ultrasound for hips, low backs and on larger patients. Both transducers are capable of a range of frequencies. For example, a linear transducer could range from 6MHZ up to 13 MHZ. Higher frequencies (13 MHZ) are used to visualize more superficial structures, and lower frequencies (6 MHZ) to visualize a deeper structure like the medial meniscus.

Separate from the frequency of the transducer there is a “depth” control that allows the clinician to adjust the view between deeper or more superficial structures. For example, adjust the depth to more superficial for visualizing the lateral epicondyle. This setting will increase the screen size of the structure to improve image detail. As you go deeper the image of that area becomes smaller because the image gets filled with the deeper structures. The depth control allows the clinician to focus in on the specific depth of the structure being imaged. A linear transducer’s depth can vary between 1.5 cm to 6 cm deep, and some can reach a depth of 11 cm. For handheld portable ultrasound units, the depth control is frequently found on the pad or tablet simply by sliding your finger up or down on the screen to adjust.

“Focus” control is not found on all ultrasounds but it is important for the ultrasounds that do. The focus control allows image optimization at a specific place on the screen usually that is the area of the structure you are targeting. If your ultrasound does not have this feature it is assumed the unit automatically optimizes the entire image.

“Gain” is another control that is an important part of getting an optimal image and represents the brightness (or darkness) of the entire image being viewed. Brightness control is important because if the image is too bright it will difficult to discern the different gray scales from one another. Alternatively, if the image is too dark it will be difficult to discern the different structures. Handheld portable ultrasounds adjust the gain by swiping left and right on the pad or tablet.

There are additional controls called “Time Gain Controls” (TGC’s) that allows you to increase or decrease brightness at specific depths. On the newest units this is auto controlled but can be manually adjusted.

“Freeze” is an important control. Once the desired image is captured you can freeze the image so that the transducer can be moved without losing the image. When the image is frozen, descriptive text can be added on the screen, and saved. The save feature actually records the prior 10 seconds allowing you to scroll through and freeze the exact image(s) you need. You also have the option to save the prior video segment of your scanning, this is termed a “cine-loop.” The cine-loop feature is frequently used when wanting to view or show movement. A good example is viewing a small cine-loop (5 to 30 seconds commonly) of the rotator cuff as it slides under the acromion with active shoulder abduction. The cine-loop permits a detailed assessment for shearing of the rotator cuff or bursae as is seen with subacromial impingement.

Linear head transducer

Picture #1

Convex head transducer

Picture #2

As providers using MSK Ultrasound it is important to have a base understanding of the physics of scanning so it will be limited to the three terms that are pertinent to the parameters we use when scanning. First, MSK imaging is called “Real-time imaging,” which basically means we are viewing a series of pictures that are displayed to our screen in rapid sequence. Secondly, the image is obtained through “Pulse Echo,” which are sound pulses produced with time intervals between them to be able to receive the return echo from the body. Lastly, we primarily perform the scanning in “B-Mode” which stands for “brightness” mode, which is proportional to the amplitude of the returning echo. The brightness depends on the intensity or amplitude of the echo. Occasionally Color Doppler is used to look for blood flow in arteries and veins or non-directional blood flow that is commonly seen in tendonitis. Identifying arteries and veins under color doppler is useful to help avoid those areas while dry needling or used to just identify structures. Non-directional blood flow is a speckled (blue and red) colored appearance on the screen in an area and is indicative of the body trying to heal a certain area. Tendonitis is a great example, and this information can be key in helping with reaching an MSK diagnosis and developing a plan of care.

Achieving high intra-rater and interrater reliable images:

> *"Imagine that you rented an ocean view home for a week. You walk in the bedroom and stand right in the center of the window looking at an incredible view of the ocean. You can see it clearly in front of you framed between a house to the left and right of your view. You arise the next morning, and while lying in bed you look out the same window only to realize that all you can see from this point of view is the house to the left and no ocean. Looking out that same window has a totally different picture when you stand in the center of the window then off to the side where the bed is."*

To achieve reliability and reproducibility with ultrasound imaging requires looking through the same window while standing in the same spot. We created an easy process to standardize our view (window) and position with each structure we want to visualize. Each time a patient is scanned we follow the 5 P's of diagnostic ultrasound.

1. PATIENT POSITION- The patient's position is important to create a positive image. It is key to have the patient in a specific position each time you want to visualize a certain structure. For example, to visualize the long head of the bicep, the patient is seated with the elbow at 90 degrees, and the shoulder in neutral i.e. not internally or externally rotated. Standardizing patient position will help ensure you are creating a consistent image. Consistency of patient position will also facilitate a quicker image obtainment because locating it will be more readily predictable.
2. PROBE (transducer) POSITION- For many of the images we want to be sure to obtain two views. We use our transducer and get a short axis view (aka SAX) and a long axis view (aka LAX). Short axis view is when the transducer is held in the direction of "perpendicular to the spine" (picture #3). The transducer head points left to right on the body. Many of the muscles go in parallel direction to the spine, so when the transducer is in the short axis position the image will show a cross section view of the muscle. While in short axis, the indicator on the transducer should point laterally to the side of the patient you are scanning. There are different thoughts on which way the indicator should point, but in my experience the indicator should always point laterally regardless of which side of the body you are scanning.
   The long axis view is when you have the transducer head in "parallel with the

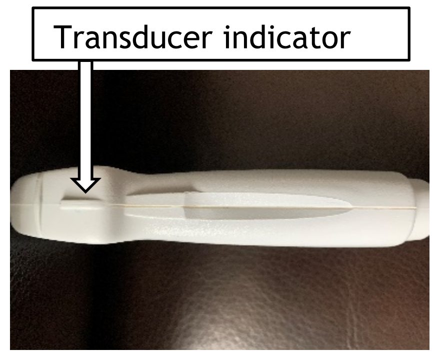
spine" (picture #4). When muscles run in the same direction as our spine then the transducer will be viewing the length of the muscle. It should be noted that each transducer has an indicator mark or light on one end (picture #5). This indicator mark always relates to the left side of the ultrasound screen image. When creating a long axis view always have the indicator mark pointing toward the head. If the transducer is in long axis with the indicator pointing cranially then the left side of the ultrasound screen will show the proximal side of the body. The right side of the ultrasound image will show the distal portion of the transducer.

SAX- Short Axis

Picture #3

LAX-Long Axis

Picture #4



Picture #5

3. PROVIDER POSITION- Ergonomically proper sit/stand positioning while scanning makes a difference. Ideally, the screen is located directly in front of you, and you are able to hold the transducer with your wrist in neutral, and your upper extremity is in a relaxed position.

   The positioning of your hand and fingers when holding the transducer is important to achieve a good image. The optimal positioning is to hold the transducer in place while simultaneously having one to two fingers contacting the patient's skin. It is difficult to get a good image if you are not stabilizing the transducer with your fingers against the patient. Without this stabilization the quality of the image will quickly fade if either you or the patient moves so placing at least one finger of the scanning hand on the patient helps ensure success. If fact, many clinicians prefer to have 2 to 3 fingers on the patient to stabilize. (Yes, you will get "goopy" from the conductor gel but it is an essential part of the process).

In combination with proper hand and finger stabilization, there are different techniques used with the transducer to obtain the optimal image. Clinically, it may require a combination of all four techniques to get the desired image.

a. Technique
    i. Fanning/translating- this is moving the whole transducer back and forth and up and down. It is usually the first step to get in close proximity to the desired image.
    ii. Toggle is different from translating because the transducer head remains stationary on the body part, and just the "tail" of the transducer is adjusted up or down. Moving the tail, while keeping the transducer head on the patient, provides an entirely different view and acts as a fine tuning technique to optimize the image.
    iii. Heel toe is the rocking of the transducer head from one end to the other while maintaining contact with the patient's skin. This rocking technique is used in the dark areas of an image to alter the way the sound wave is rebounding, which results in a cleaner and brighter image.
    iv. Rotation is the turning of the transducer much like turning a knob. Muscles, tendons and nerves do not all run linearly, using rotation may be necessary to view the entire structure.

Instructor notes:

I was taught early in my scanning education that when you are using any of these techniques, that you need to scan very slow or you will miss the image you are trying to obtain. You will scoot right past it and get frustrated. So as one of my instructors said to me, "Be a Pinto not a Lamborghini."

4. PARAMETERS- The term parameters refers to the knobology or functionality of the controls on your ultrasound unit. Some ultrasound units have presets to allow selection of MSK scans as opposed to cardiology, nerve etc. Some units, under the MSK setting, have the option to choose a specific joint to scan. Having these presets is like going to a ballpark and getting to your "section". They direct you to the general part of the ballpark from there the use of depth, focus (if your machine has one) and gain are used to fine tune the exact image desired. In other words, in the ballpark example, the depth, focus and gain get you to the exact seat.

5. PICTURE- To get a high quality and consistent picture we need to stand in the exact same place at the window so that we see the exact same picture each time. The way to standardize the view is to position a bony landmark in your "window" whenever possible. This landmark validates when we have the right

picture frame and from there, we can build up from the bottom of the image to clarify the rest. There will not always be a bony landmark when scanning but in the live course you will learn what the bony landmark for any structure should looks like so that you can look out the same window at the same place as everyone else.

Remember, we are not looking or searching for pathology, but we are trying to find normal. If you can't make your image look normal, then you likely have some pathology.

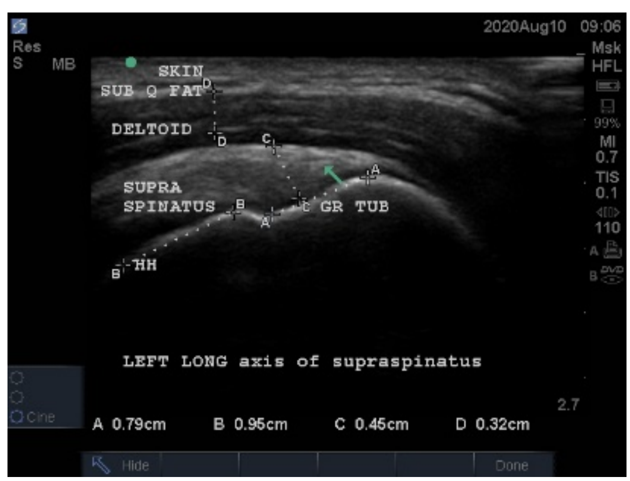
When reading an image, always read the image from the base, where the bone is, up superficially to the skin. This the way to both document and read ultrasound scans. Below is the common way to describe an image from bottom to top.

a. Bone
b. Hyaline cartilage
c. Synovium and synovial fluid (when possible)
d. Joint Capsule
e. Ligaments
f. Muscles
g. Nerve when applicable

Labeling the image is crucial for later reference because it is difficult to remember all of the specifics. If other clinicians will be viewing the image it is particularly important to provide detailed references and perspective. All ultrasounds units have this labeling ability via a button called "text". Below is the minimum that should labeled on an image.

A. Lt or Rt side
B. Body Part or primary structure
C. Probe orientation (LAX or SAX)

There is an arrow feature that can be used to bring attention to specific structures or issues on the image. There are also controls that allow measurement of thickness and diameter of structures.



An image is created when the transducer emits a sound wave into the body that bounces off the different tissues and structures. The altered sound wave is rebounded back to the transducer head where it is reconfigured into the ultrasound image seen on the screen. The less dense structures will appear darker on the screen. The darker structures are termed hypoechoic, meaning less echo and less dense. Conversely, a dense structure will appear as a brighter on the screen and is termed hyperechoic i.e. more echo dense. Other structures such as vessels or cysts have no echo at all and appear as a black image on screen and is termed anechoic or without echo. Different structures have different characteristics and range in different shades of grey on the image from very hyperechoic down to hypoechoic or even anechoic.

Hyperechoic (denser) structures typically seen on ultrasound are:

a. Adipose Tissue
b. Foreign bodies
c. Scarring
d. Calcification
e. Fibrosis
f. Stones
g. Lipomas

Hypoechoic (less density, less echo) structures typically seen on ultrasound are:

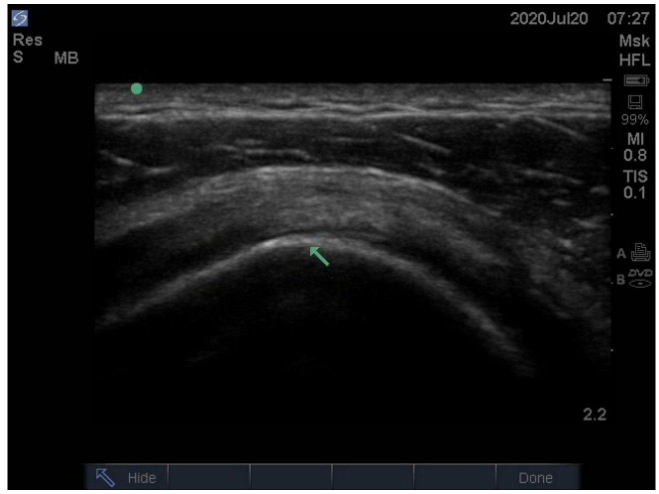
a. Active inflammation
b. Edema
c. Tears

Anechoic (without density) structures typically seen on ultrasound are:

a. Cyst
b. Vessel
c. fluid filled structures

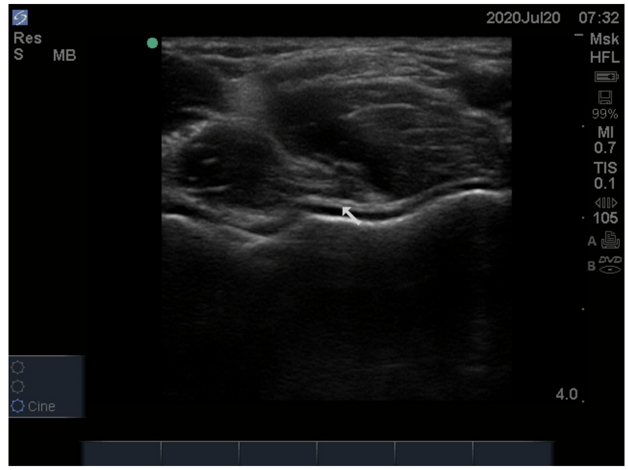
Normal Structures: What do normal structures look like in an ultrasound image? A reminder, the intent is to find normal tissues and structures. If that is not possible then there is likely something pathological.

1. Cortical Bone will be hyperechoic and should be continuous and smooth in appearance. If it is not normal, we may then identify arthritis, fracture, neoplasm, cyst etc.

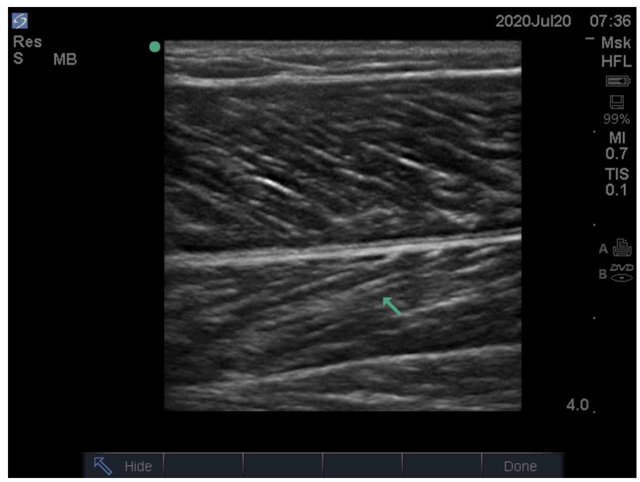


2. Hyaline Cartilage
    a. Anechoic/black. As we age it may become grayer in appearance. This is because the cartilage has less water and will become denser and have a more gray appearance.
    b. Thick band of anechoic area sits above the cortical bone
    c. Follows along the bony contour. If it does not follow the contour you may have just identified edema in or around the joint.

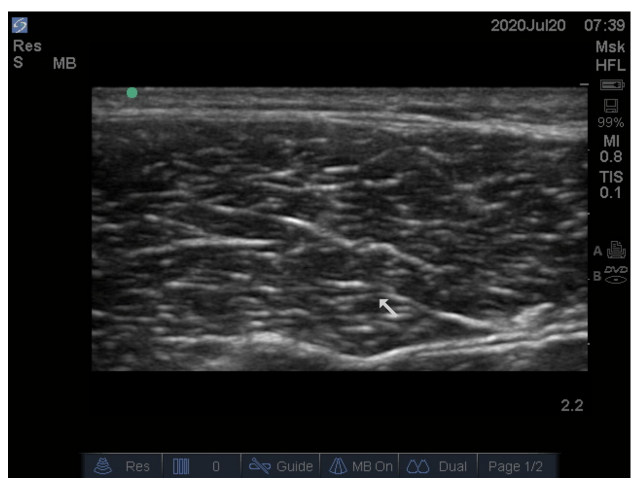
3. Synovial membrane and joint capsule
    a. Sits superior to the hyaline cartilage
    b. This is visually a combined looking structure of membrane and capsule in a normal joint
    c. Hyperechoic, well defined homogenous/uniform
    d. Thickened hyperechoic area that follows the bony margin



4. Skeletal Muscle in Long Axis
    a. Repetitive lined feathered pattern
    b. Hyperechoic muscle septae border (which is the muscle membrane) with Hypoechoic bundles



5. Skeletal Muscle in Short Axis
    a. Speckled Hyperechoic appearance
    b. No diagnosis is made in this view; it acts as a supplement to LAX



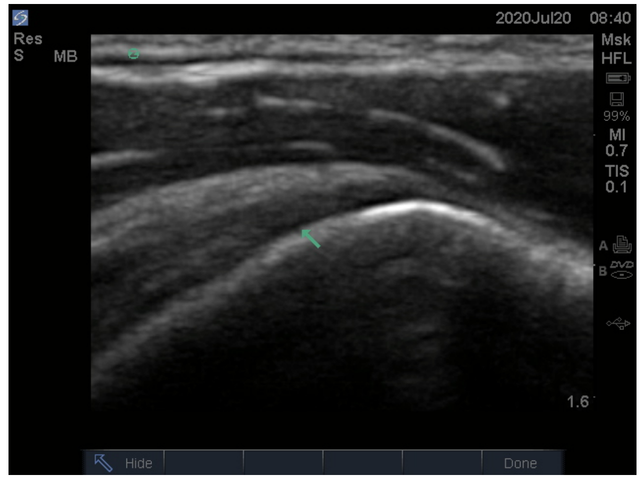
6. Ligaments Long Axis
    a. Found between two bones along the fibers in the direction the ligament runs
    b. Frequently, less echogenic than tendons

7. Tendons Long Axis
    a. Hyperechoic
    b. Brighter than ligaments
    c. Fibrous striated look to it

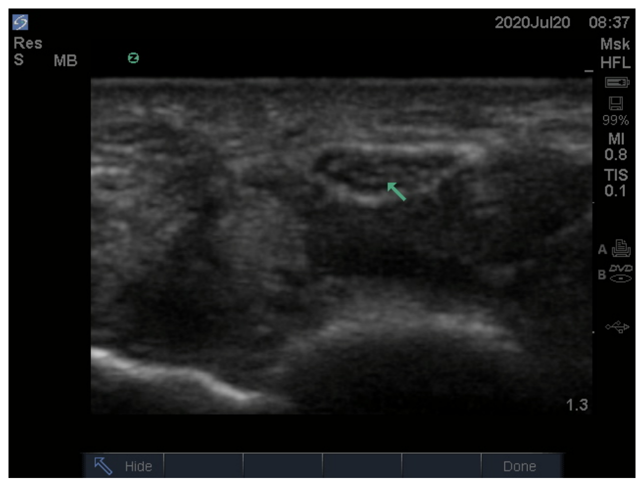
8. Tendons Short Axis
    a. Visualized within a tendon sheath
    b. “Bristle Like” and compact in its fibers

9. Tendon Enthesis/Attachment Long Axis
    a. Two Criteria Required for Normal Finding
        i. Tapering wedge shape tendon contour
        ii. Anechoic linear/uniform interface along bony margin

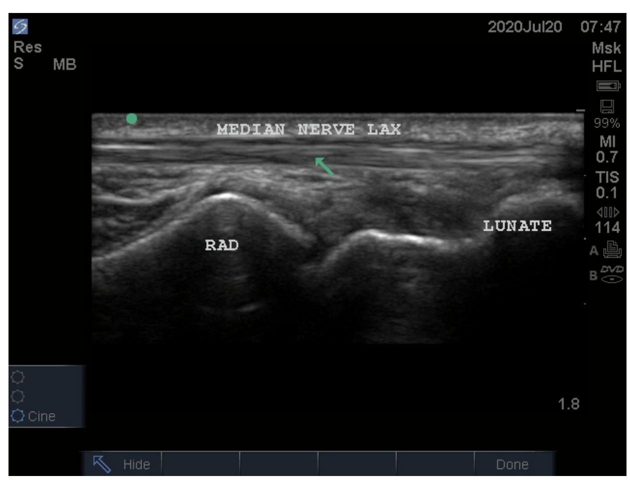
This is called the tendon "Footprint" (Sharpey's fibers)



10. Peripheral Nerves Short Axis
    a. Usually with a perineural hyperechoic outline
    b. Nerves have a " Honeycomb" appearance within the nerve

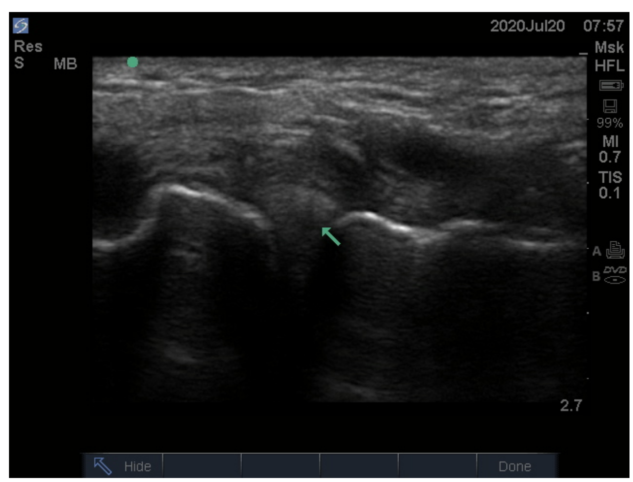


11. Peripheral Nerve Long Axis
    a. Less bright/echogenic than tendons
    b. Parallel hyperechoic lines with dark separations
    c. Often adjacent to anechoic vascular bundle
    d. "railroad track"..."collection of rods look

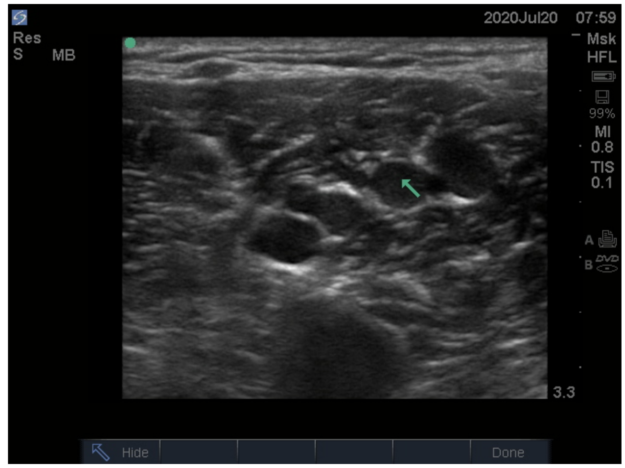


12. Bursae
    a. Usually less than 2mm wide is considered normal
    b. Anechoic appearance and typically separates two structures.
    c. Can be seen as a “black thin line” (because it is not typically filled with fluid) bordered by Hyperechoic BRIGHT peri-bursal fat.
    d. Exception is the suprapatellar bursae commonly is visualized and larger as it communicates with the knee joint

13. Fibrocartilage (meniscus and labrum)
    a. Homogeneous and triangular look
    b. Only see the outer margins and may need to decrease frequency of probe to visualize
    c. Grey appearance most of the time due to bones.
    d. Black lines through is indicative of tear.
    e. Example TFCC, labrum, MM, LM, A-C

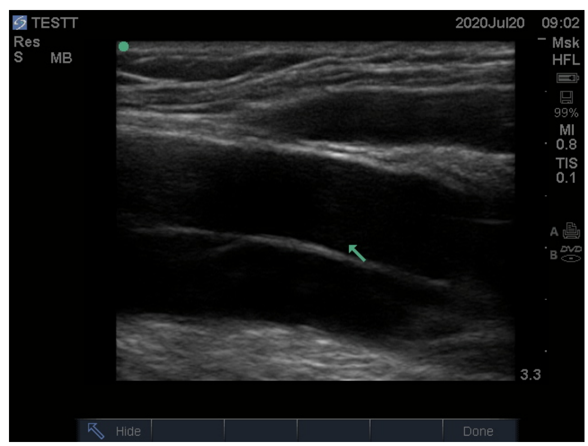


14. Veins (SAX)
    a. Anechoic
    b. Compressible on sonopalpation. Sonopalpation means using the transducer to press down on the body part.
    c. Accompanies vascular bundles typically



15. Arteries (SAX)
    a. Anechoic
    b. Non-compressible
    c. Found with veins and nerves

16. Veins and Arteries LAX
    a. Run alongside each other
    b. Anechoic
    c. Doppler can help distinguish between the two



Anisotropy is a self-induced angle generated artifact frequently seen when obtaining an image with a muscle or tendon. This is the most common artifact in MSK ultrasound. Shown by unequal properties showing as an artifact image and can be mistaken for a soft tissue tear.

Other artifacts in ultrasound:

- Foreign body in the tissue appears with posterior shadowing as seen with glass in foot or even gallstones
- Surgical hardware has a bright comet tail below the hardware

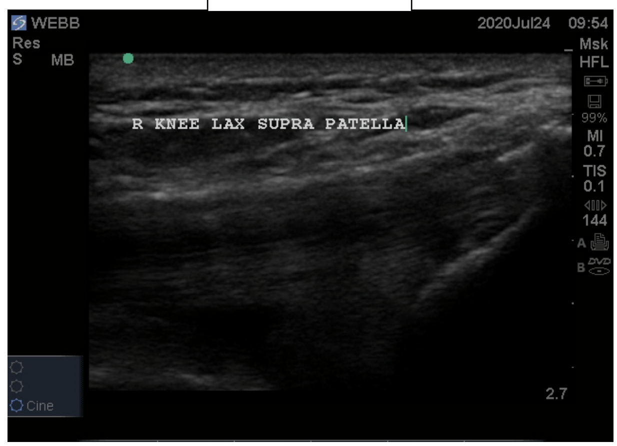
- Reverberation artifact multiple, equally spaced linear echoes deep to a needle

The most common pathology identified in MSK imaging is TENDINOSIS. There are some key characteristics: (pictures 6 & 7)

1. Hypoechoic looking instead of hyperechoic
2. Missing its fibrosis look, non-fibrous
3. Tendon is thicker
4. Neovascularization on doppler

Picture #6

Picture #7



Tendonitis:

- A good indicator of tendonitis is seen on color doppler. Turning on the color doppler you will see what is called non-directional blood flow. Non-directional blood flow looks like a twinkling of red and blue flashing on your screen in the area you are imaging. Tendonitis is not nearly as common of a finding as tendinosis. Most times when it is observed it is in Jumpers' knee.

Chronic Bursitis:

- With chronic bursitis the bursa will be larger than 2mm thick and can have septation like lines within the bursa.

To summarize, when scanning try to be consistent with our scanning protocol by using the 5 P's to get a reproducible image. Using our ultrasound techniques, we want to appreciate the bony landmark of the image and then identify and clarify the rest of the structures superficial to the bone. Attempt to make the image look as normal as possible, if that is not possible then evaluate for pathology.

When charting findings as a provider it certainly is appropriate to give a diagnosis as a MD, DO etc. As a Physical Therapist one must be careful that we do not provide a medical diagnosis. Instead we should document what we see or for that matter what we don't see in relation to specific pathology. For example: *The Supraspinatus tendon in LAX does (or does not) demonstrate tendon thickening as seen with tendinosis.*

Dry Needling under MSK Ultrasound:

You were provided our PowerPoint that lists the available research on the effectiveness of dry needling tendons. Although more research is always needed, we can utilize the current research to know that percutaneous needle tenotomy (PNT) creates fibroblastic proliferation in a tendon which intern causes collagen formation to assist in tendon healing. The long-term results of this technique rivals that of PRP injection and prolotherapy and falls well within our scope of MSK practice.

Dry needling under the ultrasound guidance improves treatment accuracy when needling into tendons or any structure for that matter. It does require practice to acquire the psychomotor skills required to become proficient at holding the transducer, visualizing the anatomy and delivering the needle. One of the first clinical pearls is to utilize a longer needle then you normally would for treatment. This is because the insertion point of the needle is at the end of the probe frequently about a ¼ of an inch away, which requires a longer needle to cover the distance. It is commonplace with the ultrasound to use at least a 50 mm length needle but even longer needles are used depending on location and patient size. In our MSK Ultrasound we utilize the B mode to identify tendons. Many ultrasound units now have a mode called needle enhancement. It will change the angle of the sound wave being emitted to help return a bright signal of the needle back to the screen for better visualization. If you are fortunate enough to have this accessory on your unit, do not forget to turn it on. Regardless whether you have this option or not, it is recommend that when you first set the needle into the skin that you advance the needle just under the skin parallel to the probe. This is your best chance of clearly visualizing the needle. Most targeted structures are deeper than the skin so slowly and partially withdraw your needle while keeping it in the screen image; then redirect the needle a little deeper always keeping the needle in sight on the screen. Continue to dive deeper with the needle until you advance it to the point of the pathology. If the target is a tendon you will find research that varies on needled dosage from fenestrating the tendon anywhere from 15 to 40 times. While needling different areas in the body, you may lose some visualization of the needle, or you may just see the tip of the needle, and at other times you may just see the tissue moving but can't see the needle itself. Depth of the structure to be needled, practice, proficiency, amount of adipose, thickness of your needle, ability to keep the needle under the width of the transducer, and the location you are needling are just some of the factors that influence your ability to visualize your needle while performing PNT. As noted in the PowerPoint you want to be sure you clean the transducer and the skin before performing the procedure. There are several disinfecting products available, but it is not recommended to use alcohol-based products on the head of the transducer. Utilizing alcohol will dry and crack many of the transducers out there and shorten their utility.

MSK Ultrasound is an exciting and useful endeavor with many benefits to start utilizing and incorporating it into daily practice. The ability to show and give visual feedback to a patient about what is going on in their body in real time is priceless. A study by Lumsden et al. (2018) looked at patient perception on receiving immediate feedback on their shoulder problem from their Physical Therapist using MSK Ultrasound. The results speak for themselves. Ninety six percent of the patients found the scan to be of "high value" to them. Ninety seven percent rated the scan to benefit in all aspects regarding the ability to understand their shoulder problem and feel reassured about their problem.

The cost of MSK ultrasound units are now what can be called affordable and the quality of image is truly incredible from what it was years ago. The size and portability of the ultrasounds allow us to have fewer units and needing less space to do the same amount of work. The ability to recognize a full thickness tear and refer the patient to an Orthopaedic surgeon allows patients to save visits for when they need them most is a tremendous benefit given the limitations in rehab visits.. The Point-of-Care ability to give patient information without awaiting referrals to doctors and recommendations for more imaging elevates our quality of care to a new level. These are just a few reasons to be excited about utilizing MSK Ultrasound. I hope you find taking the live workshop as exciting as we do teaching it. This live course is 95% lab time so you will be able to return to work on Monday and start applying what you learned with confidence! See you soon

Dr. Steven M. Coppola PT, DPT, MSKUS

Lumsden G, Lucas-Garner K, Sutherland S, Dodenhoff R. Physiotherapists utilizing diagnostic ultrasound in shoulder clinics. How useful do patients find immediate feedback from the scan as part of the management of their problem? *Musculoskeletal care.* Mar 2018;16(1):209-213.