Therapeutic Modalities: Ultrasound

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- [Fawn] Today's course is therapeutic modalities: Ultrasound. Today's presenter is Dr. Scott Cheatham. He is an Assistant Professor in the Division of Kinesiology at California State University, Domingos Hills in Carson, California. He's the owner of Sports Medicine Alliance. He received his Doctor of Physical Therapy and his Doctor of Philosophy in Physical Therapy. He is a Board Certified Orthopedic Physical Therapist and a Certified Athletic Trainer. He also holds several fitness certifications and is a Certified Ergonomics Specialist. Dr. Cheatham is a national presenter for various organizations and has authored over 100 peer reviewed publications, textbook chapters and several home study courses on the topics of orthopedics, health and fitness and sports medicine. His professional responsibilities include; being an associate editor for the NSCA Strength and Conditioning Journal, Journal of the Canadian Chiropractic Association and a manuscript reviewer for several other peer reviewed journals. He is an education and research consultant for various health and fitness organizations. His research interests include myofascial and interventions and the efficacy of interventions for various musculoskeletal pathologies. His current clinical practice includes; sports medicine services, general orthopedics and sports performance training. Welcome back Scott. So glad to have you.

- [Dr. Cheatham] Thank you, Fawn and I would like to thank the team at occupationaltherapy.com for providing me this opportunity to speak to everybody here. So everyone welcome. I'm glad you're here. This is our second presentation in a series on therapeutic modalities. Let's get kind of into the good stuff. Just from the start, I wanted to disclose that I am getting an honorarium for this course but there I do have no financial or other conflicts with this presentation. All the material used in the presentation has been provided with permissions or cited properly. So for myself and again, thank you Fawn for that great intro. Besides me teaching at the university and being a researcher, I'm also a clinical owner. So I have a current orthopedic practice, but also though too, especially important for this course is that I'm also an adjunct faculty in the master's of occupational therapy program at Cal State Dominguez Hills.

The focus of this talk is really gonna be how ultrasound can be used in a treatment strategy specifically for the occupational therapist. So I'm gonna do my best to kind of try to blend what I learned as a faculty member and what I still teach in the MSOT program. But also I want everyone to consider, especially as we get into the topic of ultrasound, how does it fit into your general treatment strategy for patients with different conditions? And I think that that's gonna be an important part because in this two hour talk, we're gonna be digging into a lot about ultrasound, but I want you to think about how it kind of fits in to your regimen and how can you use it as one of the tools in your toolbox. So before we get started kind of with the content of the presentation, there are three learning outcomes that I would like participants to be able to obtain. And the first one is to be able to discuss the scientific and physiological principles behind therapeutic ultrasound.

Also discuss best practices for therapeutic ultrasound for different musculoskeletal conditions and also discuss the indications precautions and contraindications in any adverse events for therapeutic ultrasound. Now, when we look at the agenda, I wanted to kind of premise it first is that as we all know, the science and the application and research of ultrasound is very comprehensive. I did my best to try to find a balance between the science application, research, hygiene and documentation in a two hour kind of concise presentation. So just kind of remember from the onset that there's textbooks out there and there's other research articles and stuff that may go more in depth into the topics and stuff. So let's kind of consider this a nice, robust overview of this topic. I wanted to kind of premise that from the beginning because we're gonna cover all the essentials but if you have a desire to dig deeper into this topic, you guys can email me afterwards and I can send you guys some resources that go super deep into the physics, the science, et cetera of the topic. So now let's start with module one, the basic science. And I think this is important to set the tone for the discussion because we need to really understand how ultrasound works so that when we apply it to a patient, we know when and where to sequence it in our intervention. And I think

that that's an important topic. But before we get into the science though, it's always great to look at the history of therapeutic ultrasound. Now, if we look at this slide from left to right, we can see that ultrasound was ultrasound waves was explored all the way back in the 1930s for medical purposes. They first tried it for looking at imaging, back in the thirties, they tried for different type of therapeutic medical purposes, but then it wasn't really established too much. And then about 20 years later from the 1950s, that's when we started seeing a separation of the different ultrasound waves. Some for imaging and then also some for therapeutic purposes.

And so in the 1950s, we started seeing the advent of therapeutic ultrasound primarily used for tendinopathy or tendonitis and also bursitis conditions. So between the 1930s and the 1950s, we started seeing some of the research start coming out about this technology and how it can be used therapeutically for patients. And then as we kind of fast forward almost 30 years, we can see from 1950 to 1970, the technology, the understanding of ultrasound waves and the application pretty much became worldwide in the 1970s. And so that's when I believe kind of at least what I learned from the legends in OT and PT and stuff. That's where in the 1970s where it started being used on a regular basis as one of the many modalities that we use. So then from 1970 on, we can kind of agree that ultrasounds kind of a staple or a tool in your modality toolbox that can be used on a regular basis or occasionally with different patients. So it's kind of interesting to see the history because when we look at all the research, there's a huge body of research that began kind of almost like in the 1940s, there's some early reports and then it has progressed from today. We have this huge body of research discussing the evolution, the progression of therapeutic ultrasound technology. I think that that's always great to kind of start with to have an understanding for that. Now, another thing to consider too is and I mentioned this quite a bit in our first presentation in this series was that we always have to consider the phases of tissue healing. If some of you had watched the first presentation, I really made it a point to stress that if someone has surgery or someone has an injury, the body interprets it the same way

and it goes through this time dependent process of healing. If you look in the literature, there's typically three phases. The inflammatory phase, fibroblastic phase, and then the maturation phase. And that could be anywhere from one day, all the way up to two years. And so within each phase, I think it's so important for the occupational therapist to consider three main points. The first point is when is the optimal time or phase. When is the optimal phase to use ultrasound during a patient's rehabilitation program? I think that that's important to determine.

Consideration number two, how will ultrasound enhance the tissue healing process and the patient's overall recovery. And then consideration number three. What is the optimal sequencing of interventions with each client including ultrasound or modalities. And I think that these three points are important to consider because I don't know about all of you who are listening and participating in the lecture, but I've seen more of a trend where modalities aren't so much a primary treatment, unless someone's maybe acute or it's for a specific purpose. It's one person piece to a comprehensive intervention strategy. So I think it's important to facilitate and use your modalities correctly. You have to introduce the modalities at the right time within each phase to help facilitate healing function movement and the whole person. So from an occupational therapist perspective and looking at the biopsychosocial model and all that, how does ultrasound in your treatment regimen for each specific patient kind of the door for more function, more confidence. A quicker healing process. I think it's important to remember these three considerations as we go through the lecture today because that's gonna help drive your decision making. So your clinical decision making should be when and where to apply the modality to stimulate some physiological process. And I think that that's kind of the newer thought process versus everybody as we know in the old school clinics, PT or OT. I used to work in clinics as an aid, honestly, where everyone got ultrasound and hot back and STEM. And those were for billables and all that.

Well, that as you know, there's some ethical concerns with that, but also though, too, the insurance obviously caught on and they're giving you what? Six bucks to do STEM or ultrasound or whatever. They're not paying very much. So that's where the newer thought process is, is that we use modalities when we need to, to help facilitate some type of outcome. I think that that's kind of a nice overview as we get into the science now. Please consider those three as we go through the lecture and also how you can apply it to your patients. Now let's kind of get into what is therapeutic ultrasound. So on this slide, I just put an image or just a basic ultrasound machine. When we look at the image on the left, we can see that we have our normal. We have our normal digital display. We have our buttons with all of our settings, but most important though, we have a soundhead where the electrical current goes into. When we switched here, I want to show that this is important is that the therapeutic soundhead. The therapeutic ultrasound soundhead is where electrical current goes up here and then it's converted to a mechanical ultrasound energy, and it's coming out the face or the flat part of the soundhead. And I wanted to stress that to where the soundhead is perhaps the most important piece of the ultrasound equipment, because that's where electricity is converted to mechanical ultrasound energy. And that's our first kind of scientific concept.

Now, when we define therapeutic ultrasound in this slide, we can see it's a high frequency sound wave used to induce a biological response. Inside the soundhead, or some people call it the transducer or the applicator is a crystal inside the soundhead. So if I go back to the slide, we can see this metal part, there's actually a crystal inside. I just want to make that point that there's a crystal inside. So basically the AC, the alternating electrical current is driven into the soundhead. The AC current strikes that crystal and it causes the crystal to expand and retract which creates a sort of vibration. The change in the crystal results in a transmission of a ultrasound wave that compresses and rarefracks. So if we look at the image here, we can see down here, that the electrical current is gonna strike the crystal. The crystal is gonna compress

and rarefract, which is come apart. So you have this crystal moving, this transmits an ultrasound wave from the surface of the transducer and the ultrasound wave that comes out, replicates the compression and the rarefraction or coming apart of the crystal sound wave. This ultrasound wave coming out has parts of the sound wave that are very compressed, parts of the sound wave that are far apart or what are called rarefracted. So as the crystal is expanding and retracting, the ultrasound wave or beam that's coming out is reflecting that crystal moving. It's a dynamic, consistent wave that's actually coming out. And so the big thing to remember, the take home for this slide is, is that because the crystal is moving and it's driven by electricity, there's a conversion from electrical current to mechanical energy and that results in a sound wave that's compressed and refracted as it's getting driven out of the soundhead and so that's kind of the take home here. When the soundhead or the ultrasound wave is applied to human tissue. It goes through a process called attenuation and the term attenuation is reduced energy as it passes through the different bodily tissues.

So if you guys are writing some notes and stuff and there may be some new clinicians here who are first kind of learning about ultrasound, or some people who need some review. Let's go over the aspect of attenuation. Now, when we look here at the diagram, this is the tissue interface. The tissue interface is typically like the skin. So as the ultrasound wave strikes the skin, some of the wave is gonna reflect off of the skin. Some of it is going to refract, and then some of it is going to be absorbed or transmitted into the deeper tissue. So we can see that as you're passing the soundhead over the skin, the ultrasound wave is gonna be bouncing off the skin, but also it's gonna be absorbed by the tissues. So this whole process is called attenuation where the ultrasound wave is gonna be reduced because some of the wave strength is gonna be lost because some of it is reflected and refracted, and then some of it is absorbed. I think that that's important to understand as we are doing treatments and stuff, because that's why we always move the soundhead and that's why we have different settings to try to get into deeper tissues or more superficial tissues. So our

next concept is the ultrasound wave in the body. So very simply, there's different tissues of the body that absorb the ultrasound energy more and very simply high collagen tissues absorb the most energy.

So for example, ligaments, tendons, fascia, joint capsule and scar tissue all seem to absorb the energy the most. So if you look at the body of ultrasound research, we see that ligament and tendon issues, plantar fasciitis, they seem to do pretty favorable with ultrasound. Now more dense tissues like bone and cartilage tend to reflect the energy off of them. So really simple. Again, if you guys are writing notes, this is a great take home is ultrasound likes collagen, and that's how I believe in that. So ultrasound seems to do really well for these collagenous structures versus trying to go over bone or even cartilage. Another thing too that we want to consider too is muscle is so dense. A lot of energy is lost in the muscle. So heating up a muscle is not always effective as more collagen tissues that absorb it the most. So you may want to make a little side note that the layers of the muscle inside the sarcomeres and stuff. You tend to lose a lot of energy trying to heat a dense muscle. So it's more of the collagenous structures that tend to react favorably from ultrasound. So then as we move forward in our kind of scientific review, there are two types of ultrasound waves. Now, remember back in the prior slide, we're saying okay, the ultrasound wave is created by a vibrating crystal. It transmits or shoots out a ultrasound wave from the soundhead. Well, there's two types of waves. You can have a continuous wave where it's 100% moving all the time, and then if you look below on the diagram, you can have what's called a pulse wave or a pulsed wave. A pulsed wave gives you a latent period or a rest period in between ultrasound waves. So there's actually a gap between waves. Depending on what your setting is for your ultrasound, you can use a continuous wave or you can use a pulsed wave that has a rest period in between to stimulate different physiological processes in the body. I think that that's another important point on when, how, and where we do ultrasound with patients.

Let's look a little bit deeper into these sound waves, into these different type of ultrasound waves. Continuous is basically considered a thermal effect because the ultrasound wave is striking the tissues. It's striking the skin and the tissues and being absorbed at 100% consistency, that causes more of a thermal effect. And so there's a lot of studies that have looked at continuous ultrasound and have clearly shown that it heats the tissues locally. A couple of degrees and it creates more of a thermal effect. Now, obviously for you to have a goal of heating a patient's tissues, it's gonna be affected by the intensity. How strong you set the intensity, the frequency of the wave and also the tissue type. So we understand that maybe a ligament, might heat up quicker than trying to do a big dense muscle. So consider continuous is thermal. Now pulsed is non-thermal because if you think about it, there is a latent period or a rest period in between each sound wave that allows the tissues to cool down a little bit, depends on your setting, and we'll talk about that a little bit later. So pulsed non-thermal is mainly used to create a mechanical effect in the body. So think about this. We're not trying to really heat up the tissues too much. There's always gonna be a little bit of obviously temperature change, cause you're creating this effect but we're not going continuous.

As we go pulsed, our goal is to create some type of mechanical movement in the tissues and cellular structures. So scientists have found two actual physiological responses from pulsed ultrasound. And one is called cavitation, where you get obviously that vibration and we know that's being caused by the crystal. The crystal's moving is sending out this sound wave that has compression and refraction. That's striking the tissues. That's creating this mechanical vibration, it's being transmitted in. So as the tissues are absorbing this pulsed energy, they're creating vibration of these gas bubbles inside the tissues. The goal is to create what's called a stable vibration by moving the soundhead and being safe and not creating any unstable where the settings are too high or the machine is faulty. So the goal is to kind of create these cavitation where it's a stable cavitation where we're getting some vibration and

movement. Along with this cavitation, the pulse ultrasound also creates what's called acoustic streaming. As the ultrasound wave is being absorbed by the tissues, it's stimulating movement of fluids along the boundaries of the cell membrane. And so scientists have found out that that increases fibroblastic activity, intracellular calcium, the sarcoplasmic reticulum, or the golgi apparatus, et cetera. We're getting that intracellular calcium, alterations in cell membrane activity and wall permeability, and also increases in protein synthesis. From the powerhouse of the cell. So we're getting that mitochondrial stuff and all that good activity from the non-thermal effects. So again, we kind of have developed two approaching treatment strategies for therapeutic ultrasound. So one is continuous thermal, the other one is mechanical non-thermal.

And the question is when and where would you use those settings in your patient's treatment strategy? This mode of heat transfer is called conversion. We discussed this more at length in our first presentation, but I wanted to bring this slide up again just to show that it's a conversion of that electricity to mechanical energy. And so if we look at the bottom, very two big points. Non-thermal is typically a pulsed wave, it's used for mechanical. Thermal is a continuous wave and it's used to heat up tissue. So just remember that the physics behind it is conversion, which is a conversion of non-thermal energy to heat. That's the vibration. So the sound wave is vibrating sound, it bounces and transmits and out the tissue, that creates heat within the tissues. As we look at some of the physiological occurrences, what happens with continuous thermal? If we go clockwise here. If we go clockwise along the diagram here, we can see that the research has shown. Research has suggested that ultrasound decreases pain, muscle spasm, increases blood flow locally. It can decrease scar stiffness, increase nerve conduction velocity locally, increase local metabolic rate, decreases joint stiffness and increases soft tissue extensibility. So we can see that basically ultrasound, it's gonna penetrate deeper than a superficial hot pack, but it's gonna have similar effects. It's gonna heat up the tissue and make things more pliable. So it's pretty much that simple. But I also want you to remember though too, even if you're

using a continuous 100% cycle of ultrasound, you're still gonna have a thermal and a mechanical effect. It doesn't go away. Both of them are gonna have mechanical. Just kind of consider that is that a lot of these physiological responses are a combination of the thermal and mechanical. As we looked at pulsed non-thermal, it's primarily used to promote tissue healing and repair. It's beneficial within all the tissue healing phases, but also too, post ultrasound is used to drive transdermal drug delivery or we call it photophoresis.

I'm sure everyone here has heard of that before, where you'll take some type of nonsteroidal antiinflammatory, or even a corticosteroid like dexamethasone, you put it in some gel and the ultrasound will drive it into the tissues and stuff. That's where pulsed ultrasounds used the most is really to promote tissue healing and to drive medication, but not so much creating a thermal effect. The next principle that's important to understand is that air is a poor conductor of ultrasound energy. So some type of conduction media or medium is needed to maximize delivery. So typically, we'll use ultrasound gel. Like a gel pad, you can use mineral oil, different lotions, or you can do water immersion. Any of these mediums will help transfer the ultrasound wave into the tissues because when the ultrasound wave is shot through ambient air, it gets struck with other particles in the air and other things and it's a poor conductor. So rule of thumb is you have to have some type of gel or oil or lotion to be able to transfer it successfully into that tissue interface in the body.

Another conductor that's popular is water immersion where you can stick someone's ankle in a plastic tub and then you stick the ultrasound handle in there. But just remember, if you're in a metal tab. It sounds kind of weird, but don't do it. Because the water turns into a complete conductor. I wanna definitely kind of impress upon everybody that the different media are important but typically ultrasound gel is probably used the most out of everything. I think it's important to understand that we have to use a media to heat up the tissues and stuff. So bottom line for module

number one. Is that ultrasounds transfers energy from the ultrasound head into the tissue interface by conversion. Ultra sound creates a thermal effect and a non-thermal effect. High collagen tissues absorb ultrasound energy the most and then a medium is needed to transfer it successfully into the tissues. So please remember that because as we get further along, we're gonna talk about more of the application of things and we will talk about how it applies to different things. So I do see a couple of questions coming through. I think we'll be able to answer those in the coming modules. So hang in there everybody. We're almost there.

Now module number two is, I like to do this especially early on in the lecture is very important is what are the indications and contraindications? Ultrasound as we can see in the research has several indications; pain modulation, treatment of soft tissue shortening. That means like a tissue contracture or someone has a tight joint. Dermal ulcers, surgical skin incisions tendons and ligament injuries, fractures, carpel tunnel syndrome, and obviously driving medication through the process called phonophoresis. So we'll talk about the clinical application of those here in a little bit but those are the main indications in the literature. Now ultrasound has been used for other things, more therapeutic but those are the main things that have support and the evidence. And so those are important to kind of hang on to when you're looking at using ultrasound as part of your treatment strategy. So now when we look at precautions and contraindications, these follow along with a lot of the other modalities, and when you look at general precautions, obviously acute inflammation. Epiphyseal plate are very controversial. If you look at the research, there's a lot of older studies that say that if you ultrasound over a plate, you might stimulate early growth and the sealing of the epiphyseal plate.

So there's some controversy there, but I think the standard of care is you stay away from that in a growing kid. Pretty simple. Now fractures are also precaution, but there are some super low-level ultrasounds that are used to heal a fracture and we'll cover

that in a second. We also have breast implants and then obviously poor mentation. If the client lacks cognitive ability or they can't feel what's going on and stuff, that's definitely a precaution to make sure it's safe. Now, obvious contraindications is especially for therapeutic because it's not ultrasound sonography, it's totally different. So we need to be careful with doing therapeutic ultrasound around a pregnant woman's stomach area, also any type of malignancy over nerves, veins and eyes, obviously. Joint cement and plastic, that's another one that's controversial because some orthopedics feel that it's okay to do ultrasound around a knee replacement and so some do not. I've used it before more like in the popliteal fossa or the distal hamstrings, but I've never done ultrasound directly over a knee replacement approaching it from the anterior or lateral part where it's more superficial. That's just something that I've used other things like a hot pack if I wanted to soften tissue before manual therapy. So just something to consider because that's another kind of controversial topic.

Obviously thrombophlebitis or any type of DBT, obviously over a pacemaker, reproductive organs and then obviously impaired sensation or circulation. So those are all just general, but obviously as a professional, you would screen first and make sure that any type of modality is safe for your individual client. Now adverse events. We can see here too. The big one's gonna be burns. So real simple, you got to keep the soundhead moving. So if you guys are writing notes. Ever since the beginning, before you turned on the machine, move the soundhead. I do a little bit of legal expert work, and I've gotten several cases of the last 10 years that I was de pod on as an expert where the aid. So the OT Tech or the PT Tech was doing an ultrasound, didn't move the soundhead and burn the patient. We have to be cautious and we have to be vigilant, especially with ultrasound, because it's a very powerful modality. There's also standing waves like if you leave it, the standing waves can also affect the tissues if you leave it in one spot. We also have to think about these days too about cross-contamination and cross-infection. So you got to clean the soundhead. You got

to clean the skin. We'll talk about that in the later modules. So the take home message here is; the biggest adverse event that I've personally seen and my practice as an expert in stuff is burns. Obviously the picture here is a little bit more dramatic, but it just to illustrate that you gotta keep the soundhead moving and you have to have the settings appropriate. So if you're gonna do a superficial area like the ankle or the elbow joint around there, you have to use a setting that's safe for that and we'll talk about that soon. So because the potential to burn people in my opinion is much higher with ultrasound than with the hot pack.

Now we know that the hydrocollator packs can heat up really high, but for some reason, it seems that the ultrasound waves can also burn the bone quicker. I've gotten more cases with ultrasound adverse events than a simple hot pack. So just something to consider in your practice. I think it's good reminders for the group here for us to look at again precautions, contraindications, and then adverse events. So now we're gonna go on to module three. Now, if you guys are writing some notes and stuff and you guys want to ask any questions, please save those for afterwards. To me, this is probably the most important module for this discussion because we're looking at how to set the ultrasound. Once we determine our treatment if we want to go thermal or non-thermal, we're gonna use all these settings. I think this is a very important module. When we look at the focus of ultrasound, we realize that it's a deeper heat because if you look at this slide here, if you look on the left, we can see in our first presentation. In my first presentation, we discussed as a team and there's a lot of questions on all the superficial heat. Those only penetrate the skin and myofascial into the muscle maybe two centimeters or less. The deeper heat ultrasound can go greater than two centimeters. Sometimes some research says it can go all the way down to five centimeters.

So think about this, ultrasounds considered a deeper heat modality. So if you're working around a bony area, you definitely have to keep that soundhead moving. You

definitely have to have the settings for more superficial tissues and we'll talk about that next. So just something to consider that it's a deeper heat and it's gonna penetrate a lot deeper into the tissues. The clinical question here is, what are the therapeutic ultrasound treatment parameters? Well, when we look at this, we have several parameters and I wanted to put everything on one concise slide. So if we start at the top, we're gonna discuss the frequency. That's the speed of the ultrasound wave being transmitted out of the ultrasoundhead or the applicator. The duty cycle is the ultrasound wave gonna be continuous 100%? Or are you gonna have a 20% rest period or a 50% rest period in between sound waves? The effective radiating area is the size, the circular size of the sound wave coming out. Intensity is how high you turn up the machine, that determines the strength of the ultrasound wave. And then as you know, we have what's called the beam non-uniformity ratio and that's basically looking at the sound wave that's coming out. It's not perfectly circular. So the sound wave is kind of asymmetrical. It has different shapes and stuff. So we have to consider that because when we moved the soundhead, we're trying to make sure that the tissues are absorbing the sound wave, but we're not keeping it in one spot to cook our patient. That's important. And then also when we talk about duration, how long each session should be. The number of treatments and frequency, and also the speed of the soundhead movement.

So we're gonna get into those right now and I think that these are all important topics, so that you guys can make good decision making when you decide to use ultrasound with your patients. So when we look at frequency, simply put, frequency is a speed of the ultrasound wave coming out of the soundhead. And so we have two common frequencies; three megahertz and one megahertz, really simple. Three megahertz is for superficial tissue. The sound wave is being transmitted rapidly out of the soundhead and it's striking the tissue interface very fast, so there's a very short wavelength. It's coming out very fast. As it's reflecting and refracting off the tissues in a rapid three megahertz frequency, the superficial tissues are absorbing it more and so less of the

ultrasound wave is being absorbed by the deeper tissues. The 30 years of research has studied three megahertz, I mean, consistently over the years. And they found that it's striking the superficial tissue so fast, it's actually gonna heat them up more than the deeper tissue. So the rule of thumb here is three megahertz for superficial tissue. And in general, it would be considered less than or equal to two centimeters or less, kind of in there. If the goal of our treatment is to go deeper, then we would use a one megahertz setting. The sound wave is coming out of the ultrasoundhead at a slower frequency. That slower frequency somehow is allowing more of the ultrasound wave to be absorbed by the deeper tissues. The studies over the years have shown that the deeper tissues from two to five centimeters tend to be effected mechanically but also heat up.

So think about this. If you're gonna go thermal and you want to heat up the tissue, and you're working around the elbow, you would use a three megahertz setting because that's superficial. If you're trying to get something deeper, let's say like the patellar tendon. It's a little bit thicker in there. Maybe there is a lesion on the quadriceps or there's some scar tissue on the quadriceps. It's a lot deeper. You may want to use a one megahertz setting because that's gonna penetrate deeper. Or another great one is, if you're trying to do some ultrasound to the thoracolumbar fascia in the low back, very thick and dense, you have all the per spinal muscles, you have the back there, you have all this tissue, all this fascia. So one megahertz would be appropriate for a deeper setting plus a deeper effect. So try to keep in mind too that we have thermal and non-thermal, superficial and deep. So those are our settings. That's gonna be our decision making process, depends on our goals of the treatment and also what type of physiological response we're trying to stimulate. So here's just another schematic of if we look here 3.3, again, it's going to strike the tissue interface much more rapidly. It's only gonna penetrate around the two centimeter. There's some studies that give it a little bit more. So that's why I put the arrow a little bit more, but in general, we're just gonna consider it as two centimeters or less. One is gonna be striking the tissue much

slower, so it's gonna be able to be absorbed more. And again, that's just the physics and that's what researchers have found. It's pretty interesting. And that's typically at a continuous mode. When we look at the settings on the machine, we call it duty cycle. So it's a duration pulse. It's a time on versus the pulse period, which is the time on plus the time off.

So it's pretty simple. If you do a continuous duty cycle, your goal is to heat up the tissue. If you do a pulsed setting. You turn the machine on at 50%, then you're gonna get like that one to one ratio. If you set it for 33% or 25%, or even 20%, that's where you're gonna have different rest periods in between the sound waves. So if we look here, and I think this is a great schematic of the duty cycle. 100% continuous means that the ultrasound wave coming out of the soundhead is 100% continuous the whole time. If you do a one to one, there's gonna be 50% of the sound wave will be on, off, on, off. 33% pulsed will have a one to two. So you might have one part on, two parts off. One wave on, two waves off. So you're gonna have this rest period in between. So as we go from 50% down to 20%, we create a longer rest period in between those pulse waves, those ultrasound pulse waves. And so the greater the gap, the less the tissue is gonna heat up. If you guys are writing some notes, this is very important. 20% pulsed tends to be the gold standard for non-thermal ultrasound.

So for pulse ultrasound. So if you're looking at ultrasound in a more superficial area or if you're looking to drive medication, all the research is pointing to 20% because that has been shown over 20 or 30 years of research, that it produces the least amount of heat. Now you're gonna get a little bit, obviously cause you're increasing activity mechanically, so keep that in mind in your notes that that's gonna be the least amount. Now, another thing that's been popping up in the research, and if you guys have like a typical modalities textbook. A lot of the textbooks consider pulsed 50% as a non-thermal, but there's been some more recent research over the last 10 years that have shown that 50% pulsed is strong enough, even though it's pulsed, it's strong

enough to create a thermal effect. Not as much as continuous, there is some temperature changes with 50% pulsed. And so depending on the ultrasound unit you have, there's typically three or four settings where you can go continuous 50%, 25% and 20% or some just go to 20%. It depends on what ultrasound unit you have, which gives you the settings. That's gonna come into play when you purchase those expensive ultrasound units. You want to look at the duty cycle and what settings you can set it at, because you want to be able to have the ability to go thermal/non-thermal, continuous and pulsed.

So just keep in mind, 50% might give you a little bit of warmth, 20% gives you the least amount of temperature increase because there's a rest period. The tissues get to cool down in between those ultrasound waves and the rest period, that latent period. Here's kind of another what researchers have put out another prescription if you're looking at the pulsed ratios. That if you have an acute injury, that's what then a couple of days, you can use the lower level pulses at 20% and 25% because those will stimulate the mechanical effect but those won't heat up the tissues. And like, as we talked in the first presentation, sometimes people believe that heat can negatively or positively affect the healing process. So if you have an acute injury, the standard right now for ultrasound has used a lower level pole setting. Then as you progress to subacute, you can go up to 50%. And then if you have a chronic injury, your duty cycle can be anywhere between 33% to 100%. So it depends on what you want to do and what are your goals and stuff. That's kind of one evidence-based kind of algorithm that a lot of professionals use when it comes to that from there.

So as we move forward, we can see what the pulse ratio. It kind of gives us some guidelines on that. Now the second and most important, one of the most important aspects is the effective radiating area. It's a cross sectional size of the ultrasound wave coming across the soundhead. It's called the ERA. So the ERA is really how big the ultrasound wave is being transmitted out. Because that's gonna determine your size of

treatment area. Here's the next kind of point or rule is that the treatment area in relationship to the ultrasoundhead is you always treat an area that's two times the transducer soundhead. So for example, common size soundheads can be one centimeter, two centimeters, five, 10. I've seen bigger ones before, so you always go two times the size of your soundhead. So basically, as you can see, if you're following what's recommended in the research and what's been known, you're really treating a small area with your ultrasound. So if you do a big area, you're gonna lose a lot of mechanical and thermal effects because as you're passing the soundhead back and forth, the energy is gonna be lost in those tissues over time. And I think we know too, that the temperature increases from thermal only last. I've seen research lasting about anywhere between three to six minutes. The tissue temperature increase. Obviously it's gonna dissipate and the tissues are gonna cool down. So the rule of thumb is only go two times the size of your soundhead.

So if you're working on the elbow, you're gonna use a smaller soundhead. If you're gonna use something bigger like the thoracolumbar fascia or if you're looking at one of the knee ligaments or the patellar tendon, you would use inappropriate soundhead, because then you can use the treatment, but you want to make sure that your soundhead isn't too big or it's not too small. So you just have to make sure that you kind of follow that two times the size rule and then that'll help guide you because the ERA will determine that will determine how effective the ultrasound is for your treatment. Now, when we look at intensity. Intensity is basically almost like I call it the volume. The volume of the ultrasound machine. It really determines the strength of the ultrasound beam or the wave coming out and the intensity is measured in watts per centimeter squared. So please consider that when you chart. So when you chart and we'll get to it later, but I wanted to really emphasize it. When you chart ultrasound, you have to put the intensity. So for example, if we followed the rules again. If you have an acute injury, some research recommends a lower ultrasound level of a 0.1 to 0.3 watts per centimeter squared intensity. Subacute can go 0.2 to 0.5. Chronic can go 0.3 to

0.8. Now remember, the research has covered anywhere between 0.1 all the way up to 3.0 watts per centimeter squared. The research is really all over the map. In the next module, I'll be able to give you guys some guidelines on some general numbers and stuff, but this is one kind of evidence-based kind of algorithm that they use for intensity. So remember, intensity is how strong the ultrasound beam or the wave is. Then we have another important aspect.

Now, if you remember before, we talked about how the vibrating crystal inside the soundhead is sending out this continuous ultrasound wave, it's transmitting it. Now we know that the ultrasound, the energy particles are having compression and refraction. They're kind of moving. Well obviously when the ultrasound beam comes out, it's not gonna be perfectly shaped. It's not like a laser, where it's gonna be perfectly round. There's gonna be some asymmetries to the ultrasound wave and so scientists and the FDA and all that had took a look at the ultrasound wave and they created what's called the BNR, the beam non-uniformity ratio. And if we look at the equation, that's called the spatial peak intensity divided by the average intensity. I'm gonna advance slides and then I'll come back, but I want everyone to see it. And I think the diagram here is a little confusing but if we come here, think about this asymmetrical beam that comes all the way down. And so as a sound wave is coming out, we have a spatial average intensity. So the spatial average intensity. The spatial average intensity as it comes out, we're gonna see that it's gonna have some asymmetries, but then in the middle of the ultrasound wave, and then yeah, we can see right in the middle. The center of the ultrasound wave is gonna be the peak.

So we have this asymmetrical sound wave that's kind of coming out, it's compressing and it's refracting and stuff. When all these physics are included into an ultrasound wave, and they're striking the tissue interface. And they're striking the tissue interface. I'm gonna go back to the slide now. When they're striking the tissue interface, it's gonna create a maximum point of intensity. The government and all these companies

and stuff looked at this ratio and said, wait a second. We have to have a lower BNR ratio, else we're gonna burn the tissues. The BNR is typically already taken care of when you buy a FDA approved unit in the United States. But it's important to understand the physics of saying okay, if I have a soundhead and I leave it in one spot, I'm gonna have this asymmetrical wave that's compressing and refracting striking the tissues. Well, there's gonna be some hot spots and there's gonna be some cool spots. It's kind of it's moving. It's a sound wave. As it's striking the tissues, it's reflecting and refracting, but if my ultrasound unit doesn't have a low BNR, I can damage the tissue. And so this is what happened in some of the earlier models in the 1930s, 40s and 50s of these ultrasound units is that they didn't get the ratio fixed inside the machine to create a more even ultrasound wave, so that when it strikes a tissue it's not gonna cook somebody. So I think that that's kind of the science behind it. So the BNR is just something for you to understand that it's there.

Most commercial ultrasound units out there, already have an approved lower ratio. You can be confident in general that the ultrasound beam that's coming out is gonna be more even and there's not gonna be these asymmetrical parts of the wave striking the tissues and potentially burning somebody. But another way to control for this is simply what? Move the soundhead. So that's something that we have to consider is the effective radiating area. How big of a treatment do we do. Also too, the BNR is we have to keep the beam moving, but we have to make sure too, that we understand that there's gonna be an asymmetrical wave hitting the tissues. And so that leads to one of our last kind of principals, our last treatment settings is what is gonna be soundhead motion. And so the rule out there is you can do a longitude North circular pattern. Your speed is gonna be four centimeters per second and your total area is gonna be two times the size of your soundhead. And that's a general one, I've seen three seconds, I've seen four seconds. It depends on what textbook you read or what research and stuff. But I think it's important to keep the soundhead moving. Now I'm move it quicker over superficial areas. That's what I do personally. I do quite a bit of ultrasound in my

practice. If I'm working with tendinopathies or I'm working with some type of postsurgical joint contractures and stuff. So we'll get into that a little bit later, but I want to make sure to let you know that I do move it a little bit, but also patient feedback's important.

You need to monitor them throughout, and if they feel warmth, you either need to turn down the intensity, change the settings or move the soundhead faster. We have to do that too because again, what is the goal of ultrasound? Are you trying to heat up the tissue? Are you trying to stimulate healing? That's kind of what we're looking at when we're talking about these parameters and stuff. And so here are some considerations for the occupational therapist. Frequency. In summary, superficial or deep. Duty cycle, thermal or non-thermal. What's the size of the treatment area? Intensity. What's the standard intensity. Patient feedback's important. BNR, what tissues are you trying to affect? And also too, you gotta keep the soundhead moving because you know that that sound wave is pretty strong. You want to move it four centimeters per second. The treatment duration is obviously gonna depend on the treatment area. And also the treatment frequency depends on what they are on the healing stages and what is your treatment goal? And that's why I kind of capitalized treatment goal. What is your treatment goals? So that would determine the frequency. There really isn't any standards to say if I have a lateral epicondylitis or if I have patellar tendonitis, you've got to do three times of ultrasound at this setting. Everyone's different.

So it's really hard to have some type of standardized norm. But in general, though let me give you guys a couple tips that I do personally. And when I teach this and stuff and I collaborate with other professionals, this is what they do. So obviously frequency, we know it's consistent. Duty cycle, most people use 100% for thermal, 20% for non-thermal. Really the size of the treatment area. If someone's doing a larger area, they usually do basically five to six minutes per area. They may do two treatments. For me, intensity 1.0 watts per centimeter squared, right in the middle approximately. I find

over the years of researching this stuff and using it, I primarily use 1.0 watts per centimeter squared for both three and one megahertz. Sometimes if I'm using a bony area, I'll go down to 0.8. So 0.8 to 1.0, that's what I commonly use and it seems to produce the physiological effects that I want. Again, that's more clinical based evidence right there. BNR, yeah, we consider that. I do move the soundhead more rapidly like I said over bony areas or superficial a little bit slower more towards four, three centimeters over a deeper area. Treatment duration. Typically though, if I'm doing a big area, I might do five minutes per area for a total time, but I usually do eight minutes or more. That's also with your billable codes, but I find anywhere between five to eight minutes is good in general, and we'll talk more about the recommendations. And then frequency, it depends on what I'm trying to do. If I'm doing phono, I might do it one or two times or if I'm trying to heat up some tissue over time, I might do it three to four, but very rarely am I doing it for several months. Very rarely am I doing it more than six times? It just depends on what case I have.

There's some cases where I have postsurgical contractures, where I may use it to heat up the tissue before my manual therapies and stuff. I think these are all considerations that we'll talk about in the coming modules but I wanted to kind of give everyone some ideas from here. So bottom line for this module is we need to match the treatment parameters with the intervention goals and the patient treatment. Everybody needs to have a working knowledge of these parameters and what to set. And then also we have to consider the safety with each patient. And also too, though, why would you do it? Why are you gonna do it? What are you gonna get out of the modality? Because if you think about it. If you look at set up doing the treatment and finishing, you're looking at probably 15 minutes of a one hour treatment on average. So you got to ask yourself how does this fit into the treatment strategy and the time I have with the patient. Now, if you have a competent OT Tech, you can definitely kind of dovetail and do that, which is awesome. Just kind of remember what are the goals and I want to emphasize that throughout this presentation and stuff. Module four. Now, before we do module four,

let's do our one hour stand up and stretch. Everybody. I have 137 people. Let's stand up. Everyone stand up. Put the arms above your head, let's do an overhead squat. Gimme 10 squats. We're gonna take a one minute rest break.

Ready? And everyone's squat down. Get a good stretch. Come back up. Give me 10 of those. Stretch. Up and down, one hour of stretch break. Keep going. Good. I'm at five. Give me five more. If you're not squatting, match in place. Let's kind of stretch it out a little bit. Couple more seconds. Good. Kind of stand up and move around a little bit. Let's do a little stretch break. We got a few more seconds of our little break. Kind of air it out a little bit, cause we're gonna get into treatment application next. Good, few more seconds. Take a couple deep breaths from your diaphragm. Open up those ribs . Really kind of stretch it out a little bit. Rotate. Kind of do this little stretch break. There's our little kind of one minute break. Let's get to it. Module four. Let's kind of jump into this. If you think about it, modules one through three. We went over science, indications, contraindications and the settings on the ultrasound machine. We went over the goals of that. So now how do we apply it? So we have our clinical indications that we talked about before, and this is just a summary slide. If we go clockwise, we have all these conditions that the research has shown positive efficacy with ultrasound. So we understand that we're there. And so with that, we have to consider how do we set the ultrasound to effectively treat these conditions.

So let's kind of look at it. Now, if we're looking at pain control, here's what the research suggests. This is a compilation of several years of research. 20 or 30 years that have shown that ultrasound for pain control. If they use an intensity of 0.5 to 3.0 at 100% continuous for a duration of three to 10 minutes with the goal of either superficial or deep tissue at a speed of four centimeters per second, two times the size, you may produce some positive effects. So I think that that's interesting, because if you think about pain control we have several things where we can affect that pain neural matrix. The complicated pain neural matrix that we discussed in the first lecture, in our first

presentation. Continuous ultrasound, if we kinda think about the science, it's creating the mechanical effect. So you're gonna be stimulating the local mechanoreceptors, also the proprioceptors and the nociceptive free nerve endings. But also you're gonna be heating up the tissue, that may stimulate in my humble opinion. It may stimulate the neuroendocrine system to release some type of endorphin. It might stimulate some endorphin release, just like taking like a hot shower. So you guys can see that the continuous may have a combo effect by stimulating through thermal and mechanical. So the research is very supportive of using 100% continuous, if you're trying to control pain and I think most likely would probably be in that more that subacute kind of fibroblastic phase. Sometimes in the acute phase, but I've always used pulsed in the acute phases.

Again, the research is still kind of weak on that, but I think it's important to kind of use these guidelines that the research is suggesting and kind of move from there. Now for soft tissue healing, we get away from that thermal effect. So we're moving away from that. We're using a lower intensity. So you guys can see the trend. You can see how my 1.0 is kind of all the way through. So we're using a lower intensity, but our duty cycle is 20% pulsed. So we know that there's a longer rest period in between waves. So the tissue is gonna be more vibrating and mechanical, not so much thermal. The research is saying three to 10 minutes. Three megahertz is actually preferred. That's interesting. Same thing, four centimeters ERA of two times the size. That's a treatment area. So the speed and total area is still the same. But what's interesting is when I looked at the research, I'm like, it's really preferred to use three megahertz because I guess most of the body has more superficial tissues which I agree. But things like in the lumbar spine we have the different layers, you got the thoracolumbar fascia, pair of spinals, . We have these deep muscles. We know that muscles won't absorb as much, but all the fascia that could be heated, but they're really recommending with the research three megahertz. So just kind of consider that you're gonna be using a more superficial setting for soft tissue healing. Now, no one says that you can't use one. I've

used one many times. For your own clinical evidence try bolt and see how it works for your patient. So again, it's all within the standard of care and it's all safe. Just again, keep the soundhead moving and just be safe.

Now, if you have soft tissue shortening, they talk more like a contracture. So if you have a hamstring contracture, someone had a total knee replacement or they're getting adhesive capsulitis, et cetera. Any type of shorn tissue, the research is supporting actually both settings. So for superficial, you're still gonna be using that lower intensity 0.5 to 1.0, one megahertz as it goes deeper. You know it's not gonna heat up the superficial tissues as much. So you can turn up the intensity more and they recommend 1.5 to 2.5. And again, this is a consensus of all the research and stuff. The duty cycle is gonna be continuous cause again, you're trying to heat up the tissue. They're recommending a longer treatment time of five to 10 minutes per total area. If you're using a 10 millimeter. Excuse me, five centimeter or 10 centimeter soundhead, you're gonna be working a small area. And again, we can use both frequencies and the speed of the soundhead's gonna be consistent.

So again, these slides here give you guys at least some guidelines to start with, and then obviously you'll adjust it accordingly. Some of the researchers actually promote getting the patient's feedback as you're turning up the intensity. And I think that that's interesting. Because as you're turning up the intensity, if they feel the warmth, then you stop there. So I've seen over the last few years. We're getting in some research for ultrasound, but it's been around so long, we're not getting in a ton of research. But some of the researchers and some of the experts who write the textbooks like Michelle Cameron, she's a medical doctor who does a lot of studies. They're suggesting on some things that you go buy a subjective report. And sometimes I think that there's a risk to that too because the patient may not always pay attention. So I always recommend starting especially with tissue shortening or trying to warm up tissue. Start with the norms like 1.0 and kind of go from there and see how it affects your

treatments. And again, sequencing and how you apply the ultrasound is definitely gonna factor into your treatment strategy. Now, when we look at ligaments and tendons, we're gonna follow along the same thing. We know that they're superficial. We know a lot of our ligaments are superficial, but just like the glenohumeral joint, like, if you're gonna work on the hip joint, we have some deeper ligaments of structures. The research recommends kind of collectively an intensity of 0.5 to 1.0. Your duty cycle is gonna be 20% to 50%. And then the duration is gonna go three to 10 minutes and frequencies can be superficial or deep depending on your goals. And then obviously the speed and the total area of treatment is gonna be along the same rules right there. So I thought that that's interesting is where we're doing more of a pulse duty cycle with them.

Now, another interesting thing is bone fractures. I don't know if anyone here in the group has actually used these devices. I have a lot, cause in my area here in Southern California, I deal with a lot of runners. So I do some high school cross country and professional and I get a lot of those stress reactions, stress fractures. More so recently, probably the last, I would say, 20 years, they've kind of debunked those precautions on a fracture. The researchers have found that super low intensity ultrasound. We're talking 0.15 at a 20% duty cycle. So think about this. Non-thermal super low is causing this low-level mechanical vibration into the tissues. Now the frequency is gonna be fast. The frequency is not gonna be as fast as a three megahertz, but it's gonna be a little bit faster than the 1.0, so think about this. We have this kind of this moderate level frequency low-level vibration that's occurring, and you put it over the fracture area using a specific device and applicator pad that has shown good efficacy for actually helping bone fractures heal quicker.

So I think that that's interesting. Most of the time though, if you're talking about simple clinical lingo, they call it just a bone stimulator. Does that make sense? And so I think that that's kind of another term that they use, but it's really super low-level ultrasound.

I've seen it do very good outcomes with different patients. Especially shin splints, especially lower foot and more superficial areas and stuff. Now I've gotten a few athletes who have had like a stress form of fracture because they're growing and they're running 40, 50 miles a week. The stimulators to me, I don't feel that they work as effectively with the deeper tissues. So in my opinion, superficial fractures basically from the knee down, the tibial tuberosity, the shin, there seems to be some good clinical evidence that I've seen and the research supports it. So something to consider if you guys are working with more athletic populations. Now remember, also this can apply to hand and wrist. If there's a lot of CHTs in the group here. Even some of the more superficial injuries and stuff, TFCC and all that, low-level ultrasound pulsed may have some effects on the ligament structures but also we know that it's effective on superficial bone. So we have a lot of just different things we can use it for. Something to consider. To me, this is more newer technology. Then the ultrasound waves that have been studied since the 1940s. That's kinda my opinion. One of the most widely studied musculoskeletal issues is or we call it the nerve entrapment is carpel tunnel syndrome. There's been quite a few studies when we look at the research that have shown efficacy for ultrasound using a 1.0, 20% duty cycle, five to 15 minutes with a one megahertz sending.

So going deeper at the same speed in the area. I thought that that was interesting because obviously we have the transverse ligaments with carpel tunnel and all that. I've seen clinicians, cause when I work with my CHTS, an entrapment of the ulnar nerve, the Guyon's canal, et cetera. A lot of these entrapments along kind of the hand and wrist. I've seen some ultrasound being used a lot. It depends on it and I'm sure we have some experts in the group that could definitely share some thoughts I'm sure about how it works with that. Basically the take home here is the majority of research for carpel tunnel is saying that it works pretty good. So I think that that's interesting to consider. And so when we look here, here's a typical setup for ultrasound just as a review. In case we have some new clinicians in the group here, or if we just we have

some of our more senior season professionals. Here's just a quick review. Before you do ultrasound, we always recommend inspecting and prepping the treatment area. That means maybe wiping it with a alcohol wipe or something cleaning the skin. We obviously turn on the machine, set the parameters, we apply the medium. Then we immediately, what do we do? Start moving the soundhead. Don't forget. If you're working with an aid or a therapy tech, OT or PT, you got to train them to move that soundhead. Start the device, administer the treatment, recheck clean and chart. So again, very simple, but again, I think this is a great reminder for everybody that we have to move the soundhead. So important. Let's move on.

Phonophoresis. I love phono. I think it's a great adjunct to help control inflammation and calm down tissues. The research is pretty good on this. When we kind of appraise the body of research on phonophoresis, they come up with these settings. A lower level of intensity. Point 0.5 to 1.0. A 20% duty cycle. Because again, what are we trying to do? We're trying to drive the medication into the tissues. And we know that if we go 20% for five or 10 minutes at a frequency of three megahertz, we can increase the permeability of the skin and the myofascial through the mechanical effects. Remember the acoustical streaming. Through that mechanical acoustical streaming, we actually increase the permeability. We open up the skin per se and drive the medication into it. Now some studies have used one megahertz for deeper, but in my opinion three megahertz that I always use seems to be effective. And again, we keep the same speed and the total areas as our standards. So I think phono using some type of NSAID or anti-inflammatory can be effective when you're trying to control inflammation and calm down tissues, or if somebody has that chronic tendinopathy and you're really trying to kind of reset and get them to become more functional. I think phonophoresis has its value more than ultrasound in some cases.

That's what I'm finding clinically just in my practice when I treat my patients. So then when we talk about phono We're just doing a quick kind of summary, we do the same

recipe. We're inspecting the prep and region. We're gonna go clockwise here. We set the treatment parameters. We apply the median, medication and gel. So remember, I recommend using ultrasound gel with the anti-inflammatory. One of the most common things is as you put, like let's say one CC of Dex in. Three or four to one with the gel. You put it in ultrasound gel and you mix it. That's very common in most clinics and stuff. Or some people might use the diclofenac anti-inflammatory cream or some type of cortisone cream. And a lot of times people will mix that with ultrasound gel to kind of create a medium but you're also gonna dilute the medication a little bit. Because remember, even though we're doing phono at a low-level, you still have to monitor for tissue interface irritation. Cause remember you're driving in medication. So you have to go back to your basic screening of the patient's medications and make sure you're not double dosing them with an anti-inflammatory. I've had clinicians that have worked for me over the years where the person's on.

Let's say they're on like a prednisone pack cause they are in a lot of pain. And then the physical therapy assistant cause I'm mainly working with the PTs, or the PTs are wanting to do a phono and then they've come and asked me and I've always reminded them no, no, no. They're already on an anti-inflammatory. So you want to be careful double dosing them with a cream, which is transdermal and then an oral. So you want to be careful. And again, I know that these are reminders for a lot of people here, but it's good to hear it again because we need to be safe with our medication and we have to chart it appropriately. So after you apply the media, again, move the soundhead, start, administer, recheck, clean, document. So again, it kind of falls into that same mixture, but I wanted to use this slide to remind everybody check your patient's medications and make sure that the indications for phono are there and that you charted appropriately. Because that's important because you are using medication on a patient, so that's different than a standard ultrasound. So there are some more legal risks using a medication. So you want to be careful, especially if they're on blood thinners, if they lack sensation. If they're on other anti-inflammatory like a

corticosteroid or an NSAID. We just have to be careful with that. Also to think about your asthmatic or your people with COPD. If they're taking in inhaler that has a steroid in it, again, that's double dosing them. Please consider these little nuances as you apply them because sometimes when we're busy in the clinic, we don't always stop and check everything and we all know that we get busy. So this are some of the cases that I've ran into over the last 10 years are where mistakes are made.

So remember, busy clinic, mistakes can be made, take your time when you're administrating the modalities, monitor yourself or the tech and make sure that the patient responds favorably. That's the goal in my opinion to be 100% safe. So now let's get into some treatment examples. And this is kind of an algorithm. So the next couple slides are kind of giving you an algorithmic approach just to kind of summarize this section. So if we're working on soft tissue shortening, the goal is to have a thermal effect. Duty cycle is 100%. If the depth of the problem is superficial, we're gonna go three megahertz with the lower intensity. If we look at the right, if it's deeper. If it's a deeper lesion, we're gonna go one megahertz with the higher setting. And we know that we can go higher because it penetrates deeper. Our treatment duration on average is gonna be five to 10 minutes. Two times the ERA with a four centimeter, with a slow, nice even movement.

Next slide. If we're looking at more of delayed tissue healing like a chronic condition or we're trying to promote some type of tissue healing, we're getting this chronic, pain and all that. We may want to try a non-thermal ultrasound. The recommendations in the research is to go as low as possible, 20%. Some units even go 10%. If we go 20%, we know that there's a longer rest period. So we're theoretically gonna have a non-thermal effect. A superficial problem will follow the same rules, three megahertz 0.5 to 1.0. That should be up to five centimeters. We can go one megahertz and we're still gonna use a lower intensity here. That's kind of the recommendations. We're not gonna go the higher one as we did in the thermal. Treatment duration on average is

gonna again be five to 10 minutes. And the other settings as far as speed and treatment area are gonna stay consistent. So those are some ideas there. What about integrative treatments? Well, I wanted to add this slide for everybody on here's what I kind of suggest if you're gonna integrate ultrasound into a treatment strategy. So for example, if you're looking to create a thermal effect and you can insert any kind of condition you want, maybe you're working with the post total knee replacement and they have a hamstring posterior tissue contracture, they're lacking extension.

So theoretically, on the gastrocnemius and the hamstring, the tenant's right there. You can do some continuous ultrasound to prep the tissue, kind of warm it up. Then you can immediately jump into your manual therapies or your tissue techniques. If you want to do some strain, counter strain. If you want to do some type of reflex, inhibition, art, whatever you want to do, you can do that. And then from there, once you get the desired effect, you more than likely want to retrain that area. Do some neuro reeducation. Maybe do some active motion movements, some contract-relax, do a little bit of PNF approach, get things turned on, Upregulate that nervous system and then from there, if they're functional, you may want to jump into some integrative movement patterns. Maybe have them do a little bit of a mini squat with the reach. If it's someone more advanced, maybe do a lunge with some type of twist or movement pattern.

So remember, we prep the tissue, we treat the tissue, we reeducate locally, turn on those motor patterns and then we integrate. So that's kinda my approach when I come to anything from a tight joint or some type of contracted tissue or if I'm trying to get a thermal effect. That's kind of a recipe that I like to follow in my clinical practice. Now, if my goal is to have a non-thermal effect, and I just want to promote healing, let's say for example, if I just had somebody who just had surgery or they have a fresh injury and I'm not trying to heat up the tissue, I just wanted to kind of create some mechanical movement in the cells and the tissues. I'm gonna prep the tissue with an ultrasound

first. Then I'm gonna do my manual therapies, tissue techniques, maybe I might just start off with some light effleurage, some tissue. I might do again, some of these tissue techniques. I might get into some deeper tissues to get some movement in there. Maybe a little bit of lymphatic light massage, whatever you want. And then from there, I might try to reeducate if I gain new range of motion. We want the brain to accept that new range of motion and also to download the software right to move. So remember, neuro reeducation is your patient is downloading the software to move more efficiently. It's all about movement. Then from there you integrate.

So once they download the software, you integrate hopefully into a new range of motion, hopefully into a better efficient muscle contraction. And then all of a sudden, the neuromuscular system gets activated, you upregulate and they're starting to have improvements and stuff. So those are two general recipes that I personally use when it comes to ultrasound. I like to use it to prep the tissues before my manual therapies. Now, again, it's very individualized and it's not on every single patient, but I find that these recipes work pretty darn good in my clinical practice. Now phonophoresis. This is an interesting take because I have some clinicians OT or PTDC, they do photophoresis first. Now, in my humble opinion, you're driving medication into the area. I want to keep the medication in the area as long as possible. So I don't want to all of a sudden drive in medication and then do manual treatment, have the patient do some type of therapeutic intervention and flush out everything that we pushed in there. And again, this is just a personal in my humble opinion kind of approach. So when it comes to certain things like an acute injury or someone has a very flared up tendon. That tendinopathy kind of cascade, I like to do photophoresis last. Post-treatment.

So maybe I do start off with maybe a hot pack and kind of warm up the area, kind of prep the tissue, as we know to like a hot pack kind of relax the patient, they're in pain, get them to calm down a little bit, then I'll do my manual treatments. I'll reeducate and I'll integrate. But maybe at the very end, I might do some cryotherapy and maybe cool

them down a little bit. And we only know that that lasts from the other lecture, maybe about 10 minutes. The body reheats and then from there, maybe I wait a couple minutes. Maybe I have them stretch a little bit and then at the very end, I might have them do a phonophoresis session to put medication in and then go home and relax and hopefully, that's gonna help it calm down. Now that recipe I've used before has worked pretty good with patients with plantar fasciitis and the patellar and Achilles tendinopathies. And so again, if you think about it, after therapeutic interventions, I do a little bit of ice. Maybe even like an ice cup massage, then I let the body kind of rewarm itself after a couple of minutes and then I'll do a photophoresis. Somehow the ice with the phono seems to work a little bit of magic for some of my patients and they claim it helps them out.

So again, something to consider in your practice as you integrate ultrasound into your treatment strategy. So bottom line is when we talk about application. Ultrasound and phono have good utility for different musculoskeletal conditions. We can see, right? Mostly, the current research provides some clinical guidelines, and the treatment parameters should be chosen and adjusted based on like we talked about research goals and the patient's response. And again, you're gonna see this throughout. We have to consider the safety of it. When and where should we apply it from there. Now, as we move on, we're gonna do a quick summary of the research. Now, as I mentioned in the beginning of the talk, we have like 30 to 40 years of research that's out on ultrasound. And so the body of research is huge. So basically I did a literature appraisal, evidence-based appraisal basically going back 10 years. Going back 10 years. I think it's important to look at the current research and see how the evidence is applied.

So in general, let's just go to bullet point number two. There's moderate evidence supporting the treatment of this overall. Let's kind of move forward now and talk about the most relevant evidence with the related clinical question. So one of the clinical

questions that comes up is does ultrasound ensure decreased pain, increased joint range of motion and function after an injury or the diagnosis in some pathology like carpel tunnel syndrome or whatever. So we can see here, the most recent research from 2010 which was a Cochrane review all the way through 2019 most of the current research is on knee osteoarthritis, and all these studies have reported favorable outcomes with decreased pain, increased range of motion and increased functional measures, either functionally like gait or using a patient related outcome measure. Now, if we look below though, there are some more recent studies. A body in 2020 just did a Cochrane review. A big systematic review showing that ultrasound didn't do well with low back pain. Karakas and the other study, Papadopoulos looked at knee OA and lower extremity pain and didn't find anything significant outcomes. And then obviously back in 2010 Shanks and his group didn't find anything with the foot.

So again, with everything we do in medicine, we're always gonna have mixed reviews. Nothing's ever perfect. So we understand though, but the majority of evidence as we can see is pretty much pointing to that the knee joint may react more favorably to ultrasound and that may be from the superficial nature of the joint. Think about low back pain, there's a lot of deep musculature and tissues there and general lower extremity pain. When we looked at this study. Well, there's of a lot of types of pain, there's neuropathic, there's vast you can have vascular claudications, there's a lot of different pain responses that can occur. In general, it seems like the research is suggesting that knee OA have the best outcomes among these known diagnoses. So then from there, as we go through, we move forward. Does ultrasound provide greater benefits than low-level laser? Well, there's been several studies ever since 2014, all the way up to 2020 which Asheghan et al. They found that ultrasound provides similar benefits as the light therapies. There's another study in 2018 that also found that ultrasound was better. But then in 2019, another study found that the laser was actually more favorable than ultrasound.

So again, something to consider in your practice is that ultrasound and low-level laser may have similar effects. The majority of the research is suggesting that. Now next clinical question. Does ultrasound provide better benefits than the Extracorporeal Shockwave Therapy or EST? That's another one that's used especially for plantar fasciitis. I know a lot of research is really touting this EST. Some recent studies from 2018 and 2019 showed that both modalities provide good benefits for plantar fasciitis and rotator cuff tendinopathy. So it was pretty interesting. But then also though, too, another recent study, and then an older study I pulled from 2001. A little bit older show that EST had greater benefits. So again, we're starting to see some mixed research, but at least it's supporting the efficacy overall of ultrasound for different things. And then obviously phonophoresis, we had the same clinical questions. Does it decrease pain increased range of motion and affect function? And the majority of studies that came out since 2014 supported photophoresis cause you're driving in medication. And then there was a study back in 2013 that compared phonophoresis to shortwave diathermy therapeutic ultrasound and they found that all three work the same. I think if we're looking at an evidence based appraisal, we could say that that the majority of evidence supports phono for low back pain, cervical pain, knee OA. But we also have some conflicting evidence too, so it is something to consider. And then when we look at photophoresis a little bit more.

This will be our a couple of our last slides in this section is, does it provide greater benefits than therapeutic ultrasound? Well, if we look at the plus, the majority of the evidence supporting it, shows that phono's better than ultrasound for knee OA, myofascial pain syndrome, subacromial impingement syndrome, that's SIS. Those are 2014 studies. Lumbar disc disease, TMD and low back pain. Now there's other studies coming from 2014 to 2020 that have showed that they have similar outcomes for some of the similar diagnoses. Low back pain, fascial pain, knee OA and carpel tunnel syndrome. It really depends on what you're looking at. So when you're doing an evidence based appraisal of phono, we can see that in some cases it might be

favorable than others. So something to think about, but again, that's why in the beginning I said that it has a moderate support in the evidence because there's some mixed outcomes in the research that question some of its efficacy with certain things. So the bottom line here is we can see though, that the overall body of ultrasound evidence has been going on for the last 40 to 50 years. We know that. It's been a long time. There seems to be a consensus that ultrasound is a staple in our toolbox. It's being used. Most of the studies have shown that pulsed or continuous ultrasound seem to have effects. A lot of these studies that I reviewed, some of them report the ultrasound level like pulsed or continuous, some of them do not.

So that is an inherent weakness in the research because as a clinician, I'm like, well, are you trying to do a non-thermal or thermal effect? A lot of times it is say one or three megahertz, superficial or deep, and so I thought that that was interesting. The body of evidence that I summarize earlier does support both methods for different things. One key thing to understand is most of the studies using phonophoresis use specific anti-inflammatories; dexamethasone, diclofenac, ibuprofen and piroxicam. Piroxicam is also an inside family. So those are the main medications that they used. So again, there could be other phono cocktails per se that are done. I know more recently, some therapists here in California are using CBD. They're using phono with CBD. I think it's a little bit risky at this point, because we don't know all the effects of CBD, but the patients claim that it works really good. And then a lot of the clinicians are saying, we'll wait a second. It's non-medicated. And because it's coming from the hemp plant or whatever, it's more natural. So just something to think about with phono and how phono is being applied with some of these newer CBD kind of natural herbs and substances. Something to think about. Now we're gonna move on to module number six, which is device hygiene. This will go pretty quick.

So we're on the home stretch here everybody. Hang in there. I'm pretty straightforward. We got to clean the soundhead. It sounds kind of redundant, but it's

so important because I know a lot of times when I worked in the clinic before, especially before COVID. We get busy in the clinic, the aid is ultrasounding somebody, basically they wipe off the soundhead with the towel. They wipe off the patient's skin, then the patient leaves. Or you come over and you start the treatment. You might've washed your hands, but the soundhead was not cleaned afterwards. Now, when I do ultrasound, I cleaned the patient's skin immediately. I just take an alcohol wipe. Wipe the skin, let it dry. Wipe the soundhead, let it dry as I'm setting up the machine. So that's what I do every single time. The CDC and the EPA recommend an intermediate level disinfected. And that's basically a 70% or higher, isopropyl alcohol wipe or pad. So basically your alcohol wipes. you can use some of your Sani wipes and you're more stronger EPA approved. Also to the Clorox wipes and stuff have been now considered an intermediate level disinfectant. I don't know necessarily you would take a Clorox wipe and wipe someone's skin.

So I'd be a little bit careful with that, but I think wiping the soundhead could be appropriate or simply having a package of the alcohol prep pads or the alcohol wipes next to the ultrasound unit. Probably the best practice from that. Now when we look at safe treatment sequences, really quickly, one through six, here's some reminders. Obviously wash your hands before. You can wear gloves if you want. Step number two is prep the patient's skin, most research is saying 60% to 70% alcohol content. I say, go hire 70 or above. Administer the treatment with the gel. If you're using the lotion or you're using the ultrasound gel and you have the tube that you squeeze it out of, make sure your tech wipes off the handle and wipes off the spout. You got to clean everything and I think that that's important to understand as we're trying to be more clean in this day and age. Step three, obviously you administer the treatment. Step four, monitor during the treatment. Step five, clean up, reinspect, sanitize the soundhead, wipe off the soundhead itself, wipe off the ultrasound unit if you need to, clean the dispenser for the ultrasound gel. And then obviously, you kind of take care of your PPEs if you wore one, wash your hands, document and move on. So those are

just some reminders for everybody. I know we're all professionals here, but it's great to kind of hear it again just to make sure we're being a little extra cautious on things these days. So bottom line, pretty simple. An intermediate level disinfectant. Also two, very important point, the second bullet. Follow the recommended wet times. Big importance there.

So what that means is you gotta let it dry. You gotta let it dry and you need to because that's what kills the bugs. You just put a alcohol to kill the bugs. Well, you got to let it sit there and kill the bugs. You don't just put it on and wipe it off. I'm also to wear proper PPEs as needed as a professional according to your treatment setting. Almost done guys. On the home stretch. Module seven: Documentation. This is very important. And we're gonna look at the diagram here. We're gonna go clockwise. We always describe the modality used, body region, treatment parameters, patient positioning and their response. To me the patient response is a key indicator to protect yourself during and after the treatment. How do they respond to that? Because again, I have a current case right now because I'm an expert with the Physical Therapy Board of California, where an aid left a hot pack on a patient who laid on their back. They left them in a room without a bell or anything. The patient felt really hot, was yelling their name, finally got up and then they have a second degree burn on their back from a hydrocollator pack.

So again, a case like that would be being in a busy clinic and a lack of supervision. And so again, when we use these modalities, I think we should use them sparingly overall, but they should have a purpose and they have to be monitored. So now when I'm working in my clinical setting or I'm at someone's house and I'm working or whatever, if I'm gonna be doing a modality, I'm either doing it myself or if the age sets them up, they're right next to me. Or I'm in line of sight or there's some type of signal. So the minute that they get hot, I'm jumping in there and we are setting them up. We're either adding more layers of towels or we're doing some adjustment. I think that that's an

important reminder as we do this. Now, as far as the billing codes, the CPT codes for 2020 have not really changed. We know that the ICD 10 codes have been updated, but so far when it comes to PTOT billing, 97035 is a universal code for all of the ultrasounds, including phono. One of the sister sites physicaltherapy.com has a great article on the coding and so I put a link here. So I recommend everybody if you're looking for kind of an update on coding, click on that link once you get a copy this PowerPoint, or just cut and paste it. And there's a great article on coding and kind of what's the latest from there. So here's some common charting examples. And again, these aren't perfect. Every chart note is gonna be different as they apply to each patient and so it's important. So here's a couple of examples and then we'll finish up the lecture here. So if I'm gonna be doing a thermal effect, the rationale is gonna be for pain control or soft tissue shortening. I'm simply gonna put ultrasound 1.0 watts per centimeter squared intensity times eight minutes continuous to left knee quadriceps tendon. Five centimeter soundhead with ultrasound gel patient supine. Patient tolerated treatment with no incident.

So you can see that's again a very rudimentary example, but I've listed all my parameters. I listed the modality and I listed the patient's response. Non-thermal. Focus would be soft tissue healing, ligament tendon injuries, carpel tunnel or a bone fracture. If I'm doing the special unit, but in general I would chart ultrasound 0.5 watts per centimeter squared times eight minutes, 20% duty cycle versus continuous above to write distal Achiles tendon, 10 centimeter soundhead with ultrasound gel patient prone, patient tolerated it. So again, we're using that same kind of recipe. Where I'm going through those steps. And then obviously phonophoresis is mainly for pain relief or some type of anti-inflammatory effect. My daily note would be very simple. Phono, I would put 0.5 setting eight minutes, 20% duties cycle pulsed. To the Achilles tendon, 10 centimeter soundhead with one CC of dexamethasone and gel. So basically, don't forget to name the medication that you use. And again, that's just a general kind of observation. It's not perfect. Every state is different. Every state practice act. The

insurance carriers want different things. So you really have to kind of navigate on what is the best charting for you and your patients. Patient prone and then patient tolerating with no incidents. So again, I'm sure that there's other versions of this that you guys can come up with, but these are just some rudimentary examples of how to include all the essential information for your modality. A lot of times too, you can put pretreatment, post-treatment, you can name the sequence if you want to. I think as long as you have all the general information in here. As long as you have all the components and another clinician can pick it up and understand it, then you know you're on the right track. So remember, if someone picks up your chart, they should be able to understand it and continue where you left off and that's kind of a rule of thumb. So again, bottom line is we have to document everything we do. And so we understand that patient injuries and misuse and poor supervision can happen with modalities.

So final thoughts. In my opinion, ultrasound should be an adjunct to a comprehensive strategy. Choosing the best parameters for the specific phase of healing. Also, what type of condition is gonna be the key. You might have to play with the parameters a little bit to help it. And then also though too, you gotta make sure you document appropriately. So to me, those are the three big things, and that kind of correlates what we talked about more in the beginning of the considerations of when to do it, how to sequence it and why you're doing it. I would like to thank everybody for attending. I love to share my thoughts and stuff with the group. And again, we're done. So I want to fill the couple of questions and kind of finish up. If anybody has specific questions, please feel free to email me at my university email address and I'll do my best to respond to you as soon as possible with some thoughts. So if the host can fill the couple of questions, let's kind of finish up.

- [Fawn] Thank you very much, Dr. Cheatham. The first question we have coming in is, is pulse ultrasound preferable with lateral or medial epicondylopathy.

- [Dr. Cheatham] Yes, and Linda, I think that that's a great question and yes, it is. I think the 20% polls to 50% polls has been recommended for these tendinopathies and that's kind of in the research and stuff. Also too, if you're working around the elbow, you have a lot of superficial tissue, so you have to go three megahertz. I usually use like 0.5 heat with the pulsed and the goal is to stimulate healing in the tendon. So that's why you're looking for the mechanical effect. And again, that's just something to think about and what the research supports.

- [Fawn] The next question is, is it safe to use ultrasound on the extremities, like for example, a hand or a lower leg of a person with a pacemaker.

- [Dr. Cheatham] Chaya, that's a great question. There's been controversy on that as you know. Some people believe that if you use ultrasound distally, that it's not gonna affect the newer pacemakers and stuff. I don't know about you, but professionally, I don't know if I want to take the risk. To me, a hot pack can get similar stuff, but gosh, I don't think ultrasound is the ultimate kind of intervention that would do it. If I have anybody with the pacemaker, I do know electrical STEM and know ultrasound. That's just a personal preference. But again, if you do it, you gotta make sure you cover yourself while you do it, because if something adverse happens, that's gonna be an antigenic treatment. You're gonna get yourself in trouble. So great question. Just please be careful. That's a tough one. Next question.

- [Fawn] This is a great question. Why doesn't the vibration from the crystal irritate the nerve with carpel tunnel syndrome.

- [Dr. Cheatham] I saw that in the chat and Linda, that's a great question. I don't think we can answer that at this point in the research. Because yeah, I understand what you're saying is, is when the sound wave comes out, you're getting the compression

and refraction and you're getting the vibration. I would have thought the same thing. It's almost kind of like a tunnels when you're tapping. But for some reason I think it's set at such a low intensity, maybe it's not effecting that median nerve or whatever. So I don't know. There hasn't been any research on patient perceived irritability with ultrasound and carpel tunnel. I've never seen anything that says, 30 patients complain of irritability. That would be a great study. My research lab is close right now. I wish I could think of something like that. So great study in the future to really look at that. But at this point in time, I have no answer. That's a great question. Let's keep it for the future because I really would wonder if that would kind of irritate things. So great question and sorry, I couldn't answer it fully.

- [Fawn] Another one is when you document, do you need to indicate the megahertz when you're documenting.

- [Dr. Cheatham] Yes. If we kind of go back to the PowerPoint. I just used the thermal effect, so it would be obviously pulsed. And then the thermal effect and the ultrasound thermal effect, you would also document. And again, I used it as a one or three. My apologies if this slide was kind of confusing, but yeah, if you're using thermal, you would document one megahertz. If it was non-thermal right or superficial, you can go either one or three. So yes, you need to document the megahertz.

- [Fawn] Last question would be. What would be a good unit to use at home, for example, like an athlete at home.

- [Dr. Cheatham] They do sell some home units, either one or three megahertz for superficial or deep. The home units, I don't know if it would be safe to have a patient use it. Now, if you're gonna use the bone stimulator, that's usually prescribed through a physician for like a fracture or something like that. If you're just gonna prescribe and give a unit to a patient, you gotta be careful cause they can burn themselves if they

don't move the soundhead. So I would say, try to keep it on the clinical level if you can, or use one of those low-level specialty bone stimulators that seem to be safe for people to use it at home. And again, just one last summary. Yes, whenever you chart, please make sure you include the megahertz which is if you're gonna go deep one megahertz or superficial will be three. All right everybody, thank you so much.

- [Fawn] Thank you Dr. Cheatham for a great talk. This is second of three parts series. The first part should be in the library very shortly and then we will also have another live course next week. So looking forward to that. Thanks so much. One more thing I do want to make mention of. We do have the article that Dr. Cheatham mentioned by Kathleen Weissberg that is on the PT site, the article he cited. We have copied that over to our site so you can access it on our site as well. It's a recording and you can get credit for that if you want to take a look at that, and those parameters should be in the handout that's attached with the course. Thank you everyone. Hope everyone has a great rest of the day. You join us again on continued and occupationaltherapy.com.