ICSC03-Section1IntroModalities.txt

ICSC IMAGING Module 3
Section 1_ICSC03
Instructor Dr Chad Warshel
Video Lesson: 1:06:16

Welcome to our FICS module on Diagnostic Imaging in Sports Trauma. My name is Dr Chad Warshel and I will be taking you through the sports imaging module. This is broken into 9 one-hour sections.

A little bit about myself, just so you know who it is that is talking to you. I am a professor at Northeast College of Health Sciences in Upstate, New York, USA. Northeast College of Health Sciences was formerly New York Chiropractic College, you might be more familiar with that name. We made the change earlier this year. I teach in the Chiropractic Program, teaching Chiropractic Students Diagnostic Imaging. I wear a couple of hats here at Northeast, one of the other ones being somewhat of a self-replicating organism. In that, I run our Diagnostic Imaging postgraduate residency. For those who are interested in pursuing a career in Radiology on top of Chiropractic, that is what the residency is there for. Just knowing that we are dealing with an international audience, to familiarize you with some of the terms so DACBR is Diplomate of the American Chiropractic Board of Radiology. Unfortunately, there's only an American Chiropractic Board of Radiology, we don't have an international group.

So, folks who have that DACBR designation, are folks who have completed the three-year postgraduate residency to meet the eligibility to sit for the Diplomate examination, and then afterwards have passed the two-part Diplomate examination put on by the American Chiropractic Board of Radiology. The only way to have eligibility is to do a three-year postgraduate residency. I am the director of our program here at Northeast. I have been running the program for a little bit over 10 years now. One of the other hats that I wear is I also have a diagnostic imaging practice that I run through the Chiropractic College here through the College of Health Sciences. I interpret x-ray, MRI, and CT for the box out in the field.

My educational background. How did I get here? Well, I got my chiropractic degree at, what was then Western States Chiropractic College and is now the University of Western States. After completing my DC, I went on and did my three-year residency in Diagnostic Imaging there as well. I got the bug to teach when I was a resident, but I didn't want to finish residency and then go right into teaching. I wanted to develop some experience. I move down to California in the United States, and I did a split practice. I spend about half my time, treating patients and about half my time reading x-rays, MRIs, and CTs. Did that for 7 years, at which time I transitioned over here to the Northeast. After I had been teaching here for several years, I decided I wanted to pursue an academic degree as well as my professional degree. I did a master's in Health Professions Education here in New York at the University of Rochester. So that is me in a nutshell. Very important from a lecture standpoint, I have no financial disclosures. I am not going to be selling any products or anything else. I have no agreements with other companies so I have no financial disclosures.

Presentation Placement: 03:40
Breakdown of topics. **Section 1 and 2 – first 2 hours.** If you are looking at the entire 9-hour module, looking at the sports-med program, the first 2 hours, we are going to be talking about imaging modalities and interpretation. We are going to talk about interpretation first and then imaging modalities, because this is approaching an international audience and there are varying degrees of education in imaging interpretation, imaging orders, owning, and operating radiographic equipment. We will start at the very basics and work our way up from there to make sure that we are all speaking the same language so we all have that commonality of what it is that we are talking about. So those will be our first 2 hours.

Section 3 – We are going to get into trauma to the face and head. It is very common in sporting events to deal with patients being struck in the head. Are there facial fractures? Is there any significant intracranial injury? We will be talking about imaging those things. Then we are going to get into more of our musculoskeletal topics. **Section 4 and 5,** we will be talking about spine trauma, as well as some other differentials things that we have to be concerned about when we are dealing with the athlete. Not just for traumatic things but also for dealing with pediatric athletes. We need to think about some developmental abnormalities, things like Scheuermann's disease.

Naturally, we will have to talk about disc herniations. Those can be considered post-traumatic or degenerative phenomena. There are a couple of different pathways there. We will also be talking about spondylolisthesis. **Section 6 & 7** we will spend 2 hours talking about the upper extremity, covering everything from the scapula down to the fingertips. **Section 8 & 9** the last 2 hours, we will be talking about the lower extremity, going from the hip down to the toe. One of the things that I will try to do during this presentation is as we look at the PowerPoint slides take you through these various imaging injuries, with some live DICOM demonstrations as we move more into a digital imaging world. There are still some folks who run hard copy film, but digital is predominately what's being done. I want to give you some ideas on how to approach DICOM images and how I deal with them when I get a disc or when I have portal access to my patient's images.

This is some of the ways I can really make sure that I am interpreting these studies to the best of my ability. I will be honest with you, as somebody who is a radiology educator in the Chiropractic curriculum, regardless of where you are, with an international audience in an incredibly wide array of laws associated with imaging and interpretation. I am a firm believer; you always review all of your own imaging. Whether you are doing your imaging in-house or whether you do your imaging in-house and send it to a radiologist for interpretation or whether you send your patient out to an Imaging Center or if you get your patients to have to bring imaging in if you are not allowed to order imaging, you should always review your own imaging. For a couple of reasons, the first one being, how are you going to get better at this if you don't practice? I am a big one. Make sure you review all your Imaging-in. It is common in the modern world when we are dealing with these patients coming in with imaging. A lot of times they come with their reports too.

One of my big rules and I reinforce this with my DC students, and I reinforce this with my residents, you never look at their report first. You look at the Imaging, you interpret the imaging, you practice the skill, then you correlate with the report, and you make sure you agree with it. Just because that report was signed off by a radiologist, doesn't mean that they didn't miss things. I had a great example just yesterday in practice. So let us work on developing those skills.

One of the things that you need if you are going to be developing these Radiology skills, you need some resources available to you. The internet is all well and good but it is got some limitations so I always like to make sure I cover some of the major texts that I will use in dealing with imaging.

Presentation Placement: 08:15 - References

Because this is a sports module, that primarily we are a little worried about trauma cases. A couple of my big books, are really, my go-to books. Any time I am dealing with trauma cases, the first and original, and one of the most well-recognized textbooks on trauma is Rogers' Imaging Skeletal Trauma. Rogers' fantastic speaker. By the way, if you ever get a chance to hear them, really the definitive text. This is where trauma imaging since the 70s and 80s has really been based on Roger's. Some other texts, Spine Injuries in Athletes by Hecht. This was a great read. It is not an incredibly thick book. It is three-quarters of an inch or so thick, of centimetre and a half. This is a great resource particularly because it is focused on athletic injuries naturally. Not an Imaging book but a clinical book, Essentials of Musculoskeletal Care. What this does is it is great for diagnosing different kinds of musculoskeletal conditions. It also talks a lot about what is the allopathic management of various conditions.

Then, probably the book that I spend more time with than any other these days not necessarily this one specific book but this series of books put out by Elsevier is the diagnostic imaging series. There's an entire, there's a huge library of books here, Diagnostic Imaging Brain, Diagnostic Imaging Gastrointestinal, you name it from an MSK standpoint.

The 2 big books, because this is predominately trauma that we are talking about, Diagnostic Imaging, Musculoskeletal Trauma, great book, and the other one kind of its sibling text, is Diagnostic Imaging Musculoskeletal Non-traumatic. So not to surprise you. We are dealing with sports injuries, spend more time with the trauma book. The non-trauma book is great when we are dealing with things like Ankylosing spondylitis, rheumatoid arthritis, or some of the other musculoskeletal conditions that don't have immediate traumatic incidents. Some general radiology references. One of the things that I get asked a lot, whether I am doing postgraduate seminars or whether I am just talking with colleagues, everybody always wants to learn more about MRI. X-rays are a relatively straightforward, kind of thing. MRI is much more difficult, much more involved. If you graduated more than 15 years ago, it probably wasn't the core part of anybody's curriculum.

So, one of the first books that I recommend starting with is in an MRI world is Major's Musculoskeletal MRI. Wonderful book, light book. It is about a centimetre and a half or so in thickness, and it is a primer. It is the 30,000-foot overview. It talks about how MRI works without getting too deep into the physics because radiology people, we can get pretty deep into the weeds when we start talking about physics. It avoids that. It gives you what you need to know about how MRI works. Then, it breaks down the different musculoskeletal regions with some of your major diagnostics. Great place to start.

Another fantastic book that is relatively new out onto the scene is Pope's Musculoskeletal Imaging, a wonderful resource up to date in materials. If you want to dig deep and you really want to learn everything, there is to know about musculoskeletal imaging, particularly with an MRI focused, Stoller is the author of the Orthopedics and Sports Medicine series. There's an extensive multi-volume series of books here, and it covers everything. This is what my residents used when they were talking about internal derangements. Of course, we cannot talk about Radiology without talking about the big 3 radiology textbooks put out by Chiropractic Radiologists. Dennis Marchiori's Clinical Imaging, John Taylor's Skeletal Imaging, and Terry Yochum's Essentials of Skull Radiology. All three are wonderful textbooks.

We live in an internet age, so, hope you are all well and good, and a lot of these do come in eBooks. But I have some website resources. So big 3. Coming to you from America, one of the resources that I do recommend very heavily is the American College of Radiology (ACR). Their website has an important thing called the appropriateness criteria. A lot of times you are going to have questions; Do I want a CT? Do I want MRI? Is ultrasound the best option? What's okay? This is my differential; how do I follow up on this?

The appropriateness criteria are a wonderful guideline, and it talks about what imaging might be most appropriate for various conditions, particularly again using a sports medicine lens to look at this. It will talk about applications of the Ottawa criteria for knee and ankle injuries. So, the appropriateness criteria are a fantastic place to start. Regional law being with this, if you are able to order imaging, and you are wondering what the order don't forget to always just call the radiologist. I would much rather spend 5 minutes on the phone with somebody and get the right study than have nobody get a hold of me, and I write a report that doesn't tell you what you need to know.

Video Placement: 14:07
Other websites. This one here, www.radiopaedia.org I have at number 2, but I should put this first on the list. As a radiologist, somebody who practices reading, and imaging every day of my life, and somebody who trains Chiropractic students and radiology residents, Radiopaedia has been the single

biggest boon to radiology education in the last 20 years. It is a wiki-style website where you can contribute cases and put in write-ups, it is moderated to make sure that the information put in is cleaned up as much as possible. It is free, which is just amazing to have a reference like this. If you want to see 13 different versions of an aneurysmal bone cyst, it'll show you 13 different versions. If you want to know, is this what sacroiliac joints are supposed to look like? This is maybe A.S. You are going to see 20 cases of A.S. So wonderful resource. They also do have a lot of other resources available, but 90% of what's on that website is free. You don't have to register, but it has really been a wonderful addition to radiology education.

Another good website is www.auntminnie.com . Aunt Minnie is a radiology term, and what it means is, if I walk into a family reunion, I know which one of these people right away is my Aunt Minnie, because I can see her and I recognized her instantly, it is all radiology term. If I see a raindrop skull, I know it is multiple myeloma. If I see a rugger jersey spine, I know it is hyperparathyroidism. Aunt Minnie is just another radiology education website. One of the things that they have that I really enjoy is they have a case in the day that you can sign up for and every day in your email, you will have a new interest in radiology cases. So, just some of those resources that are available to you to help you learn radiology.

Let us start talking about Musculoskeletal Imaging. Before we even get into all the different tools and things that we need to do. How about we just do a quick brief run-through. How do I read imaging the right way? There was a interesting study and unfortunately, I don't remember the citation off the top of my head. But there was a study that used eye-tracking software, and they watched novice x-ray readers versus experienced radiologists and they tracked eye movements, looking at studies. One of the things they found was a huge disparity between the novice and the expert. Not in all the novices, in between all the novices, they are all over the place. The experts all had a very similar way of approaching imaging and looking at different things in a study. That is one of the things we want to cultivate. We want to cultivate the ability to look at images the same way every time. Why do I want to do this? Because talks there's this interesting phenomenon in diagnostic imaging called satisfaction of search. It has been very well documented that if you have a patient, looking at imaging on a patient. Let us pick a lumbar spine. We are bringing AP and a lateral view to the lumbar spine. If there is one significant pathology on that x-ray? There's a good probability as soon as I see that pathology, I stopped reading the film. I found something and that something could correlate with why my patient's here. I can stop looking at the film. What is interesting is if there are 2 significant pathologies on an x-ray, there's a ballpark about 30% chance that you are going to miss one of the pathologies. If there are 3 significant pathologies, you have gotten over a 60% probability of missing at least 1 of the 3 because we stop looking when we find an explanation.

We must be careful and aware of that. One of the things that we want is to have a systematic way of approaching radiographs, MRIs, and CTs. So that we do the same thing every time. If we must put less thought into the process, we can put more thought into the diagnostic evaluation. Our eyes can only see what our mind comprehends. We are going to start developing this systematic search pattern. Doctors have a bunch of different ways to do this. Everybody's got their own little way probably named after themselves. Kind of like Chiropractic techniques. This is one that is fairly generic and widely used so it is an effective system for me from a teaching standpoint. I enjoy watching new students. I get somebody who is new to reading x-ray and as soon as they have x-rays up and their noses right on that x-ray monitor, they are almost leaving nose prints on my screens, and they are trying to find the smallest little minutiae that they possibly can. That is the wrong thing to do. There is an old phrase, one of those idioms, you don't want to miss the forest for the trees. If you start zooming in really close, you might be able to tell me everything about the bark of one tree, but what does the rest of that forest look like?

Before you ever get into a point-by-point search pattern, particularly we are looking at the x-ray, pull the images up, have them all on the screen and sit back. Just take in the big picture, look everything over, and just let it absorb for a second. Then, you can get into your search pattern, looking at each individual

structure. Things to be aware of and we are going to talk about a search pattern here in a minute. Make sure you look at those things that are the areas that are hard to see. On a lateral cervical, the c-spine is easy to see, the skull, the little bit of the skull we are supposed to see on a c-spine, maybe not so much the CT Junction difficult. You need to be looking outside of that central area, and make sure that you are covering the entire margin of the film. You have to see the entire thing. I used the term film realizing we are looking at digital imaging, but you want to make sure that you look at the whole thing because not surprisingly, as chiropractors, if I take a lumbar spine study, I am going to focus on the lumbar. A lot of times, there might be something in the TL Junction. There might be something in the abdominal soft tissues. We want to make sure that we are paying attention everywhere in the study.

The other thing that you want to do is, that a lot of education is stuck in old-school film and PowerPoint. When we are talking about old-school film, or when we are teaching people using power points, you have got a picture on the screen in front of you. You cannot make it brighter, darker, zoom in, or zoom out. It is the nature of hard copy film, and it is the nature of PowerPoint. That is one of the things that you want to do is you want to use all of those DICOM tools that you have, available to you. This is where we start talking about doing a DICOM demonstration. I have a single view of the thoracic in the lumbar spine study, so again, when I am starting to approach this study, I am going to do a couple of things. The first thing I am going to do is pull up a two-up window. I am going to put the AP in the lateral next to each other, and then I am going to sit back and just take in the whole thing. I did my take on the whole thing and now I am going to focus on the AP. Don't forget there are DICOM tools. Another one of those big recommendations, get your own DICOM viewer. There are plenty of free where available DICOM viewers. I should clarify DICOM, D-I-C-O-M. Digital Imaging and Communications in Medicine. It is the standardized language of computers for digital imaging. It is a worldwide standard and works really well. What you want to do is if, again, very regional dependent, but if you get patients to come in and they bring imaging from 3 or 4 different imaging centres, you ever notice where are the tools? One of these is built by company A, one of these is built by Company B, and one's company C, and they are all in different places. How come those cannot be standardized? No. But that is the proprietary nature of things. If you have your own DICOM software and again, there are many freeware versions, or you can get inexpensive DICOM viewers that are fully functional. But that way, you can use your DICOM viewer to open all these studies.

Video Placement: 23:34

The patient brings in a disk, you pop the disc and you open it with your software. You can access somebody's portal via the Internet, you can download the images, and open them with your viewer. That way, you always have your tools in the right place, and we are going to talk about tools quite a bit here today. So, as I look at this study. you know what, maybe this doesn't look like it is that large? Well then, all I need to do is I need to enable zooming in. I will zoom in, and then after I zoom in on titled, see, everything. Zoom in and then pan around. Moving the image around is called panning. I am panning my way through the image, making sure I am accounting for every margin as I am looking at the study. We got really lucky on this particular patient in that, really nice quality radiographs here. This person is pretty homogeneously thick. But what if I got somebody who's a little chunky, I got somebody who has a little bit extra adipose tissue. You might notice that some areas are overexposed, and some areas are under-exposed. One of the probably single most important tools in digital imaging is the ability to window and level. We can change the brightness and contrast. In old school films, we could not do that unless we took another x-ray with different factors. PowerPoints you know, we are talking about manipulating jpegs, so not the same thing, and realize jpegs and icons are completely different animals.

When I am looking at this study, let us say this middle portion was nicely exposed, but the pelvis was under-exposed. All I need to do is hit my window and level button. I can change the brightness and I can change the contrast. That will let me highlight different areas. If I really want to get down here into that femur, zoom in on this area on the femur. I am seeing that femur a little bit better when it was a little under-exposed before. But if I look here in the mid-lumbar, well, now there are a little overexposed.

One of the other tools, that is really, it is very remarkable in its functionality is the ability to invert images. If you are ever looking at something on an X-ray or an MRI or CT and you are not sure, am I seeing something? Is that really there? I am not 100% convinced. Invert the image. It makes your brain process differently because if this is not what I am used to looking at, so I have to think more about it, and it'll really help you decide. Is this something real or is this something not? So those are some of our fantastic tools when we start looking at these. We can throw measurements on things if we need to. If I need to measure scoliosis, I can throw a Cobb angle on things, and it'll calculate the angle for me. There are all kinds of tools available that really make this very functional for us. Make sure you use those DICOM tools. Then when we start getting into our search pattern, one of the important thing about our search pattern begin with making sure that we have that, doing the same thing every time. We are always doing this the same way, the ABCs. It is in English of course, are the first 3 letters of the alphabet, ABC, and the ABC is kind of how we phrase something like an introductory thing. The first thing we are doing is how to read an x-ray. What are we looking at? We are looking at the alignment /anatomy, bone, cartilage, and soft tissues. So that is our generalized search pattern. We are going to look at those ABCs to try to see what's going on.

We are going to do this again. I am going to pull up our x-ray that we were just looking at. As I look at this image, alignments, I am going to pull a two up so that we can see both our AP and Lat on this one. Alignment is everything where it is supposed to be? It seems like a basic concept. But again, we are making sure we are starting on a good foundational level. Is everything where it is supposed to be?

I am looking at spinal imaging, on the AP views. Is the spine straight? Is this spine leaning to the side? is the spine curved? I look at the lordosis, is lordosis normal? is it flattened? Is it hyperlordotic? I am looking for all these different alignment things. Some of the other things that we do on a lumbar spine, also pay attention to whether or not your spinal imaging is done upright or recumbent. In the Chiropractic world, we tend to do our spinal imaging upright. In the medical world, they tend to do their spinal imaging recumbent. If it is a recumbent study, you have got no postural information. Always make sure is it upright or recumbent, and obviously, these are labels are upright studies. Getting into the lateral, I am looking at the lateral again from an alignment perspective. This is where I will look at things like the 4 lumbar lines. I look at the anterior body line and see if everything's lining up. I look at the posture body line, also known as George's line, a little jog right there. I look at the spinal amateur junction line, and I look at the spinous tip line. As I am perusing alignment in this case, I noticed there was an offset in George's line, and there is an offset in the spinous processes. That is where I see this alignment abnormality, there's a spondylolisthesis specifically, an anterolisthesis there be all five.

The night that I would start investigating further and get into the bone and get into the cartilage and we will get there momentarily. If I paid attention to that a-stuff, is everything there? Is everything where it is supposed to be? The other thing we need to do is we need to account for the anatomy, and now this is at the macro level, the gross level. Count structures, there are five lumbar, and there are 2 emipelviders. There's 1 sacrum, and there are 2 femurs. I am seeing four sets of paired ribs. I am making sure all the gross structures are there. What I am doing under that a-section, is I am also looking for anomalies in the variance. Extra parts, missing parts, are usually congenital in nature, and realized again, that another one of those interesting phenomena about neural functioning. Extra parts are really easy to see when somebody has more things in that are supposed to the one that jumps out at us that just is not right, but if somebody is missing structures, our eyes tend to fill in missing structures. One of the little catchphrases radiology is the hardest thing to see is the thing that is not there.

We will start doing that from a growth standpoint. From there, we get into the bone. I am going to go to a single up on this one. When we are looking at the bone, again I have got a very systematic way that I do things when I am training people to decrease the probability of missing things and making mistakes. The first thing I assess when I look at imaging pretend, I am focusing on an x-ray right now, I look at the density. Now, the X-ray is a lousy tool for assessing bone density, and it takes big changes. It doesn't

have great threshold discrimination. It is one of those things that it is not great, but I am still going to make sure I assess. How is the bone density? Is the bone density normal? Is it increased? is it decreased? One of the things that we want to get used to doing, is that we also want to quantify things to the extent available. When I see somebody now, this person has good bone density. If this person had decreased bone density, the bones were too loosened, the cortices were thin, and the trabeculae are starting to stand out. If I see that, one of the things I want to get used to doing is quantifying if is this mild, moderate, or severe?

We know that we are not great at this. We are very familiar with the idea that, if you ask 5 different radiologists, you might get 6 different answers. It is what the bone density is, but you want to get used to it, mild, moderate, and severe. Keep life simple. This person has adequate bone density, normal, unremarkable, whatever you want to say. The next thing that we are going to do, and this is one where again, we look at that study, we are watching a radiologist, watching their eyes with tracking software. You can see there's a very systematic way that things are done. Going to zoom in. The next thing we want to do is we need to trace every cortical margin of every structure, and then assess the trabecular pattern. I am going to pick on L4 as well, it is easy to do. I traced the cortex of the vertebral body, and then I am going to start running through the posterior elements. Inferior facet, lamina, transverse process, superior facet, pedicle, pedicle, spinous process.

I am going to do that for every structure, from T10, through L5, down the sacrum, looking at the sacral foramina, accounting for the cortical margins in the pelvis. Then after I trace all the cortical margins, I look at the trabeculae and make sure the trabecular pattern is okay. I see normal crosshatch patterning there in the L4 body and L5 and so forth. Then I am going to do here once I get my tools visible. I started looking at the trabecular bone and realized, is that what the super acetabular ilium is supposed to look like? There is always that kind of cross-hatched appearance, and sometimes there's a little speculating that happens in that trabecular region. When I come down and I get down here into the femur, realizing, what's normal to the trabecular pattern? There are the primary compressive trabeculae. There are secondary compressive trabeculae. Then there is the primary, tensile trabeculae, and those trabecular patterns create a little triangle called Ward's triangle. All the cortical margins are intact, and all the trabecular patterns are normal, and basically, when you are doing this, the cool thing is by saying cortical margins are intact and trabecular patterns are normal. You just told me as a radiologist, my patient doesn't have any fractures and no tumours. You have no fractures; you have no tumours.

Then we look at cartilage. Now we have a little asterisk here. We cannot see cartilage on the x-ray, and keep in mind, that this ABCs approach works with all imaging. When we are dealing with musculoskeletal, you always look at alignment, then bone, cartilage, and soft tissue. Cartilage, I cannot see cartilage on the x-ray. No, I cannot see the cartilage on an X-ray, but what I can see is I can see joint spaces, and I am looking at joint spaces. I am looking at the intervertebral disc spaces if I am looking at the lateral. I know I cannot see the Facet Joint spaces very well when I am looking at a lateral. I even cannot see it on an AP in a lot of cases, but I can also, as a part of that cartilage, I know that, yeah the facet joint is invisible but there's the articular process. Is it too big? Is it sclerotic? Realize that there are feedback mechanisms. Things that affect joints also influence bones. When somebody decreases disk space with degenerative disc changes, they also get in plate sclerosis and osteophytes, and it kind of goes back and forth. I am looking at those joint spaces. Are they normal? Are they decreased? Are they in very rare instances, increased? Is there ankylosis? Is there any subchondral sclerosis? Is there any osteophyte formation? I am looking at all those joints, making sure I am eyeballing all the joints, and then I get into the soft tissues. The soft tissues are where chiropractors tend to fall down a little bit. This is because we are musculoskeletal specialists, and we really focus on spinal and extremity osseous anatomy, we tend to overlook soft tissues. A lot of times when I get something circled on an x-ray, we are somebody sends me a film and says, "Hey, Chad, what the heck is this?" Turns out to be soft tissue. We are going to make sure we are accounting for the soft tissues that we can see radiographically. On a lumbar spine, there's a psoas shadow. There's a psoas shadow, they are roughly symmetric. I can see

that. We cannot see the small intestine very well on an X-ray, but we do see the large intestine, and I am following all the way through transverse and then down to the sigmoid, and that all looks good.

Then I am going to start picking out organ structures. There's a liver. Fantastic, there's a childney, wonderful. Spleen, most of the time we don't see the spleen. If we do, there will be a thing tucked up there. If I start seeing the spleen below the ribs that is a problem. We are accounting for all those soft tissue structures. Now outside of the lumbar spine and we might be looking at the lungs, the heart, the trachea, c-spine, and t-spine. In the extremities, we are looking for calcifications and we are looking for swelling. We want to make sure we are looking for all those different kinds of structures as we approach our search pattern. Of course, just as a little satisfaction, we already talked about it. Our patient does have a grade 1 anterolisthesis on L5, and there are some beautiful defects in the parts interarticularis, which is why there's that step-off in the spinous process between L4 and L5. We are going to move into talking about some of the different imaging modalities and the different things that we are going to have available to us to start assessing our patients that have trauma. There are a lot of choices. Now we know x-ray is kind of the first place we go when we start talking about imaging. When we are dealing with spinal extremity trauma, we tend to start with x-rays and there's a good reason. X-ray is inexpensive, an x-ray is widely available. Depending on the laws in your region, you might be able to own and operate X-ray equipment. You might be able to refer directly for imaging to imaging centers and realizing there might be restrictions where you cannot but x-ray tends to be a first-line in diagnostic workup when we are dealing with trauma cases. But what about when do I do an MR? Do I really need it? Is an x-ray going to use be useful here or should I just go to the MR? Maybe a CT would be useful. What do I do? What's my next step? What's my tool? Time for a little insight into me. Before I became a chiropractor, I was a mechanic. Technically, I was an Automotive machinist, but it is much more easily explained by saying that I was a mechanic. So, one of the things that as a mechanic I developed early on was a pretty extensive tool collection. I am a huge tool fanatic.

These are 3 of my toolboxes and I have a couple of others because I learned pretty early on, that if all I had was a 10-millimeter wrench, there are only so many jobs that I could do. I also learned that if all I had was a sledgehammer, I wanted to smack everything wet, and that is not great when you are changing out a window. We want to make sure we use the right tool for the job. In order to do that you have to know what the tools are and what their strengths and weaknesses are. Let us talk about some of the different tools that we are going to have available to us as we start dealing with imaging. Let us start off with a regular Run-of-the-Mill X-ray. Technically radiograph. X-rays are the little photons that whizzed by the speed of light. So, you know, even though we colloquially call them x-rays, technically radiographs are a more appropriate term. Radiographs. We are going to keep the physics explanation actually really short. Basically, when we look at the human body, we have 5 general types of tissue, and five different types of materials and those five different tissues absorb different amounts of radiation. This is called differential absorption. The only reason that we can see anything on an X-ray is where we have 2 different tissue densities butted up against each other. When we see two different tissue densities butted up against each other then we can see those things. Our five densities are air, fat, water, bone, and metal. Those are the five things. Air does not stop radiation very well and of course, we are thinking about this. We must think about this photographically. Light exposes the film. So light, and yet, photons being light, when photons hit film, it makes film dark. Air, like in your lungs, doesn't stop many radiations that is why the lungs are so dark. Fat absorbs a little radiation but not very much, so it is a light grey. Water absorbs a decent amount, so it is intermediate grey. Bone absorbs, quite a bit so it is pretty white, and then metal stops most photons, so it is very white. Fats are self-explanatory and bones are self-explanatory. I don't have that much pure water in my body. Why are we talking about water? All of our solid organs are water density, so muscles and solid organs are all water density; liver, pancreas spleen, you name it, those are all water density. Vastus medialis, Vastus lateralis. Those are all water densities. The only reason we see anything on an X-ray is there is an interface between 2 of these densities. Why can I see the bone on this x-ray? Because it is surrounded by water density musculature. Why can I see that there is a change from this musculature right through here? Because there's some

subcutaneous fat, and then outside the skin there's air. Approaching this from a practical standpoint of looking at an x-ray. As I look at this x-ray, I notice this person was complaining to their doctor about a mass on the outside of the thigh. It was palpated, there's a palpable mess and I will be, "Is x-ray really the first place I would go for? But it is probably a soft tissue mass?" Well, the answer is probably still yeah.

Even though an x-ray might not be the right tool for it. It is cheap. It is easy. It is quick. It is minimally invasive. Yes, there is no such thing as we are safe, radiation exposure, but it is relatively low on our scale. Take an x-ray and see if we get lucky, if not, then we can always go to something more expensive, more invasive? In this case, we got lucky. What do we see? So, here I am, in the area of Vastus Lateralis. Notice I can tell Lateralis versus Intermedius versus Medialis because they are all water density, butted up against each other. Inside Vastus Lateralis, there is this darker area. It is not as dark as air, but it is not as white as muscle. Well, in between air and water is fat. What we are seeing here is, that this person has a large fatty lesion inside their Vastus Lateralis. Cool. So, we can use that application. Another place. Another good demonstration of using this application of the 5 radiographic densities. I would like you to take a moment and look at this lateral view of the knee. I will guarantee you, as much as I can because one of the rules of radiology is there are no absolutes. The only absolute in radiology is there are no absolutes. I will guarantee you a 99.99% certainty that this patient has a fracture. I am going to give you about 10 to 15 seconds. I want you to use your search pattern and I want you to find the fracture.

Video Placement: 47:27
Time for a great multiple-choice question. We have got an A, B, C, and D choices. Femur, tib, fib, and patella. There are 4 bones. One of those bones is broken. Think about your answer, and lock in that answer? **The answer is E, we cannot tell**. I do not see a fracture on this x-ray. All of the cortical margins are intact. All the trabecular patterns are normal. I do not see a fracture, but I will tell you what the 99.99% certainty that my patient is broken for one simple reason because I see that flat line right there. I want to get rid of that flat line so you can see what I am talking about. But when I look at that flat line. So right there, here's a flat line. Now above that flat Line, there is this darker area, and then, below the flat line, there is a more opaque area. That little flat line that we are seeing between the arrows here is something called a Light Boheme arthrosis.

This person has broken the bones somewhere inside the joint capsule. While you break a bone, you are going to bleed. So, they are bleeding into the joint capsule. But if they broke in the bone marrow, that liquefied marrow fat is going to escape as well. What's happened is this marrow fat has floated its way up and it is separated from the blood. A lot like an oil and vinegar salad dressing does, and lipohemarthrosis is a big indicator that this person has an injured captioner fracture. This is a great application of those five densities in my search pattern working on soft tissues and it says, my person's got a broken bone. I don't see the fracture, which means I need to look. I need some extra imaging. I even need more x-rays, or I need to think about getting an MRI or a CT, and we will talk more about that a little bit later. 5 radiographic densities, air, fat, water, bone, and metal. We can see a little bit of metal going on with this individual, who obviously had a bad day out on the golf course. As we are looking at this case, it does show us again the density, so air outside the patient. Subcutaneous fat, muscle is water, bones are self-explanatory, and then there's the metal for this hybrid iron. One of the things that are interesting here is, if you notice in this case that I can see the interface between the deltoid and the bicep and that is because there is a fatty layer in between them. But I cannot tell the difference between bicep and brachialis because there is no fat interposed between the two. The right tool for the right job. To know what tool is right for the job, you must know what that tool is good for. Hammers are good for hitting things. Screwdrivers are good for fitting into a slot and twisting, we don't want to use screwdrivers as chisels. What is x-ray good for? X-rays are great for looking at bones, especially if I need to count things. If there are extra parts or missing parts, great tool. It is fantastic at looking at fractures if I am looking for broken things. But I do have to realize there are some limitations. Some fractures are

notoriously difficult to see, like scaphoid fractures and rib fractures, and that is where I have got to keep that in mind which fractures might be more difficult to see.

It is good at looking at joints. Now realize when we start talking arthritic conditions, whether we are dealing with degenerative or inflammatory conditions, we are not going to see, you know, 5 days after somebody starts getting inflammatory arthritis, we are not going to see them on x-ray. Takes time before those things show up radiographically, but it is a good way of assessing those joints, and not surprisingly, biomechanics. Evaluating a lower dose. Looking for a spondylolisthesis. Is there a Scolio? Those are biomechanical concepts. Things that the x-ray is not good for, and this is a classic example of a patient with metastatic disease. The patient is elderly, has unexplained pain, getting progressively worse, progressive weight loss, and dark stools. Everything that is said that it was a malignancy going on with the patient. One of the students said, "Well, I take an x-ray, and if the x-ray is normal, I would go ahead and start treating the patient." Well, that is a problem. Because an x-ray is not good for early destruction. Negative x-rays don't rule out things like metastatic disease. Negative x-rays, say that the structure is relatively normal. But a number that we need to remember is that it takes 30 to 50% destruction before anything shows up on an X-ray, and if I have got somebody who's got a metastatic disease, it is destroyed 20% of the bony structure, and the vertebrae, that is going to be drastically weaker. But it is still going to look radiographically normal. It is not great for looking for early lytic disease and we cannot use an x-ray to rule out things like metastasis. Similarly, when I look at a generalized bone density, you know, so when we get into bone, the first thing we do is assess bone density. I realized it is got its weaknesses. Can we identify osteoporosis on an X-ray? Absolutely. Is it the best tool? No. But I am still going to look for it.

The other thing to realize is even though soft tissues are part of our search pattern, an x-ray is really not great for looking at soft tissues. If I need to figure out if somebody has a partial thickness supraspinatus there, what's that going to look like? normal shoulder x-ray. If I am trying to figure out if somebody has an MCL tear in the knee, these were collateral ligaments, am I going to see that? No, probably not. Can I see some other findings? Yes I can. I am realizing that if I am looking for soft tissue problems, an X-ray probably is a great tool you know? I might be starting there, and kind of along the example, of along the lines of our previous example. Let's talk about metastatic disease. If somebody has breast cancer that spreads to the bone, or prostate cancer that spreads to the bone, it really spreads more to the marrow than it does to the bone itself. Metastatic disease is primarily a marrow pathology, it is a marrow-replacing disease and marrow is soft tissue. X-rays are not great for looking at the marrow. Same thing for things like infections, Osteomyelitis. Osteomyelitis is an infection of bone and myelitis bone marrow. It is more bone marrow than it is bone.

This is not a great tool for those early things. If those are on my differential list, I know that an x-ray is not going to be a rule out. It is just the first part of the diagnostic workup. Now, this applies a little bit more to places where you can own and operate x-ray machines and fewer places, either folks who just send out imaging or if you have to send out Imaging. If you are taking your own x-rays, one of our huge rules in radiology is one view is no view. If we are taking x-rays of any body part, generally we want to have at least two views and sometimes three if the anatomy is more complicated. There are no absolutes in radiology things like an AP pelvis being an exception, one view is no view, and please make sure you are doing standard views. If you want to do made-up views, those are fine. I have made up more than a number of views in my own life.

However, I always start with the minimal series. Standard x-rays and not made-up things. Things that anybody that works in the radiology world will be able to recognize and start with that minimal series. Look at the clear minimal series. The number of places where as soon as it is a neck problem, I am getting seven views. That is a lot of x-rays that you really, probably don't need. So, clear the minimal series and then decide if you need some extra views. Now, again is it a little different if you are having to refer patients out? Do I have to send somebody back and forth 15 times? No. But think about what

views I really need. What is really going to change my diagnosis or what's really going to change how we treat the patient? Talking about some of the extra views, I am jumping to the bottom of the slide and look at some of the extra views in the extremities when we get to those various pathologies. I am talking about Radiohead fractures, about doing the hyper supinated view, things like that. But in the spine, the major extra views that we talked about in the spine are the obliques and the flexion-extension to use. I will be honest with you, as far as obliques go, I am not a fan of obliques, either cervical obliques or lumbar obliques. Because I can see most of what I need to see on an AP and a Lateral. I think obliques are way overdone because they can see what I need to see without the extra radiation exposure.

I will show up some pictures here in a little bit because I would like to get off, I am a picture guy. I don't like the text slide so much. So that is obliques, we will talk about that in a second and then flexion-extension. If I am worried about ligamentous injury, if I am worried that somebody has too much motion in an area, that is where reflection extensions come into play.When we start talking about cervical obliques the primary thing that we see when we are talking about cervical obliques is, that the cervical obliques are designed to show us the neural foramina, the IVFs. But they are also good for showing us the posterior elements. I can see the pedicle, I can see the articular pillar, and there's the other pedicle through here, and by looking at a set of obliques, I can evaluate those posture elements. It was concerned that is there a facet fracture there? Is there a laminar fracture? Lumbar obliques, when we look at lumbar obliques, are primarily designed. The number one thing that we see on the lumbar obliques is the pars interarticularis. With that being said, we also see the rest of the posture elements. Superior facet, transverse process, interior facet, lamina, and pedicle, so we can see all those different structures.

Cervical obliques, if I was worried about a posture element fracture or encroachment neural foramen, I do a cervical oblique. Lumbar obliques are designed for looking mostly at that parsed. Now, if we think about this though, the pars. The pars are that thing that we are worried about in patients with the pars interarticularis we saw previously. If I see a part of the effect on the lateral, why would I get a set of obliques? You know, what it is going to tell me, yes confirming what I already saw. If I am not sure, then I think about the obliques. But, what’s the most common level for us to find pars defects? L5. What's the best way to see the L5 pars? Not the obliques. The best way to see the L5 pars is this view, Ferguson's view. This is a tilt-up x-ray, so we tilt the X-ray tube up 25 to 30-ish degrees. What this does is it gives us a beautiful frontal view of the lumbosacral junction, and by doing that, I can see the area of the pars interarticularis, just as well, if not better, but I could understand on obliques and I saved a ton of radiation exposure. The other thing that I evaluate, and the other big reason that I ordered this Ferguson's view also known as an AP Angulated lumbosacral spot. The other reason I do this is when I want to look at the outside ones, beautiful view for looking at the outside.

What else? Flexion-extension views. The big deal with flexion-extension views? We are looking for instability. I have got somebody who's not getting better. I have got somebody who's got a clunk. I have somebody who says, I feel unstable. Big deal on the flexion-extension to use? They are not that useful in the acute patient, because I am dealing with somebody who's got muscles, you know if I ask my patients to do active range of motion, and that is their flexion, and that is their extension. Yeah, I am not going to see any ligament instability on an X-ray. I have got to wait until there is a fuller range of motion before I can assess instability.

Once the muscle spasms are down, if I am worried about instability, then I will think about flexion-extension studies. Not that useful in the occupation. In a case like this, we have somebody who is post-trauma, and on the flexion-extension, the most important thing I see is, wow, there is a big increase in the Atlantodental interval, I am worried about the integrity of this person's transverse ligament. Another special note from a sporting side of things. When we deal with the special Olympics, one of the things about special Olympics is, when we start dealing with individuals who have down syndrome, folks with down syndrome cannot participate in several of the more contact sports in the Special Olympics.

Unless they've got flexion-extension cervical spine clearance because there is a frequency of transverse ligament agenesis and insufficiency upwards of 22% in folks that have Down's. As we are talking about instability, one of the things we must be aware of is the types of instability, and I am focusing on the spine, not so much on the extremities right now. I am going to talk about those as we get to them. When we are dealing with spinal instability, one of the big things about spinal instabilities is 3 kinds, translational, angular, and upper cervical. So, for translational instability, I have got 2 vertebrae here and there's a little animation. I want you to watch this animation. This is translational motion. We are seeing where one vertebra is shearing on top of the other as it slides back and forth.

We typically cannot watch the motion while it is doing this. So, how am I going to assess this? Well, I do flexion-extension radiographs, and when I do those flexion-extension radiographs, there is the back corner of the vertebrae and there's the back corner and I would measure that distance. There is the back corner, there's the back corner, I would measure that distance, and I would know how much total motion is there. The cervical spine is 3.5 millimeters and the lumbar spine is 4.5 millimeters. That is an indicator of instability. Too much motion because of ligamentous damage. Now the other kind of instability is angular instability. Here, we are talking more about that instantaneous axis of rotation. You can see how the upper vertebrae are rotating too much on the lower vertebrae, and what we would do is again we will be looking at flexion-extension radiographs, and there are different ways cervical versus lumbar. I am not going to get too much into this because it is a little beyond the scope of what we are doing. What I do is I would look at the angle created by the end plates, and I would look at the angle created by the end plates, and I would take this angle. Doing this way, I would take this angle and I will take this angle and I would see how much angular motion there is. Again, we have got to find criteria for what is too much. The other instability is upper cervical instability. There's a slide with a lot of text. Let's look at pictures. The big idea here is whether we are looking at neutrals or whether we are looking at flexion extensions, there's a malalignment between C1 and C2. Here we can see where everything lines up the way it should. This is what it is supposed to look like, both on and radiographed and schematically. Well, if I go to this, in this case, I can see where C1 has translated relative to C2. C1 has moved too far while C1 is moved too far forward.

Well, first I need to figure it out because there are 2 things, 2 big things that result in upper cervical instability. It is either a problem with the transverse ligament or it is a problem with the dens. If C1 moves forward as it has in these cases, this can be either transverse ligament or dens, and I want to try to figure that out. The way that I figure that out is I come up here and I look at the Atlantodental interval. We can see here that the ADI is increased. Well, if the ADI is increased, that means the transverse ligament is gone. It is ruptured, it is inadequate. It is insufficient, it is lacking. If the ADI is normal, and again our ADI rule is 3 millimeters or less than on adults, and 5 millimeters or less than on children. If the ADI is normal, well that means that the transverse ligament is still tying the dens to the anterior arch, but it means that the dens are no longer attached to C2, and that is a dens problem. It is either an oxidant odium or a type 2 odontoid fracture. There is the remote possibility of odontoid agenesis, but of course, then you cannot see an ADI. What if C1 moves backward? If C1 moves backward, what we are seeing here schematically, that is a dens problem. Because C1 cannot move back to the dens in the way, that means that if C1 has moved backward, that this person, either has a type 2 odontoid fracture an oxidant odium, or odontoid agenesis which is what we are seeing here. That makes a great place for us to stop our first hour of imaging and sports injuries. In section two we will finish talking about the different choices that we have available to us as far as the tools in imaging.

[END]