ICSC IMAGING Module 3
Section 9_ICSC03
Instructor Dr Chad Warshel
Video Lesson: 1:06:19

Lower Extremity Injuries part 2.

I realize that this is a little different than the upper extremity in that we just kind of marched our way down the upper extremity. I reserved the knee for the second hour for the lower extremity just because it is probably the second most complicated joint we deal with in the extremities, the shoulder being the number one, knee being number two. I wanted to give a good focus to this in the second hour.

As we start dealing with the lower extremity, of course, this entire hour is going to be about the knee. Realizing x-ray is a good tool for the knee and we are going to talk about some indications for x-ray and some positive x-ray findings. But one of the things to realize about the knee is, much like the shoulder, a lot of the things that we must deal with in the knee are going to be soft tissue injuries and those soft tissue injuries are going to show up more effectively on MRI. Ultrasound is an option for some of the more superficial tissues. However, MRI is really the gold standard for evaluating the knee anytime we were dealing with soft tissue components.

I want to start off by doing an overview of knee MRI, and a little tour of some of the anatomy of the knee. So, when we start looking at knee MRI, again we are dealing with standard planes on the knees, so it is going to be axial, coronal, and sagittal. There are going to be combinations of T1s, T2s, proton densities. Whenever I am evaluating a knee study, just like I do with any other extremity, I always start with the fluid-sensitive sequence. I am looking for that tissue that is angry, I am looking for fluid, I am looking for edema. I could start on the sagittal or the coronal. I would start on the coronal in this particular case. I just start at the patella and I am working my way back and I can already tell this person has a severe effusion in their knee. I can see that right through there. Then as I am coming backward, evaluating the bone marrow. The bone marrow signal is nice and grey. A little heterogeneity is normal. Remember that the knee is mostly fatty marrow. As we are coming back, again I do not see anything that is hugely aggravated. A little bit of extra fluid in the knee and then I do see that there are a large fluid collection on the posterior medial aspect, very common. What we are seeing there is a Baker's cyst. But I am not seeing any edematous tissues, I am not seeing anything problematic as I scan through that area.

What else do I evaluate when I am looking at the coronal? The coronal is the fantastic sequence for evaluating the bodies of the menisci. We do not see the anterior and posterior horns as well. We are going to evaluate the bodies of the menisci. I can see the MCL is a beautiful dense, thick band. And usually, I would be able to see the entire MCL in the same coronal slices. The lateral collateral also shows up on the coronal but the problem is we usually have to look at a couple of slices to follow the LCL as it goes from the lateral femoral epicondyle down to the fibular head. And there it is inserted right next to the biceps femoris.

Other things that we are going to see. We already talked about the bodies of the menisci. We can see the popliteus tendon right here, inferior to the LCL. Making sure that you do not confuse the junction between the two for a tear. As we go more anteriorly, we can see the iliotibial band coming down and inserting on Gerdy's tubercle.

This person does have a severe intracapsular effusion in the knee extending into the lateral recess. We can see the ACL and PCL as we look at the coronal but it is really not the strong sequence for evaluating ACL and PCL injuries. That is where we really want to be looking at the sagittal instead. Now surprisingly, we can see the neurovascular bundles in the back. Not too much usually happens involving the neurovascular structures that we evaluate in the knee.

From there I would go to the sagittal sequence. The first thing I need to figure out is am I medial or am I lateral. Well, if there are no fibula, I am medial. If there are a fibula, I am lateral. So that makes my life pretty easy. I am going to start on the lateral and work my way in. We can see the biceps femoris tendon, we can see the lateral collateral and as we come in now we are seeing the menisci. The sagittal sequence is designed to really show us the anterior and posterior horns of the menisci. We saw the bodies when we were looking at the coronal sequence. As we keep going through, and of course we are evaluating the articular cartilage all of this time, we

can see the infrapatellar tendon and Hoffa's fat pad. We are going to look for edematous changes in the fat pad, scarring in the fat pad, any changes to the tendons. We already talked about how tendinosis looks when we are doing a shoulder review. So, we would be applying the same principles as we look at the tendons through the knee.

I can see the patella. I can see the quad tendon and realize some striations in the quad tendon are a very normal thing to see because while these four tendons coming into one, into that suprapatellar region. And then as I come into the area of the intercondylar notch, I can see the ACL. Now, normally when we start thinking about ligaments, ligaments are usually jet black. The ACL is an exception because it does have some different fiber components to it. It will usually have a little bit more of a striated appearance, a little bit more signal inside. One of the important things on the ACL is sometimes we do not get it sliced perfectly because the ACL does run obliquely through the knee. So, if they do not change their sagittal slicing into that orientation, we might see it on multiple slices. One of the important things is that the ACL should be nice and taut. We can see where this is really super straight, and it is very closely paralleling this cortex of the roof of the intercondylar notch, an area called Blumensaat's line. That ACL looks good and then I keep going through. I can see the PCL. This is a sports injury discussion. What does this look like? It looks like a black hockey stick. I can see that black hockey stick for the PCL. Then I start coming out onto the medial side, and again I can see the anterior and posterior horns of the menisci. This person has that large Baker's cyst. Then here the tendons coming down into the Pes Anserine and part of this Baker's cyst is actually starting to mimic a pes anserine bursitis in this case.

Video Presentation Placement: 07:00

We have looked at the sagittal, at the coronal, we now need to look at the axial. Starting at the top and working my way down, again lots of edematous change in this particular person. They have got a large intracapsular effusion but the medial retinaculum looks good. The lateral retinaculum looks good. I can see that Baker's cyst between medial gastroc head and semimembranosus tendon.

As we are coming down, where the axial is really the best for evaluating is the patellofemoral joint. We can see where this person does have irregular signal in their patellofemoral cartilage, patellar cartilage and femoral cartilage, because they do have some chondromalacia changes. We are evaluating tendons, ligaments, and muscles on the posterior aspect. Then we come down and we can see the infrapatellar tendon. We can see some of the menisci occasionally but the axial is really not a great place to evaluate the menisci because our slicing is usually too wide. Then we are coming down into the tibia. Realize this striated appearance. The tibia is very normal. Do not confuse those with fractures. Then we get down into the rest of the leg, and we can see the fibula.

That is our general anatomy overview, as we are looking at the knee. Let us start getting into some specific pathologies. But realistically, before we get into pathologies, one of the things that we need to do is we need to review, probably one of the greatest inventions of the '90s, from an imaging standpoint at least. One of the big goals in imaging is trying to decide who do we image? It would be nice if we could image everybody with every problem. Going back to a Star Trek reference, if we could have Dr. McCoy's little magic lipstick canister that we ran to the tricorder to let us know what was wrong, it'd be nice if we could image everybody. But we know that we can, it is just not consistent with an evidence-based practice in health care.

There is a group out of Ottawa, Canada, who came up with some really fantastic decision rules to help us decide when to and when not to do imaging on knees and ankles. These came to be known as the Ottawa Rules or the Ottawa criteria. Now, as we look at these, so the Ottawa Knee Rules. For the Ottawa Knee Rules these are for acute knee trauma cases. What we are trying to do is we are trying to decide who might have a fracture. If we have negative Ottawa criteria, the probability of a fracture is less than 1%, and we are talking significant fracture, not small little avulsive flakes, and things like that. We do want to make sure that we only use this in people that are skeletally mature. The concern being growth plate injuries are an entity in and of themselves. We talked about those growth plate injuries already. We only want to use this in adults.

Video Presentation Placement: 10:03

The Ottawa criteria are what are called "OR" rules. If A or B or C or D is positive then you go ahead and take a picture. If none of them are positive, you do not take a picture because the probability of fracture is less than 1%.

First thing, we look at age. If the person is over 55, we x-ray their knee because there are a greater incidence of pathologic processes in elderly patients. We do some fairly simple, fairly straightforward physical exam procedures. We squeeze the proximal fibula. Does the person say ow? You take a picture. We are looking for proximal fibular fractures, where also this will be involved if somebody has a lateral tibial fracture like a bumper or fender fracture. Everything on the exam is negative but the person does have isolated patellar tenderness, we take a picture. Then we are looking primarily for patellar fractures.

The other two parts are more active portions. First is have the person actively flex their knee and this must be active flexion to 90 degrees. If they can't hit 90 degrees, take a picture. If they can't hit 60 degrees, it actually increases the probability of fracture. There is the walking rule, is the patient unwilling to take four steps regardless of limping, both at the time of trauma and at the time of evaluation. Of course, if you are on the field that can be a little different than if we are just dealing with being in a clinic. You are evaluating them on the field and 30 seconds afterwards. The idea here is the person that must be willing to touch foot to floor. It is one, two, three, four steps. So, two gait cycles. If they are unwilling to touch foot to floor, that is going to be a positive.

If you have watched football, here in the USA, we call it soccer, a player may torqued the knee and they are on the field, and their teammates will come out, arms around the shoulders and take them off the field. They are not willing to touch their foot to the pitch. But then five minutes later, they are back on the sideline, warming up, getting ready to move around again. That would be somebody who does not pass the walking criteria because they were able to start touching foot to floor. If there is any of these things that are positive, then we can go ahead and start looking at doing some imaging. This is X-ray specific, of course.

Before we even start looking at bony injuries, I want to really reinforce looking at soft tissues. Chiropractors forget to look at soft tissues, they focus on the bones, and they might miss some of these subtle clues. As I look at this lateral view of the knee, I know that this person's got a fracture. I can see the fractures extending through the tibia and they have even avulsed the tip of the fibula here. So that might be an LCL injury or might be a biceps femoris injury. But let us say I miss those things. We all have bad days. I missed the fracture. I know with 99.9% certainty that my patient has an intracapsular fracture, and I know that they have an intracapsular fracture because one of the things I see as I am looking at this radiograph is I see there is a flat line. I did not draw that very flat, but I am also on third cup of coffee right now. I can see that flat line. Above that flat line, there is a more radiolucent area, a darker area, and below it there is a more radiopaque area. Now what we are looking at in this case, that flat line is called Lipohemarthrosis. It is also known as an FBI sign in your fat blood interface.

Video Presentation Placement: 14:03

What happens when somebody has an intra capsular fracture like we see here? Well, when you break a bone, you bleed. This person is bleeding into their joint capsule. But the other thing that happens is if we think about, well, what is bone full of? Bone is full of bone marrow, and that bone marrow is liquid fat. Well, that liquid fat is going to escape the bone through those fracture lines. The best analogy that I have ever come across for this is oil and vinegar dressing. If we take an oil and vinegar dressing, a nice balsamic or something like that, and we let it sit on the table. The vinegar and the oil are going to separate from each other. The oil is going to float on top. Well, the same thing happens here in the knee. The person's bleeding and the blood is going to be on the more gravity dependent position, and then the fat is going to be in the more superior position. Then there is going to be a flatline in between the two, just like we see the separation in the oil and vinegar dressing. If I see those, I know that I am dealing with a fracture, no ifs, no ands, no buts. Then I am going to be looking very carefully for some of those fractures.

What kinds of fractures might those be? One of the big ones is a bumper/fender fracture. This one is named because of a common mechanism where somebody is walking across the street and a vehicle comes and hits them on the side of the leg with their bumper. What we are seeing here is this person is going to be experiencing a valgus force, and with that valgus force, what happens is the MCL stays intact and acts like a hinge, and then it drives the lateral femoral condyle into the lateral tibial plateau.

We talked about this before when we covered elbow trauma. When a convex thing meets a concave thing, the concave thing loses. What we are going to see here is this person develops a fracture of the lateral tibial plateau. It can either be here where we see this vertical shearing effect. It could also be something more along the lines of

an impaction fracture. But in either case, when we see somebody who has a valgus force, one of our concerns that this person is going to have that fibular tenderness on the Ottawa criteria is that this is a bumper or fender fracture. This was interesting in that this person presented to a chiropractor. This was a motorcycle rider. They were working on a motorcycle, they went to kickstart the bike, their foot slipped off the peg and slammed into the ground, created a valgus force. Immediate onset pain. Knee blew up like the size of a cantaloupe. Went to the chiropractor. This person was hobbling in, but the chiropractor only had upright X-ray facilities, so took an AP upright knee. The person was standing on the good leg and the bad leg was hanging there. But what is interesting is if you look carefully, right up here, you will see that there is a darker area, a little bit more radiolucent area. Well, there is an FBI sign in that suprapatellar pouch, because remember, one of the criteria to be able to see the FBI sign is you have to have the beam to the parallel floor. It has to be horizontally oriented, ao we can see that FBI sign in this case.

Another fracture that happens, and this one much more commonly happens when we are with our classic pivot shift mechanism. Of course, we know pivot shift is one of those ones that always makes us nervous because the pivot shift mechanism is classic for an ACL injury. With that pivot shift, one of the other injuries that might happen is that the IT band comes down here and inserts onto Gerdy's tubercle and this person might avulse Gerdy's tubercle. That little avulsive fracture is called a Segond fracture. Now, because this is a pivot shift mechanism, not surprisingly, this person also has an incredibly high frequency of ACL tears and meniscal tears. The main portion of the lateral collateral ligament is generally going to be intact, because realize the lateral collateral ligament is the most boring of the knee ligaments. Nothing ever happens there. We are going to see the LCL stay intact. In these patients, it is usually an ACL or meniscus. But this is one of those injuries that when I see this, as soon as I see that little fracture, I know I am getting an MRI on this patient's knee because I am concerned about the internal derangement.

What else can we break? Well, let us look at fracturing the patella. Ottawa criteria, our patient has isolated patella tenderness, and it is because of a direct patellar trauma. Something smacked the person in front of the knee. When that occurs, realize the patella is actually pretty easy to fracture because particularly if the knee is flexed, that is putting a lot of tension on the patella, and if you tank the patella just the right way it is going to split much like a diamond would. And because of that one of the most common types of patellar fracture is the transverse fracture. Looking at a schematic of a patella, we can see transverse fracture is going to run straight across, and there might be little bits of comminution, it might be a little bit more top or a little bit more bottom but it is going to be short and running straight transverse. Not surprisingly, there is varying degrees of this. If they also tear the retinacular tissue and the paratenon from the quad and the infrapatellar tendon, there are going to be substantial separation between those fragments. If all the soft tissue is still intact, and you just broke the patella, a lot of times that can go conservative.

Higher velocity trauma usually results in a stellate fracture. This is where we are going to see significant comminution. Quite often these patients are going to be looking at having their patella removed because the problem here is, it is hard to put Humpy Dumpy back together again. The patella is in so many pieces, and they are guaranteed such a bad case of patellofemoral DJD that quite often the patella is going to be removed.

The vertical patellar fracture, usually against direct trauma, but this one has a vertical orientation to it. I have seen three of these and all three are people who fell on a curb and they landed straight up and down on their patella on the curb. Now we are looking at an axial view of the patella. The other kind of injury we will think we will talk about is the osteochondral fracture and we will talk about osteochondral fractures in general.

Video Presentation Placement: 20:53

Something else that is on our differential list for this is the bipartite patella, which is an anomaly that occurs during development. I would show you a case here in a little bit.

As we are looking at this person, this person has a horizontal or transverse patellar fracture. Is it a touch oblique? Yeah. Is it comminuted? However, it is predominantly a transverse patellar fracture. We can see that there is distraction between those fracture fragments. We know that the articular surface is involved. This is a person who needed surgery to put the patella back together. You can see where some wires were put in place and then some figure eights mechanic's wire, for lack of a better term, pulling the patella back together.

The thing about all these patellar fractures is they all involve the articular surface. They all guarantee a certain degree of degenerative joint disease within a couple of years. The vertical patellar fracture is the one that is most difficult to see and this one requires a sunrise view. Believe me people who have a vertical patellar fracture are not fond of having a sunrise view done where the knee is flexed and they are holding the cassette so that we can get that tangential view of the patella. Sunrise view, tangential patella, Merchant's view, they are all different names for the same thing. But as we look at this, we can see that vertical fracture running right through the patella. Our distinction is, vertical patellar fracture here, well that looks like a fracture too. This one is a bipartite patella and we can see where this does have smooth well-rounded coordinated margins consistent with a long-standing abnormality like a bipartite.

The other patellar fracture is the osteochondral fracture. Now this is a patient when I look at the alignment, we know, when we look at radiographs, we can do the alignment/anatomy, bone, cartilage, soft tissue search pattern. This patella is not sitting in the patellar groove the way it should. And when we are looking at a sunrise view, realize this person's knee is flexed. That is going to pull that patella into the trochlear groove of the femur. Well, why is this person's displaced? Because they have a medial retinaculum tear. I do not see the medial retinaculum but I know based on the alignment, the medium retinaculum is no longer intact. This person had dislocated their patella and in doing so they had fractured the articular surface. We can see a divot through here. There is a little debris down through here where that person has an osteochondral fracture.

Now on our differential list for patellar fractures is the bipartite patella, and what we are looking at here is an extra ossification center, and it never unites in. One of our big clues is the most common location for these is on the superior lateral border of the patella. It is incredibly uncommon to see a fracture right through there. Unless you get somebody who smacks you with a hammer and chisel right on that superolateral aspect, that'd be uncommon. Plus, it is got some of the undecorticated margins. What is interesting when we start looking at these bipartite patella is generally these are incidental findings. We want to make sure we do not confuse them with fractures. If you are not sure, X-ray the other side. These things are bilateral 80% of the time. But one of the things that is interesting about a bipartite patella from an athletic standpoint is that these can become symptomatic in athletes who are doing repetitive heavy quad work. We can see this in runners. We can see this in weightlifters that are doing squats and dead’s, anybody who is doing repetitive quad work because if we think about it, the quad is coming in and inserting across the superior part of the patella. This portion is connected by fibrocartilage. And if the lateral components of the quad are pulling repetitively, they can injure that fibrocartilage.

This is a great segue to look at an MRI on a patient that has a symptomatic bipartite patella. I have somebody who has got patellofemoral pain, chronic, insidious onset, chronic pain, and they come in. Ottawa criteria do not apply. I takes her some radiographs to see what is going on, then I see a bipartite patella. But now this person is symptomatic, the pain is very focal, and it is right around the area of that bipartite. I know that I am going to go to my fluid sensitive sequences. We are here in the knee, if we can tell, here is the lateral side. Now this is a STIR, so it is a little grainy and it is a poor-quality MRI because it is an open MRI. But as we come forward into the patella, so right in through here, we are starting to see the patella, and then over here in the patella there is a huge amount of edematous change. This is a symptomatic bipartite patella. The bony fragment itself is edematous, the fibrocartilaginous junction is edematous. We are looking at Bipartite Patella Syndrome, and of course what is the best treatment for this? Rest, take it easy, give it a chance to heal. Things should be okay. If it has a repetitive recurrent issue, then it can be removed, and the quads can be reattached.

Video Placement Presentation: 26:26

Something else that is on our differential when we start looking at knee is the potential for a Nursemaid's knee. So again, patellofemoral pain, one of the questions is what else might be causing Patellofemoral Pain aside from the patellofemoral joint, chondromalacia, and things like that? Well, one of the other things that is on that differential list is Nursemaid’s knee. This would be somebody who spends quite a bit of time on their knees as part of their event. I cannot say specifically that I know that this is a frequent thing. But one of the assumptions that I would make is that this might be something I would tend to see in somebody who's involved in curling. The person who is sliding the rock is involved on their knees quite a bit.

As I look at a knee MRI, pulling up the sagittal and looking at a fluid sensitive, we are on a T2 sagittal, what do I see in this person's knee? Here is the patella, and there is the prepatellar bursa, full of fluid. When you palpate these, you can palpate there is a fluid feel to them. It feels like there is a little water balloon deep to the skin. We can see that prepatellar bursa and of course checking for any recent skin abrasions or lacerations and to make sure it is not a septic bursitis. But otherwise, a simple prepatellar bursitis.

On our differential for this, something we talked about in the first hour of lower extremity, is the Morel-Lavallée lesion. Making sure you know is this a bursitis versus had this person had a shearing force across their patella, and now we are seeing that fluid collection from the hematoma starting to encapsulate as a Morel-Lavallée. I already touched on patellar dislocation but wanted to revisit this one as we start looking at some patellofemoral issues. One of the great candidates for developing patellar dislocation, we see this in bicyclists. It is also fantastic for any other running sports where there are lots of pivoting and shifting going on. I have seen this in soccer/football. I have seen this in rugby. There is a interesting YouTube video of a female rugby player who dislocated her patella while she was on the field. She just laid down, she smacked her patella back into place, got up and started running again.

We can see with that patellar dislocation, one of the important things for this person is disruption of the medial retinaculum. Sometimes retinaculum is a difficult thing to assess. There is a lot of edema. Did they tear the retinaculum? Is this new or is this old? But one of the other things I see, the patella almost always dislocates laterally, and when that patella dislocates laterally, the medial patellar facet is going to ram into the lateral femoral epicondyle, and we are going to see what are called kissing contusions as a great indicator that this person has had a patellofemoral dislocation. I am going to make sure I watch very carefully for in this patient is to see whether or not there is an osteochondral injury, osteochondral fractures being very common in these patients.

Another big, relatively common cause of pain in athletes because this is a relatively frequent finding is a remnant embryologic fold inside the knee called a plica. There are four different players. But the medial plica is the one that is most likely to be symptomatic. It is a band of fibrous tissue that goes from the joint capsule to portions of the fat pad. We can see there are that nice plica right through there. This is implicated in patients that have clicking, snapping knees. We can see some transient locking in patients that have plagued. Definitely worthwhile getting imaging to see what is going on, and then help to make those decisions. Does this person need surgery to release that plica or not?

From there, we get into osteochondral injuries of the knee. Already touched a little bit on the patellar osteochondral fractures, but really, that one is not the more common. The more common involves the medial femoral condyle. This is quite often as a component of an ACL injury. We can see some shearing forces happening inside the knee and the tibial spines can impact the femur and shear off a piece of the articular surface. A big area, lateral aspect of the medial femoral condyle. Other location is going to be that patellar location with a dislocation. This is one where generally this person is going to have positive Ottawa criteria and more the walking rules than anything else or possibly the flexion rule, depending on how stable or unstable the fragment is.

Looking at the straight on AP and lateral, this one is subtle on the AP view. But right through here, we can see where there is an articular surface defect. It is on the lateral aspect of the medial femoral condyle. It is very subtle, but we can see a curvilinear change through here. Just as a side note, make sure we do not confuse this with an abnormality. What we are looking at there is an os fabella, which is a very common anomaly where there is an extra piece of bone located in the lateral gastroc tendon.

The thing about these osteochondral fractures in the knee, single traumatic events or cumulative stress can do these as well. Sometimes they are hard to evaluate, and one of the best additional views to do is, using a tunnel view. This is a flexed view of the knee and you are angling the X-ray tube, and you can see that articular surface defect more effectively. Plus, it is also great to see if there are displacement of the fragments into the intercondylar notch because that notch is one of the locations that osteochondral bodies like to hideout.

Already touched on the patellar osteochondral fracture. With a patellar osteochondral fracture, lateral patellar dislocation. As the patellar service is going out of the trochlear groove, it will fracture off a piece of the articular surface. One of the things that we end up seeing done in patients with osteochondral fractures is these patients

will usually end up getting MR arthrograms because evaluating the stability of the fracture fragment is an important thing for conservative versus operative management. This will be injected with a contrast to try to figure out stable versus unstable fragments. It is also possible to not have an osteochondral injury, but to just have a chondral injury, where cartilage is usually fairly squishy, but if you hit it hard enough, it becomes more and more solid and it is more possible for that cartilage to fracture or tear. What we will see when we look at an MR, we will see a defect in the articular surface. The tibial articular surface is nicely maintained. The femoral surface comes across, stops, restarts over here. This person has a chondral injury. This one is an older injury, because in the acute chondral injury, we will usually see some adjacent bone marrow edema that we do not see in this case.

Video Presentation Placement: 34:08

As we continue on our journey through the knee, we have done quite a few fractures, it is also time to think about some of those soft tissue injuries. In this particular patient, this is more of a middle-aged gentleman. You can tell there are some degenerative changes in the knee. He was doing that most classic of all middle-aged athletic events, mowing the lawn. If you've been in some suburban areas, you know that there are a lot of competitiveness here. I think it qualifies as an athletic event. He was mowing the lawn, on a hill. An overweight gentleman, lots of force going through his leg. And while he was working on cutting the grass on this hill, suddenly, his leg collapsed out from under him. As we are looking at this, he had positive Ottawa criteria that he could nott bear weight. But what is interesting is as you palpate the leg, the patellar wasn't tender, the fib wasn't tender. He was able to flex his knee, but he had problems with extending his knee. And when you look at his knee, just even before doing all this, you can see that there is a large sulcus, there are a big divot above his patella. The fact that he had lost his extension capabilities, was unable to walk on the leg, it was a pretty good call that what we are seeing here, if you notice that divot in the superior soft tissues, this gentleman had detached his quad. It is a rupture of his quadriceps tendon. Typically, that happens right near the base of the patella. Then as the quad comes off the patella, the patella tends to shift downward, and we see that this does have a patella baja appearance to it. It is subtle but there is a little redundancy to the infrapatellar tendon. This one typically requires surgery and it did in this case.

What else can involve the structures around the patella? Well, one of the things that we see in the infrapatellar tendon, Sinding-Larsen-Johansson otherwise known as jumper's knee, which is usually a more common colloquial term for it. Who do we see this in? Hurlers, people that like to do hurdles, fantastic candidates for seeing this particular thing. It is usually in their leading leg because with the leading leg, there are a heavy quad pull to kick the leg up to get over the hurdle, and what we are seeing is either tearing of the infrapatellar tendon at the patellar apex or we can see bony fragmentation at the apex of the patella like we are seeing here. We see this a little bit more commonly in children than we do in adults, but it can absolutely happen in adults as well if they are doing the heavy, repetitive quad work.

Video Placement 37:08

This is one where I want to kick over to a live demo on a case of Sinding-Larsen-Johansson. This is an athletic 19-year-old female complaining about she'd been doing quite a bit of quad work as a runner, was developing progressively worsening pain at the apex of the patella. Originally, had been written off as a chondromalacia patella or patellofemoral pain, but then it started to get worse and really started to localize. I am going to kick over to the sagittal on this case, and as we pan in, so we are starting on the lateral aspect, you can see the menisci. And as we are coming into the patella, watch the patellar tendon. We can see that patellar tendon, infrapatellar tendon. And as we come in towards the apex of the patella, suddenly it gets really wide, and we are still seeing some intact superficial fibers. But the deep fibers are really being disrupted and there are some edema in the apex of the patella. We can see this nicely on this T2 where there is the infrapatellar tendon, all of a sudden, it loses that integrity right through here. There are still some superficial fibers which is why the quads hadn't let go or the infrapatellar tendon hadn't let go and retracted the patella superior. But this is a beautiful example of a Sinding-Larsen-Johansson, jumper's knee.

Video Placement Presentation: 38:36

Now Osgood-Schlatter, you must read the docs. This is one that is not a radiographic diagnosis. Osgood-Schlatter is a pediatric patient. Again, a running sport. Pick your favorite running sport with little children and well it is very

common to see this condition. They start developing a lot of pain at the insertion of the infrapatellar tendon. This is not a radiographic diagnosis, rather a clinical diagnosis. You got a runner, they got pain, it is tibial tuberosity, they got Osgood-Schlatter. If we do X-ray these patients to rule out other things, what we are going to see is fragmentation of the tibial tuberosity. It is an easy diagnosis, and typically addressing biomechanics and putting the child into a Cho-Pat brace. Most of the children will not take the time off the sport for this to heal up on its own until they get in between sports. You can see that there are also some thickening of the infrapatellar tendon. So, we deal with the chronic issue in this one and then eventually get the child to rest for a while and it will usually resolve.

What else can create some pain in the leg? Iliotibial band syndrome. Typically when we talk about IT band syndrome, we think about it down towards the knee but realize IT band syndrome can hurt all the way up to the hip. Again, clinical diagnosis, typically there are focal pinpoint tenderness over the iliotibial band. Sometimes you can sense some edema as your palpating. Not usually something we need advanced imaging for. If we do get advanced imaging, we can see in this case, this person does have a mild intracapsular fusion. But they have also got edema, deep to the iliotibial band more approximately. So not surprising that would go along with an iliotibial band syndrome.

This is a classic history. This is one that is really, common as far as conditions go. The history is incredibly classic. Something we see a lot in tennis players. Tennis players a lot of times will complain about, "I was pivoting around the court and all of a sudden, it feels like somebody just hit me in the calf with a tennis ball." They tore their plantaris. The plantaris tends to tear at the musculotendinous junction, which is going to be up closer to the knee. It can tear down further in towards the Achilles. But usually that is going to be accompanied by an Achilles tear. So usually, it is going to be much more up towards that musculotendinous junction.

I would pull this one up. This is a 16-year-old tennis athlete and had a really sharp stabbing pain in the backside of the calf. I always go to the fluid sensitive sequences. I am going to coronal STIR. I am going to start in the front and work my way back. Window this little bit just to make it easier to see. So there are the patella, there are a mild intracapsular effusion. We go back, the menisci look fine, the iliotibial band looks good. And then right here, on this lateral aspect of the leg, in between the gastroc heads, I can see a substantial degree of edema. I can see that same thing if I were to kick over to the axial. I can see there are a substantial degree of edema there on that lateral aspect. Well, that is where the plantaris muscle comes in. This person has torn the muscular tendinous junction. and there are some edema and hemorrhage along the pathway of that plantaris. Generally, this is the left-alone kind of lesion, not typically surgically repaired because it is not a major contributor to function in the lower extremity.

Video Presentation Placement: 42:42

The last of the fractures that I want to talk about before we get into ligamentous injuries, because of course, with the knee, ligaments, and menisci, those are our big deals. This is a patient who has an ankle injury. But one of the rules that we always want to keep in mind anytime we are dealing with joint injuries is when somebody has a joint injury, we always check out the joints above and below just to see how things are doing. This is somebody who is complaining about an ankle injury. They had twisted their ankle, and in twisting their ankle, it is subtle, but they fractured their medial malleolus, and with that medial.

There is an ankle injury. One of the things that is possible is we are looking at a neutral, but part of the damage is did they damaged the interosseous membrane? Did they have a high ankle sprain? Well, when that medial malleolus goes, then maybe the talus rotates and shoves the fibula laterally. They are focusing on this because they can feel a lot of pain, very superficial structure, lots of swelling. But as you start palpating up this person's leg, the tib feels fine. You are starting to come up the fibula. Then suddenly, there is a proximal fibula fracture. That means that this is something called a Maisonneuve fracture. One of the ways to think about a Maisonneuve fracture is like a wishbone injury. We take the wishbone of the turkey, grab the parts, spread it apart. Same thing is happening here. As this injury occurs, this person is damaging the interosseous membrane. The tib and the fib are separating from each other distally until eventually there are enough of an anchoring point that holds the fibula in place, and then the fibula is going to fracture. That is why we always want to make sure we check out the joints above and below, and in this case, we can see that Maisonneuve injury.

That is going to bring us into the ligamentous injuries of the leg. Not surprisingly, when we are dealing with knee injuries, the vast majority of the injuries are going to be soft tissue. The fractures are all well and good, they are easy to see radiographically. The positive Ottawa criteria are wonderful. But what are the ligaments like? What are the menisci like? Let us make sure we are paying attention to soft tissues. And we know that this is predominantly going to be an MRI diagnosis. We can use ultrasound for some of the more superficial ones. But again, lots of user dependency on that. We are seeing more and more use of ultrasound. Particularly, every major sporting team generally has ultrasound on the sideline to make sure that they are… You know, we are dealing with fairly expensive players here. They are going to make sure they try to get the best management possible.

Video Placement Presentation: 45:36

When we start dealing with patients that have ligament injuries, the two big ligaments that are going to be injured are the ACL and the MCL. The anterior cruciate ligament and the medial collateral ligament. The PCL tears occasionally, the LCL is a boring ligament. Nothing much ever happens with the LCL. So not too terribly worried about lateral collateral ligament injuries. ACL and MCL are going to be the vast majority of all of these. One of the things that they are, is they are a part of this thing called O'Donoghues terrible triad, or O'Donoghue, It goes by a couple of different names. I am unhappy. If my ACL and my MCL are gone, I am probably a little more than unhappy. That is pretty terrible for my athletic career.

How do these injuries happen? Well, for the ACL, it is a pivot shift. Plant the foot and rotate. With that planting the foot and rotating, hear a pop, hit the ground because the ACL is gone. Now, what is interesting, when we start talking about these, as a part of that injury, there are also a typically a transient subluxation of the knee. That can result in meniscal injuries, that can result in MCL injuries, and that is O'Donoghue unhappy triad, O'Donoghue terrible triad. ACL, MCL, and meniscus. Typically, the posterior horn of the medial is the classic codon to use. O'Donoghue has really been extrapolated out to be all meniscal injuries, just posterior horn of the medial is the most common. It is also possible to see other things. Osteochondral fractures can happen when we start to see those ligamentous instabilities. Well, one of the things that might happen is the ACL might be intact and the person evolves their tibial spine instead.

Already talked about Segond fractures as well. If I do a pivot shift, and I hit the floor, because I heard a pop, an immediate onset of knee pain. I am hoping this is me right now because what we are seeing in this particular case, this person, their ACL is actually intact. What they did is they avulsed the anterior tibial spine. I would much rather have an avulsed anterior tibial spine than an ACL tear because this is an easy surgical procedure. Arthroscopically, the surgeon can go in, drive a screw in, and that thing is going to be beautifully intact because the ACL is still there, just the anterior tibial spine is not attached. But the bone will heal really nicely. So that is where we are going to wind up going into an MRI though, because what is going to happen more commonly as the ACL goes?

What is interesting is how the thought process on the ACL has changed over the years. It used to be conventional wisdom that there was no such thing as a partial thickness ACL tear. One of the goofy little phrases was when an ACL goes, an ACL blows. It blows up. But now there are something mysterious about it, the ACL is two different ligaments. There are two different bundles of ligamentous tissue inside an ACL. There are an anteromedial bundle and there is a posterolateral bundle. Depending on whether the knee is an extension, or flexion, it is possible to tear just one of the bundles and get partial ACL tears.

Video Presentation Placement: 49:13

We want to start looking at the MRIs to evaluate what is going on. It is difficult to distinguish the anteromedial versus the posterolateral. History is kind of important, and the orthopedist can tell when they scope it. We can tell that there is partial tearing, though. What are we going to see? Well, let us look at some diagrams and see what we can see. Now I am going to start off with the ACL rupture. I am going to go in reverse order from what I have here on the slide. What I am looking for is the ACL. I am paying attention to the sagittal. I showed you an ACL at the very beginning of the hour, where the ACL is a dense taut band that follows the Blumensaat's line. As we scroll in on the knee on this person, and we are starting on the medial side, I can already see that there are a lot of fluid in this knee. This is an unhappy knee. There are the PCL. Now the PCL we see on a couple of slices, but it is intact. It is redundant, it looks fine. But then when I try to get into the area of the ACL from the anterior tibial

spine, coming into the medial aspect of the lateral femoral condyle, I never see a ligament. Well, all I see is a little bit of dandelion fluff floating around in the wind. That is an ACL rupture. This person has a completely ruptured their ACL. One of the things that happened with that as we pan out through the lateral aspect, notice that there is bone marrow edema in the anterior aspect of the lateral femoral condyle and the posterior aspect of the lateral tibial plateau. When an ACL tears with that pivot shift mechanism, what happens is there are a transient subluxation. The tibia is going forward, the femur is going back, and this portion of the femur slammed into this portion of the tibia. We are seeing that kissing contusions concept that we saw previously. So even if I overlooked the ACL tear, I see those kissing contusions. That should be one of my big clues that I am looking at a ruptured ACL. So that is the rupture. Now let us look at what a partial thickness tear looks like.

Video Presentation Placement 51:22

We are going to go to the sagittal again. As I look at the sagittal on a fluid sensitive sequence I am coming in from the medial side. There are the PCL a little redundancy in the PCL is a very normal finding. But then as I come in through here, the ACL is still present. Now, this is a lower field strength magnus, so the ACL is not jumping out. Let me kick over to thin slice ACLs. This one, they slice in the orientation of the ACL. As I look at this one, notice how the ACL is curved, and then there are a thin band here and there are a defect here. When I see that curving to the ACL, when it is not in a straight line following the Blumensaat's line up here on the roof of the intercondylar notch, that is a partial thickness tear. In this case, because I can see where the defect is and I can see where the intact fibers are, this is somebody that has a partial thickness tear of the anteromedial bundle. That anteromedial bundle is what is torn in this individual. There is a partial thickness there. That is a discussion then to have with the orthopedist, does this person need reconstruction or do we go with conservative means and start making an informed decision there?

What about the PCL. When we look at the PCL, PCL tears do not happen that often. How do they happen? Easy. Well, let us back up. How do I assess for a PCL tear? Posterior drawer. Well, you know how you tear a PCL, you traumatically posterior drawer somebody. Big thing is here, somebody lands on their knees, something hits the tibial tuberosity, drives the tibia back, tensions that PCL. If I want to see a PCL tear in this individual, this was not an athletic event. This was somebody who had fallen from a moving vehicle and landed on their knees. As we scroll in, we are on the medial side. Lots of fluid in the knee. When somebody has an internal derangement, there are going to be intracapsular effusion. If there are no intracapsular effusion, there are no internal derangement, or it is a chronic old case. As we come in, here is the ACL looking really nice following Blumensaat's line. Here is the PCL. Now remember, the PCL is generally a dense black hockey stick in the backside of the knee. But in this case, there are a lot of high signal intensity contained within that ligament, demonstrating that this gentleman does have a PCL tear. The nice thing in this case, this is a partial PCL tear, there are still some intact fibers, and because the PCL is not super contributory to the knee, this one was managed without surgery.

Video Presentation Placement: 54:39

What about the MCL? The medial collateral ligament of the knee can also tear. This one is going to involve a valgus stress, like we saw previously in the patient that had the bumper fracture, but in this case, well we are going to see where the MCL goes instead of the tibia. One of the things is when we grade these ligament injuries, it is possible to grade ligament injuries. There are different grading schemes. I am kind of fond of one, two and three, mild, moderate and severe. So mild, some mild disruption of the fibers, some superficial edema. Moderate, we are seeing some more edematous changes, more disruption. And complete, the grade 3, would be a rupture.

Let us look at some MCL injuries. Starting in the front, lots of edema, and as we come backwards, we are in the area of the MCL. Notice that superficial to the MCL, there is this higher signal, that fluid signal in this MRI. The MCL itself looks grossly intact. That means that we are looking at a grade 1 MCL injury. When we start looking at the more significant MCL injuries, coming in through the anterior side here. I can see some MCL fibers, but then there is loss of integrity up here at the femoral epicondyle. This person has a grade 3 ACL injury. They are superficial and deep edema, and the fibers are never intact. We are looking at an MCL rupture in that patient.

Something else that can happen when we start looking at the medial collateral, somebody who has chronic valgus injuries to the knee, it is possible to see where over time that MCL can develop some ossification, and there are a

question. Is this hydroxyapatite deposition disease? Or is this a myositis ossificans? But in either case, we have a diagnosis for this called Pellegrini-Stieda. That is a good indicator of chronic MCL injury.

Video Presentation Placement 57:17

Then we are going to finish off our time today talking about meniscal injuries. We know that ligaments are very commonly injured. Now we will get into the menisci. We know that when we are dealing with menisci, there are a medial meniscus and a lateral meniscus. The posterior horn of the medial meniscus is the high traffic zone. That is what bears the most weight. That is what gets the most damage. The posterior horn of the medial meniscus, most common injury. Can the lateral meniscus tear? Of course. Anterior horns are much less likely. Can they? Of course. But the poster horns are really where we pay the most attention. The other thing that meniscus does is as the athlete ages, we are also going to see where the center part of the meniscus tends to break down. I mean something called a myxoid or mucoid degeneration depending on which author you read, where the fibrocartilage breaks down. There is a little bit more of a gelatinous central nature to it. To make sure that that is not a tear, it should never communicate with the articular surface. It will be located just centrally within the meniscus.

One of the big questions for meniscal tear management is, where is the tear? If the tear is more peripheral like we see in this case, peripheral tears are a good thing because peripheral tears are in what is called the red zone where there is still blood supply to the meniscus. That blood supply is going to allow this to heal. Once we get out into the white zone, which is more towards the more central margin, the meniscus, those are less likely to heal on their own.

A couple of different kinds of meniscal tears. I am going to give you some schematics and then I am going to pull up some diagrams. The horizontal or the horizontal oblique. We can see a tear that runs straight horizontally. Much more commonly, they run obliquely, and they almost always communicate with the tibial articular surface. We see this best when we are looking at our coronals and sagittals. We generally do not see that axial view. I just threw the axial in for completeness sake. The bucket handle tear is a vertical tear, and it separates the free margin from the more peripheral portion. One of the problems with the bucket handle is that piece can flip over. That creates a finding called the Flipped bucket handle meniscus. There are some radiology signs that are great for multiple choice tests like the double PCL sign and the double Delta sign. There is the radial tear. Radial tear just goes out from the radius of the circle, and what we typically see is a truncated appearance, where we lose the very tip of that free miniscule edge.

Then the parrot beak is a combination of a radial and a bucket handle. This one is much more difficult to diagnose. let us take a peek at some of these different tears. We know that when we are evaluating meniscal injuries, we are going to spend the most of our time on the coronals and on the sagittals. The coronals are good for seeing the bodies of the menisci. I know that most injuries involve the posterior horn, so I am going to spend most of my time on the sagittal. From an MRI perspective, we want to look at the proton densities. A proton density is the sequence or T1 that is great for evaluating fiber cartilage. As we come into this knee, we are starting on the medial side. There are the pes anserine tendons. We can see right away that this person has a massive horizontal tear in the area of that posterior horn. As we come in, there are that horizontal tear. It is communicating down here towards the tibial articular surface. Good news for this patient is it is going all the way through, so it is hitting that red zone. This is one that might experience healing on its own without needing surgical debridement or suturing. But again, that is an informed consent decision to make with the athlete and their orthopedist.

So we come into our next patient. I am going to want to be on the sagittals for this. This one is a proton density without fat suppression. We can see there is this higher signal intensity contained in the posterior horn. It is communicating with a tubular surface. It is coming out in the peripheral edge, so it is catching redzone. Just to illustrate the concept, this is why we want to use the proton density. Notice that it is not nearly as easy to see when we look at the T2.

Coming to a different patient. This time we are starting on the lateral side of the knee, you can see the fibula. Nice example of the anterior and posterior horns. One thing you want to be careful of is there is a small ligament that goes off the front side, the anterior intermeniscal ligament, do not confuse that with a tear. As we come out to

the other side, in this person, I do not see the posterior horn really well. There are some complicated tearing going on there. I am not even really seeing the anterior horn. Well, that is because as I come more into the intercondylar notch area, there are the PCL, and it looks like there are a second PCL. Well, that is because this person has a flipped bucket handle meniscus, where that meniscus flipped over and is now residing in the intercondylar notch.

The radial meniscal tear is much more difficult to see. With the radial tear, I am going to start on the coronal proton density. We are starting in the front, working our way back. I can see the dense triangle for the meniscus. Fantastic. But then notice on this one, as I am looking at the coronal, this person has two radial tears. On the posterior horn, there are a very small defect there. That is a radial tear. Then notice that the meniscus kind of goes away and then comes back. That is because we are in the same plane as a radial tear in that case. This person has a couple of radial tears, and they are much more subtle. There is part of the radial tire there, and we go from sharp and point, to blunted, to sharp and pointy. There is a second radial tear.

Now, the last topic for today before we finish off with our imaging of lower extremity trauma and finish off with all of our traumatic sports injury all together is the discoid meniscus. Not a trauma thing, but something that we see very commonly in athletes as a pain generator, is the discoid meniscus. This is a congenital anomaly. It is where we see instead of having a circular structure for their meniscus, this person has a flat plate of cartilage completely interposed between the femur and the tibia, typically on the lateral side of the knee. This does occur in about 3% of the population. This is pretty frequent.

An important finding for that discoid meniscus. What are we going to see? When I look at the coronal, I am starting on the backside, there are the posterior horns, and follow the medial and notice that the medial comes into a pointy triangle, and then we see the anterior component. But when I am looking at the lateral component, there is always a thick black bar interposed in between the femur and the tibia, and that is a discoid meniscus. This discoid meniscus has been implicated as a pain generator even if it is not torn.

Now one thing we should see when we look at knees, as we come into the meniscus, we should see what are called 2 bow ties. So we are on the medial side, there are a bow tie, thicker on the two ends than in the middle. There are a bowtie and then there are separation between the anterior and posterior horns. When we start on the lateral side, bow tie, bow tie, bow tie, bow tie all the way across. So that is that thick cartilaginous plate for the discoid meniscus, and again, it can be a pain generator in and of itself, and it is of course more susceptible to tear.

That takes care of us as far as our imaging of sports injuries goes. I hope you have enjoyed these 9 hours and it was informative for you.

Thank you very much for allowing me to help with your education on imaging of sports injuries.

To contact Dr Warshel reach out to admin@ffirscport.org

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