Good afternoon, everyone. My name is A'riel and I will be your host today for this MSK Ultrasound Pain Care Skills Training. Your presented today will be Dr. Chen. He is a board certified physician in medicine and rehabilitation with subspecialty certification in sports medicine. He has received a doctorate of medicine at Uniformed Services University of the Health Sciences in Bethesda, Maryland in 2007. He completed transitional internship at William Beaumont Army Medical Center in El Paso, Texas in 2008, followed by a residency at Walter Reed Army Medical Center from 2008 to 2011 in Washington, D.C. He has a PM&R sports medicine fellowship from Stanford University. As a military physician, he served as assistant chief of the PM&R and operating in doing freedom with the first through 26th regimens. He did the first infantry division and then as a director for the PM&R sports medicine and the PM&R ultrasound as well as associate program director for the military PM&R residency at Walter Reed National Military Medical Center. He also served as the chief of interdisciplinary pain management Center in Fort Carson Colorado. Dr. Chen is now a fellow at the Brooke Army Medical Center in Texas. He is an assistant professor at the Uniformed Services University's of health science. I would like to mention a few housekeeping rules for today's training.

This session will be recorded. If you have not done so already, please mute your microphone until the question-and-answer portion of the workshop. We have recorded the preliminary sessions and also posted them on the Pain Care Skills Training website and the sign in sheet and questions that must be completed and returned to receive credit. If you look in the file pod, you can find today's workshop agenda. The presentation and the sign in sheet is there, as well. I will put in the chat box emails that you can send your sign in sheet two at the end of the training. During the question-and-answer, please use the raise your hand feature to be called on or you can place your questions in the chat box. At that time, I will enable everybody's microphone for the question-and-answer session. I'll go ahead and hand this over to the presenter, Dr. Chen. Thank you.

Hello, everyone. Can you hear me? Testing, testing. Bear with me for a second. Okay, next slide, please.

These are the objectives for our talk today. We will talk about the basic principles of musculoskeletal ultrasound, primarily the big, broad topics of the entire body. Some of us may think of it as more neural musculoskeletal. This is especially useful in such a powerful tool to evaluate the entire structure. Today, I wish that we can go over and really evaluate how we can use this as a tool to help us better assess a patient in front of us. Primarily, we will going to focus on understanding the issue and understanding how to work with the imaging. We call that knobology. And then we will go into talking about the pathological tissue appears like. Then we will go over some basic calls to look at different portions of the body.

Next slide, please. Okay. These are the topics we will be going over. Next slide, please.

Okay. Why musculoskeletal ultrasound? It affords so many advantages. I think whenever I can use ultrasound in the clinic, I am twice the

physician I can be, seriously. You have imaging evaluation of the patient you don't have to send them off to radiology, getting a x-ray, looking at a. It pertains to soft tissue. Can save more time, the turnaround time of getting the test ordered, obtain, come back, evaluate for interpretation. Ultrasound has a superior resolution. It has submillimeter resolution. You can examine the patient during this in a dynamic way. You're not looking at one static image, you can take a patient through positions of discomfort, positions of pain. That can help you see what exactly is actually going on. Furthermore, it really helps to form an alliance with the patient. Ultrasound is a contract -- contacts for. You have to put your hand on the patient to stabilize the probe. Obviously, I believe was a blessed to put our hands on the patient and that is what needs to be done in order to appropriately perform them muscular examination. This is an extension of that. It really helps. Since we are doing the exam together, frequently I have the patient situated in such a way that they are looking at the screen, I am looking at the screen, we are talking through the examination, I am explaining what I am seeing to the patient. It really helps the patient by into the diagnosis and the treatment plan. It also helps them that you can point out, no that is not pathologic. It helps minimize the pathologizing or the capacity rising of the patient. By being able to demonstrate all these things in an understandable way, in a visual way to the patient, you form immediate street cred. You have an understanding of what you're able to do to help them. It is a terrific tool.

Next slide, please.

Furthermore, physical examinations, as some of you know, most of the physical exams, really we are looking at sensitivity and specificity of 50% to 60%. That is why a lot of examinations require a sequence of exams, compounding on each other, in order to improve the sensitivity and specificity. Even then, they are frequently not that much higher. We are only looking at 70% to 80% of sensitivity and specificity. Not bad, but having an ultrasound is going to be able to help you do so much more. It is an extension of the physical examination. Immediately and most importantly for us, it will give us clinically actionable information. That is especially or high-grade lesions. You can rule something in or out right there. A torn tendon is going to be obvious. A broken bone is going to be obvious. Immediately, you may still choose, and I do recommend that you would still order the proper imaging studies or consultation. I am sure the information you get from that examination, the physical exam, that is going to give you data in terms of initiating the appropriate treatment, additional study, or consultations.

Next slide, please.

Let's start with a knobology crash course. It stands for all the knobs that are on the instrument. Different machines do have different knobs. There are different manufacturers and different radiations. The basic, available settings are going to be generally standard.

I will go through them and talk about how we can optimize the image using those different settings. Let's take one step back and understand what ultrasound is in terms of physics, okay? It is a mechanical wave that

travels through your tissue. I have to reach way back to think about freshman physics. There are characters of wavelength, frequency, the carriers of velocity. Okay. So, the machine is going to send off a signal and bounce off the tissue and the machine listens for them. That signal is then interpreted as a two-dimensional image. It will have different characters of brightness, brightness or darkness. That will be the big interpretation of the tissue. By manipulating these different characters, the characters of the sound wave, that can influence the image that we see. That can either optimize or influence the quality thereof.

Next slide, please.

We can see that these are some of the things we can influence. Most important thing we are looking to see is the frequency. In terms of adjustable settings, we can work with gain, time game, compensation, and focus.

Let's start with frequency. It can generally be divided into high-frequency versus low-frequency. The cutoff line is generally somewhat artificial and generally is actually indicated by the type of transfusion that you have. So frequently less than five megahertz constitutes low and anything above constitutes high. There are also ultrahigh frequencies available that are up in the 20 megahertz range. The higher, the better? Not necessarily. Let's talk about why. As the sound wave is transmitted through the body, a couple of things happen. Number one, whenever you run into a tissue that has change in the density, then sound waves get reflected. You can also scatter. So, it can go back and away. If it is picked up by the transmitter, you have image interpretation. If not, it may appear darker or just not pick up at all. When they scatter, just imagine you throw a water balloon at the wall. It explodes in all directions. That is kind of what scattering is. A signal is returned and received by the transmission. More importantly, the sound wave always will attenuate. Attenuation is the process in which the mechanical energy dissipates by conversion into thermal energy. In ultrasound, we are looking for mechanical energy, the sound wave, the vibration being transmitted through the tissue. We wanted to bounce off and return at the mechanical energy picked up by the tissue. If it converts into thermal energy, that signal is just lost, at least as far as the imaging is concerned. Why is this important? This is important because the higher the frequency, the more the ultrasound wave is susceptible to attenuation. Therefore, that means the higher the energy, the higher the frequency, the more the depth before the sound wave gets converted into thermal energy or is lost through attenuation. So the implication is that the larger, the higher the frequency that you use or that, the less depth you will be able to see clearly. Conversely, the lower the frequency, the increase in the depth that you're able to visualize. That is an advantage. Conversely, a larger, the lower the frequency, the larger the period. If you look at those squiggly lines of interpretation that we have up on the graphics, the larger the period, the larger each wavelength is, the smaller the resolution. Think of this as the lights on your TV. I remember when 720 P is standard. Now for KTVT is the standard. -- 4K TV is the standard. That means you may see tissue deeper, but each individual pixel will be bigger. Things are fuzzier and not given in as great detail visually. The plus side again, there is none

other -- there is another plus side, you will have better temporal resolution. Think about the refresh rate. Those who play video games may know this intimately. We are talking about how fast the screen refreshes and therefore how clear and how smooth the screen appears. The lower the frequency, the faster, the better the temporal resolution. The converse is also true. If you're trying to look at these structures, if you're trying to look at this using high-frequency probe, you will have a lower temporal resolution because now the machine is automatically adjusting to listen longer in between. These are all the different factors that go into, that influence the way sound waves can influence your image quality.

Let's move on to how we can adjust them. Next slide, please.

Earlier, he mentioned that the most important adjustable settings include Gain, time gain compensation, or TGC, and also focus. Let's talk about each one of them in turn. Gain is the signal being received by the transfer user after it bounces off from the tissue and is interpreted by the machine into brightness versus darkness. This is just a global way to turn up or down the entire picture in terms of the brightness. This is frequently used to help improve visualization. If I were conducting an exam in the exam room and I choose not to turn off the light in the room, now the picture gets a little washed out from the light. I can turn off the game -- gain to Bruce that a marriage. To boost that image what we aim to achieve is the correct ayes pressure of the tissue. So, it is mostly dark with a marble appearance like a state. This will generally look hyperechoic. The blood vessel, it looks very seven and anechoic. We try to aim to achieve appropriate echo texture or appearance with different tissue.

Next is time gain compensation, frequently known as TGC, tangled golf Charlie. -- Tango golf Charlie. You can get a particular location where you can drag it to increase or decrease. Essentially, you can choose just a particular depth. Or all of them in all the separate from each other. You can modify each location independently. That is what differs it from a global gain change. Most will use this to change the brightness or the gain. Frequently, we use it to change the gain in the deepest portion. Recall that attenuation. So we may have a loss of sound beams due to the conversion of mechanical energy to thermal energy. Therefore, you have less returning from the depth no matter what. TGC is frequently away we tune and equalize the entire picture.

Next slide, please.

The last one is the focal zone. This is a setting that most machines have, but some may not. I am talking about even very nice machines. The truth is that the more advanced and probably standard instruments today are so advanced that they can tune this on-the-fly. This setting may not be available because machine has essentially taking care of this for you. It is available. It is useful. The focal zone comes in from the fact that even though we kind of conceptualize sound being as a plane of sound that comes from the ultrasound, in reality, that we just have X and Y dementia. There is also a Z dimension to a that means the sound being has depth. The common representation is just a credit card. It has about

one millimeter of thickness to it. That sickness actually is not consistent. That thickness undulate's. Where comes the closest, it is the most focused. It requires volume averaging. Therefore, the square in that Z dimension, where it is the narrowest is the focal point. By moving the focal point, the focal point can help you hone in and demonstrate a particular tissue well at a particular depth. It is useful to help when you are doing your diagnostic examination. You can help to localize, to really visualize a particular project well. For those who are, who have to interpret the ultrasound, re- frequently -- we frequently put the ultrasound below the depth of the target tissue. Above it, as I talked about the narrowest point, by lowering that focal point, you have greater with or depth of that sound being.

We talked about the concept of gain and the echogenicity. Let's define echogenicity now. We used the word hyperechoic, anechoic, hypoechoic. That is the amount of brightness on the screen. Hyperechoic is very bright. It is more white. Hypoechoic means it is darker, shades of gray. Anechoic means there is no signal, so it is completely black. All the tissue has characteristics, signaling densities. That gives them a particular appearance. That has to do internally with what is going on inside the tissue. For example, muscle, it is generally 27 -- hypoechoic. Think of that as a state. What do we have, structurally speaking? We have the muscle and it is surrounded by Paramecium. Those tissue, those are the tougher connected tissue, the more connected tissue. That goes into the tendon. So, there is the change of contrast because there is a change of the medium. So, it looks very hypoechoic and then you have these bright spots because those are the tougher tissue, so they are therefore brighter. Likewise, tendons are very tough, tough tissue. You will see very dense fiber and you are going to see that gray and you will show more of a hypoechoic. What about nerves? With nerves, we're looking at this. We will have the cell in some varying amount of mileage. It will have very soft tissue. The structures that hold it together will be your up in the area him and your parent Miriam -- your tendons. So tougher tissue. You have a honeycomb appearance that looks much darker than the outlines of each calm, which is brighter because of the connected tissue. They are brighter and tougher and therefore are brighter. Your goal is to optimize the visualization and the appearance of the entire field in order to correctly identify each tissue type.

Next slide, please.

With that said, the most important concept that has to do with echogenicity is the concept of anisotropy. It is an artifact by definition. If the appearance is an hyperechoic artifact due to the fact that the sound being is not reflecting directly back to the receiver, back to the transfer user, in a moment we will show an example. On this example, you can see you have the tendons. This is an example of a tendon. You can see, the left side of the screen on the top left image, you have sort of a hypoechoic appearance towards the face of the Beake. On the right side, the right-top image, you can see that I removing the transfer user to a different location. In order for the sound being to bounce back nicely to be received, the lesion is now normalized. If you look at the bottom left image, you can see that the bicep tendon -- earlier, I mentioned that tendons have hyperechoic appearance, right? In

the bottom right image, just with a slight tilt, now the being is not hitting on it at an optical angle. It is being reflected away and not being received by the transfer user. The tendon gives a hypoechoic appearance after the tendons have disappeared. This shows you how minute movement can make a very big difference. This meet even influence your diagnosis. The top two screen pictures, it is the difference between tendinopathy versus not. The most important thing to take away from these two slides is the fact that you cannot make a diagnosis of a hypoechoic lesion until you rule out other causes. You cannot make a diagnosis unless we can first rollout that that is just an MSK artifact. It is very important. There is often operator error. Also, there are many lesions within the ultrasound that have more of a hypoechoic appearance. Did I say hyperechoic? I meant hypoechoic. Are there any questions so far? We are about to go into a different topic. We will research this concept furthermore. Are there any questions so far? So far so good? Okay.

Next slide, please.

As I said, there are many lesions that have hypoechoic appearance. Probably the most important one that helps to really show help you make that determination or diagnosis, tendinopathy. That is the chronic tendinitis that is no longer inflammatory. Physiologically speaking, there will not be a high amount of infiltration by inflammatory cells. Rather, what you see is a disorganized bundle of collagen. Sometimes with neovascularization, there is some blood vessel in the area. They generally don't belong in tendons. It is a hypo vascular tissue. So that is an abnormality. This appears as hypoechoic in an ultrasound. As you can see on the screen, you can see that that is the patellar tendon. So just over the patellar area. The most superficial portion of that tendon fiber looks fairly bright as compared to the thicker, swollen appearing, and very hypoechoic portion. There is a distinct difference there. As you can see, you can even tell that the top portion, the more hyperechoic tendon portion as that normal appearing pattern. It delineates the bright lines very well. It appears organized. The brighter portions of the patellar tendon, you can see that not only is it hypoechoic, you do not see that real organized pattern, either. Physiologically, we mentioned that the tendon is now infiltrated with this organized collagen fiber. The more disorganized they are, the more scattering affect their business. There is also a well organized cell structure that allows really excellent echoes or returns of the sound being. Therefore, it will appear more hyperechoic. The diagnostic criteria are hypoechoic lesion, focal thickening, a cortical irregularity in the origin of the insertion, and minor features, to go -- too. That can be picked up by Doppler. Guiral so -- there also may be calcific lesions. It is a representation of injury, giving a chronic cycle of repetitive injury. This is where ultrasound truly signs -- shines. There are studies that have shown ultrasound has at least equivalent if not sometimes superior diagnostic efficacy when it comes to tendinopathy. And then you have the power these two at your disposal.

Let's go to the next slide, please.

Are there any questions so far? If there are any questions, please feel free to type. I will pause for one minute. Okay? All right. Let's move on. Okay. What I would like to do is to go over some easy ways, protocols essentially, to help evaluate, to help assess these common conditions. We will go over a few in the shoulders, some in the elbow, the hip, the knee, and the ankle. I want to provide you with essentially a point-and-shoot protocol to assess, to look for these lesions, okay?

Next slide, please.

We will start with the shoulder. We will talk about what subacromial bursitis looks like. We'll talk about rotator cuff tendinosis and rotator cuff tears and biceps tendinitis.

Next slide, please.

For rotator cuffs scanning, we will mostly be looking at supraspinatus. It is the most common offending or injured portion of the rotator cuffs due to the fact that it is pinched, you have to travel through a bony window within the subacromial space. Injuries most commonly start with [Indiscernible]. Due to the fact that you go through the subacromial space under that window, we need to position the shoulders specifically to evaluate that area. I would generally recommend this modified -- Crass position. I would scan right next to the patient so that, in this graphic, this patient has the left shoulder being evaluated. So the left-hand is on the left back pocket. I would pass and pushed through that arm to extend, extend it into a really extended position.

Next slide, please.

As you can see once the next slide comes up, you can see that. What it does is it brings the super soulmate it -- sublimated portion of the shoulder up to be evaluated. You want to probe across the anterior shoulder and toward the mastoid. It can stay in line for the most part.

Next slide, please.

What you are looking for is a pocket, okay? Let's see what this looks like. The most superficial layer is the skin. The next layer will be the deltoid muscle. After that, then we go to the deeper tissue.

Then that very bright layer is the cortex. It is very bright, very hard. The next layer is superficial to the right cortex, cartilage. Then you keep going. And then you are going to see a bright strip, superficial to that tendon. You will see something dark and yet another bright strip. Those two bright strips between the arose, that is the bursa. That is what situates in between this is a very dramatic picture of the bursa. It is actually thickening and complex. Normally, you will see a dark area. It is just one millimeter. If it is larger than that, if you relieve the pressure of the thickening, you push down and [Indiscernible - multiple speakers]. Again, you are looking for a space in between that bursa, okay?

Next slide, please.

In the same image now, we can now see the same position. We have the transfusion for the in interior shoulder at a 45 degree angle towards the mastoid. This is good to evaluate the tendon. You can see for tendinosis and impingement. You can look for thickening of the tendon. The tendon shows a gradual tapering. At that, he can maintain thickness throughout its with -- or length, sorry.

And then you can see some tissue that appears more hypoechoic. This shows our diagnostic criteria for tendinosis. You see cortisol irregularity. We are showing that.

Next slide, please.

Here is another picture with a different view. We really have some moderate thickening of the tendon right there. We can also appreciate that, if you look at the superficial tendon, there are two stripes. There are two bright stripes. You can see that those two stripes are separated from each other. There is a mild amount of active bursitis, as well. As we go more towards the left side of the picture, that peters out. This particular shot is not exactly in line with the tendon, but somewhat oblique orientation to it. We are seeing visually on the left side of the screen more of the actual muscle fiber. More towards the middle and the right, that is the part that is a good demonstration of a thickened bursa.

Next slide, please.

This is yet another picture I think that demonstrates it pretty well. You can see that there is focal thickening right there. It also almost connects and becomes yearly -- nearly indistinguishable. You can appreciate that the para bursal fat, there is a line that delineates the two layers. In this case, that is definitely within less than one-millimeter thickness. It is laudable. That would be a different story. A static image, it comes to ultrasound, it is a different image.

If we go to the next slide, we can talk about rotator cuff tear. We're using the same imaging position. Now we are really looking for cortical irregularity. On the left side, you can see that a single line now has more of a [Indiscernible] appearance. You can see that it is connecting to the defects. That hypoechoic region, it looks really hypoechoic. On the right side, you will see that you also lose that beak appearance and instead you get a tapered appearance. The contour just kind of becomes more of a sickle appearance rather than having that big dent at the base of the footprint. The entire thickness just tapers down into a sharp point. That is also the presence of a very significant tear. In fact, the one on the right side is a retraction. That entire insertion of the tendon is torn off on the entire footprint.

Next slide, please.

We have talked about in the last few slides the first few conditions for the shoulder, the bursitis, the tendinosis, and the rotator cuff tear. Let's talk about biceps tendinitis. Here, you will have the patient have

their arms down in neutral. The palms would be facing forward. Normally, the patient would be in this position I would ask them to put their hands, put their palms on top of their [Indiscernible] facing to the ceiling. You want them in a good anatomical position. And then if you start the transverse access, the picture on the right is where you see the injury. In between those two is the bicep. It overlies it and forms the bicep tendon. The tendon is very generally hyperechoic. The overlying deltoid, you also have the terminal tendon of the subscapularis coming from the very medial portion of the lesser cuticle.

If you go to the next slide, let's look at what it would look like in the pathological condition. Typically, what you will see is called a targets on. This is the anechoic rim around a tendon. In tendinitis, you can see that. The tendon will be bright, and the rim will be anechoic around it. It will be anechoic around it. This rim tends to get larger; it gets accentuated as you move distally.

As you slide distally, moving down the shoulder, if you see that there, you will see it gets brighter and brighter, larger and larger. That is because where the bicep tendon crosses the pectoral tendon, it axes as a pinch that prevents it from draining any further distally. So, it attenuates distally. Always be careful in anisotropy. We show that there is a graphic where we show that bicep tendon can disappear entirely. Be aware of that. By doing the tilt during this examination, we can see if the tendon goes from very the 26th two a more appearance, more hyperechoic. That can distinguish the tendon itself from the surrounding fluid. Next slide, please.

Let's move on to talk about the elbow conditions. I think the most common ones that we will see are the medial and the lateral epicondylosis. We will talk about these conditions.

Next slide, please.

So the scanning position is the elbow inflection. Depending on if you are scanning laterally or medially, you will either put the transfuse or in the long axis over the lateral [Indiscernible] or the medial [Indiscernible]. -- At the condyle -- epicondyle. For the medial epicondyle, the elbow will be at 90 degrees. And then you can have it flex and still have it come down for the medial epicondyle. Then you can visualize where it points to. Likewise, the medial epicondyle, the wrist flexure, it is pointing in that direction. Next slide, please.

This is what a normal lateral epicondyle will look like. It gives you that sort of end plate appearance, some of like what we saw on the supraspinatus a moment ago. Then you have this tendon that rests over the elbow joint and the radial set and the radial neck and you have the super Nader over the neck. And then we have a very superficial tendon. Generally, you will not have much tissue between the skin and the tendon. Very, very superficial. The tendon has that very organized hyper Cork appearance. You may also see some ligaments to the structure we have seen here. It is being pointed out by the solid triangle. That is actually the radial collateral ligament that bridges that.

If we go to the next slide, let's see what pathological tissue will look like.

You can see that on the top left, it is much more thickened. It is not a collateral ligament, but the entire tendon is more hyperechoic compared to the previous slide. The entire tendon is more hypoechoic. On the bottom left, you can see that the deeper portion really takes on a hypoechoic appearance as a distinct lesion. In this particular case, it looks almost anechoic. We can also evaluate this in transverse access. It is a small tendon, two or three fingers width. So, it can be between the two images on the left, the bottom left and the right, and then a partial tear. This brings back, this reminds me to mention the important concept to radiology, you need multiple views. It is really helpful. Diagnostically, but we're talking about today is in one single plane, but you are never wrong to get another view. You can alter your transfuse or 90 degrees.

Next slide, please.

Let's move on to the hip condition. We will talk about this. Obviously, that is a common condition that we see frequently in a primary care setting, an MSK setting. When we look at this, another hip condition we may evaluate for is pretty deep. I believe that this is a high-yield thing for us to talk about.

Next slide, please.

As many of you know, Ritter token to Eric Payne -- greater trochanter Eric Payne syndrome is the insertion site where it comes from the gluteus medius and the gluteus minimus and then overlying it is the I.T. band. and the pain syndrome is the bursitis, the inflammation of the bursa. Now that we know in the last 5 to 10 years, multiple MRI studies show that are commonly, probably 90% of your lateral hip pain is really a tendinosis rather than bursitis. The view that we are going to look for in this area, there are two views. The starting view that we will use is essentially a straight transverse access across the greater toe credit -- trochanter. That I look for that bony peak, which is a little harder if the patient is a little thicker, but generally pretty amenable. You put this in a transverse access just using the shaft of the femur as your access. Which are looking for with slight adjustments is this right bottom graphic. You will look for a Perley -- fairly sharp peak. But you have is the bony peak of the greater trochanter. And then you have the gluteus minimus tendons and the gluteus medius tendons. If you go back to the bony contour, it follows bony contour from the left to the right and you see a peak. It kind of drops off and you see that peak right there. That indicates the depth. It is conceptual. There is no inserting onto a. You do frequently have a bursa there that is actually painful. If the bursa were painful, the patient would have a posterior lateral pain rather than a lateral hip pain. Then superficial to the tendon, you can see a little mental structure indicated -- ligament structure coming from the right side of the screen towards the middle of the screen. That is what it would normally look like. Just by moving over the surface, then you can evaluate each tendon appropriately. Let's look at the next slide and see what that would look like.

The next slide, we can see this is the gluteus minimus.

Going all the way down to the bone, that is the anterior facet. The gives us a very good of that echotexture. You can see that at a certain point, it becomes more hypoechoic. The tendon stands out. As it stands out more, you will have increased [Indiscernible] right there. So you have the next layer of more hypoechoic tissue. That is your underlying area. Superficial to the TFL, you have thick tissue near the I.T. band. Or official -- were superficial to that is the subcutaneous band. On the right side of the screen, you can see that in transverse access. In a look indistinguishable. The tendon normally looks the same. Not an unimportant context is that tendons are generally best evaluated in the Long axis. Next slide, please. You have here gluteus minimus tendinopathy. It takes on a curve contour. That is not normal. That is indicative of thickening. Along with that, you have the velocity. You can see the particular texture is really reduced. It appears much more hypoechoic. Likewise, in the transverse axis, you can see that outlined by that double-headed arrow. You can see that tendon structure in transverse axis, it is much more hyperechoic. Tendinopathy is tendinopathy, right? We are looking for focal thickening, sometimes lesions.

Next slide, please.

Tendinopathy is what you will come across most commonly. I think in my decade of doing MSK medicine so far, I have only seen one gluteus medius tendon tear. So we are looking for a general deficiency of the tissue, specifically because with all the bleeding, you would get a collection of fluid through bursitis, which is indicated by the asterisks here. If you do see a bursitis, you get accommodation of the two pictures. We see that a small collection much like what is indicated by the asterisks on this graphic with core delineation from the underlying tendon and the overlying I.T. band, the tendon underneath look more like the two sides with normal appearance or abnormal appearance. That is what I.T. band bursitis will look like. Anything one millimeter or less in terms of death is considered physiologic. Next picture, please.

Next slide, please.

For the knee conditions, we will talk about patellar tendinopathy.

Next slide, please.

This is also a common condition. In our populations, I think it is a reflection of all the running, all the work that people do. More commonly, it is a straight up clinical diagnosis. But I think ultrasound does add to buy-in for the patient. The patient knows that the knee is not broken. So often, I have patients come in who, the pain can be a little more vague and they are worried that if there is a joint, the joint has fractured off and they have free-floating cartilage going somewhere. And then you poke at them with your examination to rule out particular issues. Than the pain is very specific to the tendon and you put a transfuse or on there. Will want to do for the imaging, the

transfusion has access to the tendon. Mostly, the proximal portions of the tendon is the pathological portion. That is where we will try to spend more time on. If you go to the next slide, you can see what a normal patellar tendon will look like. The left side of the scene is proximal. The right side is distal. So, we have a contour of the patellar. Then you have that tendon bridge across until it reaches the tibia plateau. The tendon, as you can see, it actually has two layers. The more superficial portion actually runs over the sharpness of the patella. Then you can see is somewhat delineated. There was not a portion that has that feature, that superficial portion. It has a little bit of an echogenicity. That is the ligament portion. The patellar tendon has a superficial portion that is in continuity to the tendon. And then a ligament portion that is just going from the patella to the plateau. The difference is what makes the patellar tendon, the tendinopathy target it. There is less tissue to disperse the force. It is more commonly injured. Very quickly, the other graphic on the same page is what the tendon looks likes in transverse axis. It has a hyperechoic appearance. Other than that, I think the one thing we can really appreciate is how large the tendon is. This is one of the larger tendons in the body. So let's go to the next slide and look at what a pathological one would look like.

We kind of see this. We have seen this picture before. This is a tendinopathy of the patellar tendon. The proximal portion is generally the preferential area affected. It preferentially affects the tendinosis.

Can everyone still hear me? Okay. Let's continue. Sorry about that. I think we are back to action. Let's continue. I was saying a moment ago that the patellar tendon gnosis preferentially affects the ligament portion. That is the D proportion of the patellar tendon. It preferentially affects the proximal portion of the tendon just coming off the [Indiscernible] of the patella. You can see it sort of circumscribes the closing portion of the patellar tendon that is more hypoechoic. Even the more distal portion to the right, the distal portion of the ligament portion of the patellar tendon has better echogenicity and better fibular appearance. In transverse axis, we have two graphics combining into one in the right lower graphic. You can really see that that tendon pathology can be very distinctively affecting just the deep, ligament portion of the patellar tendon. Sometimes, they can get large enough to affect the entire thing. Usually, it is localized.

Next slide, please.

Now I think what is unique about the patellar tendinopathy is that I think it has a higher incidence of calcific patellar tendinopathy. That occurs when there is chronic reinjury as a pattern. It can be a minuscule calcium in the body that looks brighter and casts a shadow as shown in he left lower picture. Or in the right lower picture, it looks like a spectral. Then you can see a hypoechoic shadow. There is so much being bounced off that the tissue gives you that hard structure that does not provide much in sound waves. Sometimes it can be very significant such as shown in the left top picture. It almost looks like a BB gun BB. And then some lesions might spill out and [Indiscernible]. Or it is a distinct lesion that was there. That is what that will look like. In calcific tendinopathy, as many of you will know, it really shows a

complex picture in terms of physiological for what is happening. For noninflammatory, a tendinosis process, there is also an inflammatory process with the calcific lesion. It really changes the treatment process.

If we go to the next slide, will we have here is an Osgood-Schlatter disease within a large, specific reason. You can see that instead of being a sort of flat surface that we saw a couple of slides ago, now it takes on a bulging contour. Also, we have that large calcific body that is embedded in the tendon. The tendon itself does not look too bad. There is a bit of change that comes from this. It does not look horrific. But actually, in this case, in this particular patient, it definitely was pathologic and painful for the patient. You can also see the presence, if you trace the tendons starting at the bony edge of that body, you can see that there is sort of a pocket near the interface of the tendon and the underlying [Indiscernible]. That is enter patellar bursitis. This is a very inflamed tendon and bone complex.

Next slide, please.

Let's talk about in condition. -- Ankle condition. Achilles tendinopathy, it is important for us. As a bipedal animal, it is subjected to a lot of forces. It is a confluence of two of three major muscle groups. You just pull the transfuser over. The tendon is very superficial to the skin. There is not very much fat at all. You see the tendon displaying a normal fibular pattern but looking more hypoechoic. Frequently, as we normally, our angle relaxes and that foot, the tendon goes into a curve. Whenever you have a curve, one element of the exam is to passively hold up the patient's ankle in a normal position at a 90 degrees angle position, a neutral position to minimize the curvature and facilitate during that. Despite the curvature that you may encounter in the Achilles tendon, Norman looks more hypoechoic. I think that is actually normal. We can certainly also look at it in the transverse axis, as well.

Next slide, please.

In the tendinopathy, the tendon will be much thicker. The Achilles tendon is certainly long. We are looking at 10 centimeters worth of length to work with. The swelling will be notable. If you scan up and down the tendon, you will see the painful portion distinctively has different caliber compared to the rest of the tendon. The diseased portion can either be insertional or on the side of the insertion site, or what we call mid substance. It takes on this hypoechoic appearance, all the things that we look for in tendinopathy. On Doppler, not infrequently, you will see an increased Doppler signal. So that is what tendinopathy will look like. On examination, it is frequently not hard to tell. The tendon will appear thickened. It is ropey and lumpy and painful to the patient when you squeeze it. Many of these exams really help you improve the buy-in from the patient, with Achilles tendinopathy hurting so much that people think they are ruptured. By demonstrating to them that the tendon looks diseased, but it is still in continuity, it helps the patient to think about initiating their rehab.

Next slide, please.

When the tendon can rupture, this is where ultrasound truly shines. By scanning through the width of the tendon, you can find if there is continuity in the tendon. Sometimes it may be hanging on by a thread. Other times, there may be a collection of hematoma, very hypoechoic, abnormal appearing tissue that forms a tube so looks most like the tendon is in continuity. That is just a segment of it that looks somewhat abnormal. This is where it is helpful to do a dynamic exam. You can see if the tendon moves appropriately given a possible false-negative Thompson test.

Okay, next slide, please.

The last condition that we will talk about is plantar fasciitis. It is very common and generally very amenable to appropriate rest, appropriate rehab. Unfortunately, in the population that I treat, that may be hard to come by. Sometimes it becomes a recalcitrant issue. Scanning is very simple. You put the transfuser on the bottom of the foot, one end over the calcaneal tubercle. Then you are looking on the right side of the graphic on the lower side of the slide. You are looking for that figure ligament structure. That's go through the tissue layer by layer. The most superficial is a very dense tissue of the sole of the foot. Then you have to have ligament appearance structure that originates on the bony structure underneath. That is the plantar fascia. So there is a curvature to it that frequently gives a fairly -- so frequently the ligament can be subject to a lot of [Indiscernible]. And also, non-frequently, the kind of slopes down. There is quite a bit of angulation to a. That can be overcome just by you hearing nicely to the curvature of the heel. Instead of planting the transfuser square onto the heel, try to push down into the medial arch area. That can flatten out the tendon, the plantar fascia base to go directly across your screen rather than taking on another appearance. That can help minimize the issue. Let's look at what the pathological appearance would look like.

Next slide, please?

On the screen on the right side, on the left side is a normal plantar fascia. Is outlined by across. We can see that the plantar fascia still has that tenderness ligament appearance, denser and darker than what a normal a tendon will appear. On the right side, it dramatically thickened and really has lost tremendously the fibular texture, the echotexture. It is much more hyperechoic. More importantly, if you measure it, you will see that on the graphic itself, the asymptomatic measure of three millimeters and the right side is measured at 7.5 millimeters. Studies have shown that the diagnostic work area, anything greater than five millimeters is diagnostic, in terms of thickness, is diagnostic for plantar fascia I just on an ultrasound. Coupled with a clinical presentation and also the other criteria for abnormal ligaments, that can tell you that you have the graphic findings of plantar fasciitis. On the right side of the picture, it is also notable that you see a round contour of the cubicle. It is almost a sharp edge. That is fractional. Again, that is indicative, a reflection of the physiological process. The tissue is under tremendous amount of stress.

Next slide, please.

In summary, we have talked about basically why we should be doing musculoskeletal ultrasound. We talked about how it can help us evaluate in real time, evaluate in high visual resolution how we can use it to help confidently help you take a further step towards your diagnostic confidence and help you determine how you take a step in the diagnosis and initiating your appropriate next step, your diagnostic study that you want to order or your treatment or consultation. It gives you clinically actionable information right there on the same day so you can start helping your patience. It also truly helps patients to form a reporter with you, they see -- form a rapport with You. The patient respects your clinical knowledge, that you show them that you help them build confidence in you. You know what you are doing. It absolutely helps them.

We went over protocols for a number of procedures throughout the body. Obviously, this is a very small fraction. It is a small fraction of the things you will see in clinic. I hope to give you a primer to help you get started. Certainly, with further training, there are some amazing things that I have seen people using ultrasound to help them in terms of making the diagnosis and also with doing guided intervention. Study after study has demonstrated better accuracy and also better clinical efficacy. Lastly, understanding how to use this and what kind of image you can be receiving and understanding how to use the image adjustments that are available to you on the machine. And also understanding how the different artifacts can interplay with your image. All of those tie into optimizing those factors. That will give you success in examinations.

If we go to the next slide, here I will give you some resources for further development. By any means, I don't think what talk about today is the end all, be all. I encourage everyone, whatever level your experience may be, to please check into these different resources. So, there are numbers of websites available that we have that provide free training. The first one, you can download this on the website. They have training modules and diagnostics. There is a certifying body for registering musculoskeletal ultrasound. For those of you who want to pursue that, that would be terrific. If you are able to do RMSK, it is a certification body. The training is very doable. For those of you who want to further develop in musculoskeletal ultrasound, that is definitely the gold standard to shoot for. Okay?

Next slide

There are some resources of textbooks that I have come across. A number of them I believe are available in a library if you have access to that. If you wish to purchase them, they are absolutely worthwhile. That first book is how I learned ultrasound. If you can do 75% of what that book says, you can confidently tackle probably 90% of your clinical encounters. You can definitely pass the RMSK certification exam. And then there are a few other books. Another book that is just as valuable is the second book, the Moeller, the Atlas of sectional anatomy. This book is also available, I believe, in the library portal. Essentially, it is a

sectional analysis. It is how people learn MRI. It is a sectional anatomy just like, Wright is sectional anatomy. And then my arsenal of knowledge, besides the study and the learning, the book of the study came from the Jacobson and Moeller textbooks. These two will take your gain to the next level.

Next slide. That is that. Are there any questions?

Let me answer the questions. I apologize. Sorry. The first question was, how do you accomplish local radiology? As I was saying to myself earlier, I think most people, most radiologists that I have interacted with have no problem with that. You work with your own chart. You are doing a limited graphic exam. You are claiming credit for the performance of the examination. And if you have done a limited interpretation saying this is a musculoskeletal exam for pathology affecting only a certain joint, then when the -- and that is okay and generally radiologists have no problem with that. Everyone can read the MRI and give their own interpretation. This is very much like that. If you are able to upload, but a lot of my radiology departments that I interact with, they are happy to read it. It uploads automatically and musculoskeletal ultrasound exam, there is generally no pushback, okay?

The next question is, what do you like to do for your tendinopathy first? If that fails, what do you do next? This is not in the scope of our conversation today. But I am happy to address that. Frequently, a lot of combinations, injection is not reasonable. To do a steroid injection for tendinopathy, the effect can be limited in terms of the intensity and tends to be limited in terms of duration. Studies have shown that a 3 to 6 wake improvement can probably be reasonably expected. And why you are still in the early states of treatment, I think it is reasonable to facilitate rehab. You knocked down pain come at you facilitate a participation in rehab. There is in reality a lot of lesions or conditions that are very amenable to steroid injection and to rehab, to conservative rehab, to therapy. If that fails, my next go to tens to go to various Biologics. I will say this. For the most part, POD is my go to. We try to affect it at a tissue level. We try to improve how the bodily action remodels around the lesion. I tell patience it takes nine months to build, so takes a few months to try to heal some broken or diseased tissue that would otherwise not heal by itself. A tendon does not heal. It is important that the patient understands that they have to buy in, that they have to continue with therapy. Other factors often play into this treatment. Where they and their career quit where are they in their cycle, right? Do they need to immobilize? Do they need to be functional very soon? Are they about to go through a test? Are they about to go to a school? Those are the elements that frequently play a factor. And then there are numbers of tendinopathy conditions. Right now, we are developing some radiofrequency treatment for them that will help knocked down pain. But the goal is still to knocked down the pain and then support rehab. I hope that answers the question. Are there other questions? Okay, there is another question. Today, we discussed the point-of-care of different anatomy. How integrated is it with the patients? When the patient buys income that is great. Ultrasound really plays a big part in my clinical flow. During my introduction, I am a

fellow. In my normal path, I have machines in my -- clinic. The majority of my patients will get some examination within the first or second encounter. Again, I am trying to maximize all the different things that helps us to. It saves money because I will be less needing to order MRIs. It will save the patient time and frustration and help to minimize the pain syndrome, because I expedite the care and I am not waiting for more information, waiting for an MRI in order to determine whether or not to send the person to a specialist or initiate a wider treatment. The patient by you and is humongous. I see and understand what they are looking at and what is going on in their body. It helps tremendously with rehab. It is very important you talk them through what you are doing, right? I always tell them what is normal and nonnormal.

So an 80-year-old patient will probably have arthritis. Whatever joint you are looking at, there will be arthritis. Is arthritis always the cause of pain? We know the answer is no. I frequently find that telling them what is normal and what is not normal but okay, that is actually the most therapeutic fortune for the patient. Lastly, I will use the ultrasound as a tool for guided intervention. Since I started this fellowship, the bulk of what I do is injections and guidance. That is yet another thing to send off to other specialists or take care of myself. That really improves my patient flow.

Here is the next question. Can you recommend resources or textbooks for guidance about injections with and epidural block?
Yes. There are numbers of different kinds of textbooks there are a bunch of great textbooks that go in this area. I would say you should certainly think about -- if you ask the question, I am sure you have a lot of competency in this area already. I will not tell you what to do or not to. I would recommend everyone work on their competency. Please consider in terms of whether or not you want to use ultrasound or other tools, just always consider the advantages and its advantages of the different tools. There are plenty of epidural options. They are validated using ultrasound and can probably be done very safely. I would also say that epidural ultrasound, guided technique for epidurals, the problem with ultrasound, I would generally not think of it as the most optimal to oral -- optimal tool for ultrasounds. We can have this conversation off-line. I will find you the textbook. Are there any other questions? Give me one second. I am still typing the book, the link to the book. Here is a link to the book from the publisher. It goes over all the things that you were asking earlier, that was asked about earlier. I am not sure if this is available through our library. I think it is, I think if it increases your clinical management option by that much, it is worth spending money in my opinion. Are there more questions?

Dr. Holmes says this is a great resource. Sam, thank you for your endorsement. I use it frequently myself, as well. Dr. Holmes is a pain fellowship trained position physician. If he endorses it, it is more than good enough. Thank you, thank you. Any other questions? Anything else I can help elaborate?

Okay. It looks like there are no other questions. I will turn it back to the host and I want to thank everyone so much for your participation. My contact information is available. Please feel free to reach out any time.

If you have any questions regarding the evaluation, recommendations for textbooks, I have read quite a few, unfortunately. I spent a lot of money getting them. I certainly make some recommendations. And also, for those of you who are doing a lot of interventions, I have procedural notes available, as well. If you like to see what they look like and maybe adapt them for your own clinical use, feel free to reach out to me, as well. If there are no other questions, I will turn this back to A'riel.

Thank you for joining us, everyone. Thank you, Dr. Chen. You can send me your names if you are able to not download the sign in sheet. If you are able to download it, thank you very much. You will receive credit for today.

[Event Concluded]