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ANIL

My main disclosure is that I am a Ranawat who does sports medicine, not arthroplasty, but there's a lot of arthroplasty principles in here too. So [INAUDIBLE]. So here's, you know-- I always think very algorithmically. We're going to focus on first, some basic concepts of acetabular femoral version, as well as tibial torsion, then my concept of combined anteversion or the McKibbin Instability Index.

Mike's talking to you, Mike McClinsky, I just see his name up there. Mike and I, I remember when Mike was a medical student with me and Dr. Bradley. We did a lot of elbow talks, and I remember interviewing Mike. So he'll give us, I'm sure, the ped's perspective too, but it's a lot of friends and family in this group here. And I'm talking about my approach and then a case example.

So let's talk first about acetabular version. The way you want to think of the native acetabulum, not the reconstructed acetabulum, but the native acetabulum is anteverted, right? And it's 5, 10, 15 degrees. And that's based off CAT scans.

So really is that the anterior wall is more deficient than the posterior wall. And now we can see that. Actually, when you do a total hip, you don't have an anatomic total hip cup, it's a hemispherical cup. So that's an interesting thing, and that's why they have to metalize the cup.

And realize where we get that 3 o'clock 15 degrees, that's that number that every resonant and fellow and total joint surgeon has in their head when they're putting anteversion in the cup doing a posterior approach, classically 15 degrees. Now, that number may change based off your approach now. A lot of people doing anterior approach.

But that's where you get that 3 o'clock and realize that so as you move proximally on the 1 o'clock position, is where the acetabulum is more deficient. And understanding how acetabular volume is a complex subject, it's a 3D subject, and we historically have only used 2D analysis. And we'll talk more about that with imaging and other things.

So how do we assess this, right? It's easy to assess on a plain X-ray to see. But you have to look at the native lumbar lordosis of the spine. Hip-spine syndrome is really important, and it's another variable. I'm almost not even getting into that for this talk. But it could be next year's subject matter is of hip-spine syndrome and how the spine affects the hip.

But assuming that the lumbar lordosis of the spine is normal, that when I assess you can both on [INAUDIBLE] imaging, as well as axial imaging on MR and as well as but more of the gold standard is a CAT scan.

So when you want to think of the two sides of the spectrum of the acetabulum, you can have a globally anteverted socket, which means if you look at an AP pelvis, that socket is really open. It's looking right at you. I can see the posterior wall. I can barely see the anterior wall. So you have poor anterior coverage of anterior instability. You actually can have some posterior impingement. This will lead to early OA. And this is all based off of a classic paper by Dr. Reynolds.

Likewise, if you have a truly retroverted cup, a truly retroverted cup means that you have an excessive anterior wall and a deficient posterior wall, and the way I show this to fellows and residents is I take a native acetabulum and with a total hip cup, and I completely spin the cup. And I go, that's a truly retroverted acetabulum, which does happen. And that will lead to not instability but anterior impingement. And these are both will lead to early OA.

So whenever I want to understand this subject matter, you want to understand the two extremes and realize the two extremes of acetabular version and the two extremes of femoral version will both lead to early arthritis. And that's where you get to this safe zone concept which exists on the pediatric side, on the arthroplasty side, and now we're bringing it to the sports side.

And the way I teach this is that the hip doesn't know what fellowship you did. The hip just knows the hip, just like the knee. And it's the same thing in the Europeans. Sometimes, they have a better approach to this because they don't have-- either you're a hip doctor, and you do hip arthroscopy, hip replacement. You do PAOs and they do soup to nuts and hips. And their approach sometimes can be better, but there are pros and cons for both.

So we're going to get into this in more detail, but this is quickly my 30 seconds of how do I assess [INAUDIBLE] a retroversion. First, I assess the quality of the pelvis. Is it an inlet outlet rotation? Then I first assess the posterior wall, relative to the femoral head. Is it at the femoral head? That's where the posterior wall should be, the center of the femoral head where that dot is. Is it medial, which means the posterior wall can be deficient? Or is it lateral, which means the posterior wall could be excessive or the cup could be anteverted?

Then I assess the anterior wall. Is the anterior wall medial or lateral? Then I assess a crossover sign. Too quickly, you guys assess the crossover sign without assessing the posterior wall. Because the crossover sign doesn't really mean much, unless you understand the concept of the posterior wall. And then lastly, I assess the ischial spine sign, which you'll see when you truly have a retroverted acetabulum.

So let's just talk about true acetabular retroversion like we talked about. That's that spun cup. The posterior wall is medial to the femoral head. There's a vertical posterior wall. The posterior wall is deficient.

Remember, it's not just that it's retroverted, it's how much it's retroverted. If you look at trauma surgeons, when they see that vertical posterior wall or a high acetabular fracture in the posterior wall, those are much more unstable than the low acetabular fractures because they're going to get instability in low flexion versus high flexion. So where the posterior wall is deficient, is very critical for both traumatic point of view, as well as a instability point of view.

And then you want to see a large crossover sign and a big ischial spine sign. That's true acetabular retroversion. You also can have a crossover sign with not true acetabular retroversion, which means that the posterior wall is normal. It's at the center of the femoral head, maybe even lateral, but usually at the center.

There's a non-vertical posterior wall. So you have good posterior wall coverage. You have a crossover sign. And most likely, this is a normal socket with anterior overhang. And it's really you have extra bone.

So in the true retroversion, you're missing bone. You don't want to do an anterior rim trim. In the latter case, the normal socket with [INAUDIBLE] coverage, you can take anterior acetabulum. But realize, a lot of times, that could be not necessarily from the actual acetabulum, and even could be a trick. It could be from your subspine. So subspine impingement can do that.

So now let's talk about the femur. As we know that we're all born with more anteversion, and we gradually de-rotate with time. And realize that women have a little more anteversion than men. Women are overall more flexible and have more range of motion than men.

This is a remodeling thing, just how the femur is in more valgus. And anteversion and [INAUDIBLE], the femur gets out of valgus and gets into more varus or more neutral alignment and gradually de-rotates with time, with bone remodeling. Remember, the way the acetabulum and the femur form together, it's a boy-girl relationship, and any change or any insult in this relationship can be a sign of later hip disease.

So we used to play a game when we see a failed hip, and we would say, well, was this failed hip more of a skiffy, a 13-year-old insult? Was it more of a perthes, was it an 8-year-old insult? Or is it more dysplasia, which could even be more of a baby insult? So based on the deformity of the hip, we can predict where the insult happened in the development of the hip joint.

So when I think of retroversion, I've always asked, like I remember, Jim Bradley, when we were talking about posterior slope, he's like, Anil, what's the number for the ACL? What's the number till I break the leg. He just wanted a number. That's a very Pittsburgh way.

So I put in some numbers for retroversion, right? Normal is over 15, you got mild 7 to 15, moderate 0 to 7, and severe minus 0. So these numbers are important. And these numbers are based off CAT scan. But really, the physical exam is more important. When they have obligatory external rotation, when they walk with an external foot progression angle, that really matters the most.

So looking at the physical exam, and I have a paper about this, and I want to get into more details, is really critical. Because the CAT scan numbers can be drawn by whoever wants to draw them. And we can make them really, anywhere we want to go.

And how does this happen? It's the same thing I talked about with the acetabulum. It's from, usually, a congenital deformity and an insult at one point in the developing femur. And as we know that retroversion causes anterior impingement, and that will cause arthritis.

Just like if you did a total hip, and you leave an anterior osteophyte, we would always check because if you lack flexion, you impinge in the front, and you dislocate out the back. So that's going to create more wear in your system and more poly-wear is the same thing as more anterolateral chondral labral wear.

So realize that retroversion is probably a major predictor of hip failure. We can talk also what are bigger drivers of motion loss, and that's one of the things I always talk about, is that people always think a cam creates motion loss. A cam creates a little bit of motion loss, but it's about a 3 to 1 ratio of femoral retroversion or anteversion that creates motion loss much more than a cam.

So it really goes to femur is then next shaft angle, then maybe cam, then acetabulum, then acetabulum. So just understanding that, when people say, oh, this patient's got a very stiff hip. They must have a huge cam and pincer. That's usually not the case. They must have femoral deformity with version abnormalities.

Likewise, when do we consider increased femoral anteversion This is the opposite. It's not impingement. This is associated with subluxation anterior instability psoas problems, labral tears.

When I was a fellow in Switzerland, we had one patient, they did not get CAT scans, and that was in the era that we cut everyone so as. Realize, that when I was a fellow in Pittsburgh, if you had a psoas, you didn't want to come to Pittsburgh because it was cut immediately.

And there was one patient that dislocated. And that's because the patient probably was anteverted. Psoas was probably the last thing holding the hip together. And by cutting that psoas, as the hip dislocated.

And I remember writing a [INAUDIBLE] case report on it. My dad was like, why are you writing a case report on a hip dislocation of a hip arthroscopy? You never want your name associated with that. And I'm like, dad, I didn't do the case. But that was just a thing.

So unlike external foot progression angle, you want to look at internal foot progression angle, that in-toeing gait. This is part of that miserable triad of the female athlete, where they have increased femoral anteversion. They have valgus, and they have a valgus hip and a valgus knee. And obviously, your patella is going to then also feel the problem here.

Realize, as I said before, although acetabular dysplasia can give you a little bit of this, when you really have an in-toeing gait, it's got to be from the femur. Because again, femur is a much bigger driver than the acetabulum. Femur being femoral version, then the driver of motion loss would be varus valgus then can then acetabulum. And it was done by a modeling paper by Phil Noble. And this is just the classic gait pattern.

Lastly, to really confuse you now, you can't forget about the tibia. Because God's really smart, and when God muffs up one part of the body, he compensates in the other part of the body. So there definitely are people that have femoral version abnormalities and have compensatory internal and external tibial torsion. So let's talk about that quickly.

So what's compensatory femoral anteversion? Well, that means when you have your femur is anteverted, but you don't walk with in-toeing gait because your tibia, compensatory externally rotates. Likewise, the other way around, if your femur is very, very retroverted, you don't walk with an out-toeing gait because your tibia compensatorily in-toeing rotates.

And the way you can figure this out, this is from a classic paper by Dr. Tonus. If you ever really want to get into the subject, you have to read Dr. Tonus's [INAUDIBLE] review article on version. It is better than any Ambien for sleep. It is a very dense paper. But it is a classic and you have to read it. And these pictures are from that paper.

And basically, they didn't use CAT scan. They used a lot of physical exam, and basically, by neutralizing the patella, they would assess tibial torsion. And recognize, in this scenario here, you can see how much, even though the femur has a lot of anteversion, there's a lot of compensatory, external, tibial torsion.

And you can see once the patella is neutralized, or externally rotated, you can see that foot, how much compensatory extra tibular torsion there is. Likewise, there's the other extreme if we talked about compensatory femoral version, where the femur is retroverted, and then instead of and the tibia is internally rotated.

So why do we really care? Well, the reason why I care, is that we're talking about combined version. And really, this is a concept that I have to give credit to my dad. He was the first one who invented this. It was then been glorified by multiple papers, where they say, let's add the sum of the cup and the stem when we do a total hip, and we want to get the safe zone.

If the femur is roughly 15 or 20 degrees, and the acetabulum is roughly 15 degrees, well then your safe zone should be around 30 degrees, right? And there's a tremendous amount of arthroplasty literature on this. They've slowly realized that the safe zone isn't safe, and that's because now they've gone to the back.

And I've published a lot of papers on how the back affects hip impingement, and it's really my 10-second skinny on that is, why do we focus on the core for pre-hip rehab and post-hip arthroscopy rehab, was because you want to unlock the back, or you want to restore motion in your back.

If your back has lost its ability to flex and extend, its lumbar lordosis, its flexion and extension of the spine, then all the motion to sit and to play sports goes through your hip. Actually, this is really going to confuse people, FAI patients, symptomatic FAI patients have more hip flexion than asymptomatic FAI patients. Because their back doesn't work, so they use all their motion they get through their hip.

Likewise, people with cams, who don't have symptomatic FAI, don't have symptoms are because their back works so well, the back protects them. They're called copers. That's why if you show an X-ray to a total joint surgeon, and he's like, look, there's a cam here. Here's an arthritis. And I'd say, yeah, he's got a good back. And that's really where rehab can work. Because rehab can unlock the lumbar spine.

Likewise, they realized that when some people are out of the safe zone, it wasn't because the safe zone is wrong. The safe zone is right. It's because their spine was either fixed from a fusion or fixed from degenerative disk disease. So understanding how the spine interacts with combined version, is really critical for your understanding.

And this is my dad's classic description of the Ranawat coplanar test, which is intraoperatively where he would assess the acetabular position, the femoral position, and make them coaxial, and then look at the foot. And that would give you your combined anteversion.

This system is the whole basis of the Mako total hip system. Because they basically-- you put in the femur non-cemented, and it gives you your version. And then you adjust the cup to adjust your combined anteversion. My dad never did a robot in his life, but that's the whole basis of the Mako Robotic total hip platform, which was glorified by my late uncle, Dr. Larry Dorr, who also is a pioneer in robotics in hip replacements.

So why do we care? I'm talking now about total hip, and we're like, this is a hip arthroscopy conference. Well, we found from the ped literature, that the McKibben's instability index is the same thing as combining anteversion. And so Dr. McKibben showed that if you combine the McKibben's and the pediatric hip, and you have a normal index, again, the combined version is normal, but that hip would become a happy hip.

If you're combined anteversion or your McKibben's index was very low, you would have impingement, right? So if you have a retroverted femur and a retroverted acetabulum, you're going to have impingement. So and likewise, if you have a very anteverted femur and a very anteverted socket, you will have instability, anteriorly. So this concept is just bringing these concepts all together.

So what's my approach? Well, this is a really busy slide. It makes you think. How version affects my surgical decision making? If I have a high McKibben's or a high combined anteversion, and it's uncompensated, meaning the tibia is normal, then I want to go to the femur and de-rotate the femur if I think the deformity is the femur. Lesser, I'll do a PAO, but I do it with a combined labral repair.

If I have a high McKibben's, but it's compensated, you could do a double osteotomy. In this case, I'm doing more of just an isolated hip scope because I don't want to cheat one side or the other, maybe even a dislocation. Normal combined anteversion, that's why I would do a scope. That's 80% of my practice.

Really low combined version and uncompensated, which again, the tibia is normal. This is an example would be a high-grade skippy, I would do a scope and a femoral osteotomy. And then if it's really low but compensated, but it's not that low, maybe the femoral version is only saying 0 to 7, then I would just do a scope.

So that's really always the thing. We have a hip conference like you do with multidisciplinary, and it's always scope due to be a femur, due to the acetabulum, do you do all? Do you do dislocation? Those are the four variables.

Obviously, there's been more and more scopes out there. And it's really replaced surgical dislocation for majority of impingement surgeries. In our recent systemic review of outcomes, there was not really a significant difference. But we do feel that retroversion is definitely more of a player or has a more likely to have lower problems than anteversion. So I am much more scared on the retroverted, severely retroverted hip than on the slightly anteverted hip.

So when do I scope, really? So this is a perfect example where you see a crossover, and it's not true retroversion. It's a crossover from either subspine. And this is an easy one where you can treat the cam, treat the subspine, and you don't have to worry about what you think is a retroverted acetabulum.

And the whole basis of this is to do-- you don't have to do much on the acetabulum, and you do most of your work on the subspine. The amount of acetabulum work I do is less and less every year, unless I clearly have a deep socket.

Now, when do I start adding femoral osteotomy? Well, first of all, I look at the range of motion. And if it's restricted or if it's hyper for the anteverted hip, that's really the biggest key, then I look at the number. And then I will add a de-rotation osteotomy.

And I don't do this. This is done with one of my colleagues, Bob Bully. He does it with a Winquist saw. It's pretty slick, but we scope the hip first. I'll even do a cam and all that stuff.

You got to be careful which way he's rotating and how you manage the capsule, because if you do a big capsular cut, and he's taking a retroverted femur to anteverted, well, he's putting a lot more pressure on your capsule repair. So understand which way your de-rotating will affect your capsular management, as well.

We do a lot of PAOs at HSS. Obviously, this is for dysplasia. It's a powerful tool. You have two PAOs. You have a traditional PAO to antevert the acetabulum and to bring down the lateral [INAUDIBLE] angle. And then you have a reverse PAO for a retroverted acetabulum. This is probably a 15 to 1 ratio. We do it much less for impingement, that reverse PAO, but we definitely have done it.

There's a lot of data out there. And in terms of ones that are done for impingement, there's much less. But we certainly have done the reverse PAO. And in this scenario, I will definitely do an osteochondroplasty. And this one, I'm less likely to scope the hip versus a regular PAO, we're much more likely to scope the hip and do a labral repair because of the nature of the labrum is much bigger and more unstable. And this is a classic paper from Dr. Reynolds, in [INAUDIBLE] class where he talks about his first reverse PAO.

So let's quickly get into one case, talking too much. There's a 29-year-old cyclist complains of hip pain has intra-articular signs, walks with a mild external foot progression angle here.

If you look at that lateral X-ray, you can see on that lateral X-ray it looks pretty straight. I can almost tell that the patient has a low femoral version. And this case is-- I still see a little bit of a decent alpha angle. I definitely see some overhang on the acetabulum and femoral version of five.

This is one of those cases where I'm going to say, you know what, I'm going to go for it, and I'm just going to do a scope. Just did the scope, and the patient did very well, all right. And you want to do an aggressive osteochondroplasty and really go distal for that retroverted femur.

Here's another example, a 20-year-old, a soccer player. He's got an [INAUDIBLE] groin muscle, lateral hip pain, mechanical symptoms. He can no longer play soccer can't do anything. You can see here, relatively severe dysplasia. This is a chip shot. Alpha angle is pretty small. It makes sense. It doesn't have a cam.

So when you have low alpha angles, if you're chasing alpha angles of 56, that's a normal socket, I mean a normal femur. I want you to only look at alpha angles that are in the 60s. Because anyone in the 50s, probably don't have impingement. And they will probably have good motion.

This patient had great motion, high McKibben's, a high combined anteversion. Center angle is very low. So in this scenario, we did a scope PAO, labral repair, and the patient did very well.

So in conclusion, I think, you have to understand where the deformity is coming from and look at motion, look at foot progression angle, then do your CAT scan. Figure out is it on the femur, is it the acetabulum? And don't forget about the tibia. Combine all those factors, and then do your treatment algorithm based on all those factors.

And as my father would always say, the eyes only see what the mind knows. I want to thank Craig and Pit for inviting me. And this is a great concept. Version's near and dear to my heart. And I could talk about it for hours. But I'm going to stop there. Thank you.

**KEELAN R.
ENSEKI:**

And I've been tasked today with discussing the physical evaluation of the hip with version considerations. And of course, I'll have a bit of a rehabilitation or physical therapist slant to this based on what I do. And I think you will obviously see the overlap with our physician colleagues. I will take that perspective as we use our evaluation to drive our interventions in the physical therapy domain.

Delay here. I don't know if it's my computer, or if it's just a delay in the advance. Sorry. I have no relevant disclosures to this presentation. Hope I didn't get ahead of myself there.

So when we look at our physical evaluation in the rehabilitation domain, we use this to drive our interventions. And so I will borrow or speak to a number of our consensus papers and other clinical practice guidelines that we put out, the one that ISHA endorsed, some FAIS.

The non-arthritic hip joint pain guideline, which is getting a little long in the tooth now, and I'm happy to say I think we're getting very close to having that formally approved to be published this summer and updated, which I think will shed a little more light from the physical therapy domain on some of these conditions.

I often also, in our athletic population, will reference the Doha agreement, which should pop up here momentarily. Because I do think it is a great paper and a way to-- particularly for the rehabilitation clinicians in the room --to put this into a great clinical perspective. And in this case, we'll be speaking to hip-related groin pain.

However, what you'll notice is there's really no physical therapy or rehabilitation papers that, at least to any great extent, speak to the rehabilitation implications of femoral or acetabular version. And that's where we're at. It's often mentioned sometimes even as a side note. Though we try to bring it to the forefront a bit in our updated clinical practice guidelines.

But there's not much out there on it. And part of that is it's just it's a challenging subject, and what do we do with these individuals? And some of that literature, even up to this point, has been really relegated to the pediatric population. Now we're trying to bring it forward into at least the adolescent, the skeletally mature adult population, et cetera.

And as I note here, and as Dr. Ranawat noted, these version angles, along with angle inclination change throughout development. Today, for anything, I'll be discussing we're primarily looking at the skeletally mature patient or the patient that at least is approaching skeletal maturity.

But that's not to say childhood history is very relevant. It may be the most relevant thing, in when we would see these individuals. And I'm often in this case speaking to, in the state of Pennsylvania, I know New York and most states now, we may see these people direct access.

They may not have had the benefit of seeing a number of the other individuals on this meeting. They may have seen a physician who's not a specialist, and for example, they're a primary care physician in hip pathology. So we may be the first one to at least pick up some of these clues.

It may not be-- won't be making the diagnosis. We are not ordering imaging and such as in the rehabilitation field, but even if we don't have the advantage of having it done beforehand, we may be making a referral to some of the individuals on this call. Hopefully, that's we're referring to.

So looking at this from the get go, we already mentioned history very important. If there's a childhood history, your suspicion of something with the hip joint potentially version issues that may have been missed, or maybe the patient just isn't fully aware of the relevance of having a version history or other hip-related history in the past.

If we've already established it, now we're looking at the symptom distribution and local causes of hip pain. So I mentioned here, and you see some of the different-- I go by region, which I think clinically makes sense. And we're often looking at that classic C sign for true hip-joint disorder, such as FAIS.

FAIS case, I think many of us are FemoroAcetabular Impingement. The S is just a commonly accepted addition, with S stands for Syndrome, where we look at not only the anatomical characteristics we pick up on imaging but also the functional and the symptomatic presentation as well.

So that may be one of our primary particular athletic populations, one of our primary suspicions, or I just use the general term instability, which has many underlying causes from dysplasia to micro-instability. Maybe these individuals, at this point, are OA. They may have all these other things, but they're heading down the degenerative path.

But what, and I think Doctor Ranawat mentioned this, when he mentioned this, that it perked my ears because I'm glad to hear that he did. It makes my job a little bit easier. What about all these other issues that come along with-- the periarticular issues that often come along with version or other intra-articular issues of the hip, even non-arthritic issues of the hip GTPS Greater Trochanteric Pain Syndrome, a number of diagnoses encompassed under that umbrella term at times.

IFI issue of femoral impingement, which someone else will speak to later, deep gluteal pain and piriformis issues, SI joint and lumbopelvic. Dr. Ranawat mentioned the hip-spine issue. Obviously, I don't have enough time to go into that into great detail, but again, that is something that we see in clinical practice often.

And you can really frustrate yourself if you stay too isolated looking at one area with these individuals, either the hip, or maybe they're coming through to you with back or side joint pain if you take an encompassing view of this, and really look at the entire picture a person, if you will.

OK, as mentioned, one of the first things we look at, gait. And typically, if someone walks in the clinic, we're often looking at-- when I say gait, just walking. This is an athletic activity evaluation, et cetera, which is multi-planar, can be much more complicated.

We typically think of this primarily occurring in the sagittal plane in terms of the motion at the hip, very little in the frontal plane, at least in someone who's functioning normally. We don't usually have a large pelvic drop or hike.

And not that much really that occurs in the transverse plane. We have a small amount of internal rotation happens rapidly as the foot pronates and then back to neutral pitela. But in the individual with version issues, that could be different. These numbers, relatively, may be different. And also, the extent to which they happen or occur may be different.

So gait may be one of our first, and often is, it's often the reason somebody may be there to see you, whether they're symptomatic or not may be one of the first clues as to something going on in that transverse plane relative to a version issue.

Of course, on the right here, you'll see this picture of my daughter, who is relatively anteverted, but she's only eight years old, no problems with her hip that we're aware of. I'm not looking for any either. So I just use that example it's just there out of convenience.

But again, then when we see-- Dr. Ranawat alluded to this, when we look at individuals and we see, perhaps, a gait pattern that looks abnormal, if you will. We have to look above and below. We are considering the hip, but it was already mentioned, tibial issues. Tibial torsions, lumbosacral issues all have to be considered as well.

We may not know what, relatively speaking, which areas are contributing to this individual's altered gait pattern. That's what we'll discuss as we go through the evaluation, but we have to consider it.

And then, again, we'll allude to our upcoming clinical practice guidelines as we go along here and you'll see, I'll mention the recommendations that we give. Now remember, these recommendations, if you look at a report card, and you see a bunch of C's and B's, some D's, a couple of F's that wouldn't be great if my daughter brought that report card home.

But I will say that when we did this in 2014, it was all F's. We didn't have any evidence in the rehabilitation domain. So you got to have patience with your children. Were getting better. So we have a level B recommendation where we look at just basic impairment assessment.

This is very important because from the rehabilitation perspective, this is what we can change as clinicians. We're not performing surgeries, obviously. We may see individuals after surgery. But what we can change are a number of these impairments.

However, what we also have to realize is with these impairments are not due to things that we can change strength, movement quality, mobility that we can affect in terms of flexibility. Sometimes, it's the bony anatomy. And we're not changing that. We have to work around it, consider it, perhaps refer if the individual hasn't seen a specialist yet.

But we do make a recommendation. So I think it's pretty obvious to look at range of motion, muscle power, movement coordination with things very important. We'll speak to that later. Particularly too, as basic as it seems, to obtain range of motion, strength measurements at the beginning and as we move through treatment.

Can we look at some of the evidence out there? FAIS, there has been a trend to describe decrease in internal rotation and flexion. But as Dr. Ranawat noted, the loss of range of motion, particularly in the transverse plane, is much more notable when we look at individuals with true version issues.

Strength impairments also exist in the FAIS population. Again, much of our evidence in the non-arthritis pain literature in rehab, is looked at this population of individuals. And we do know those strength deficits may be correlated to symptom severity.

However, when we bring version considerations into the impairment assessment conversation, we have some additional evidence to go over. Again, level-three evidence. OK, a couple studies here, Uding mentioned-- or Uding described in their study of 78 patients with non-arthritis hip pain, they looked at individuals with femoral anteversion and noted, as probably expected, but we now have evidence to back this up, that their external rotation was decreased and then more internal rotation.

We often talk about this. I teach an entry-level program. We discuss this, but now we have the data to show. And it's significant difference in their study and also in the study by Teddy Murray. We looked at 221 patients. And again, they found greater internal rotation on average in those with femoral and acetabular anteversion compared to those with femoral retroversion, acetabular retroversion you can see 44.2 degrees on average versus a 20.1 degrees for the latter anatomical consideration.

And then the group out of Porto Alegre, looked at strength in these individuals, small study but found the anteverted sample were weaker than the retroverted hips for external rotation when measured at 30 degrees of external rotation, abduction, and adduction.

So on top of what we know that is condition specific, so I mentioned for FAIS. There's a literature out there on dysplasia, as well. We also know when these version variations are present, this can have a true effect on your range of motion and strength. Now of these two, we may not be able to change range of motion. that's due to bony architecture.

Strength, we probably at least have some ability to change. It may be a challenge, just due to anatomical predispositions, but it is something we can change in the rehabilitation setting. But as clinicians, we should realize the potential to see these impairments and why they may be there.

And just a quick note on shrink tests. I'll give a quick shout out to Ali and Brandon, our sports residents, who did a great presentation on this. Sometimes you'll hear the excuse, if you will, that you can't measure strength without the Biodex, or as you see in the lower left, it'd be great if we all had the VLD, the bald performance force frame. But we don't in our clinics.

But there's a handheld dynamometer. Again, that's not cheap either, but obviously, that's out there in terms of operationalize how you do that. But you can use a crane [INAUDIBLE], seen in the middle picture on the left, for abduction or a tin deck. And now there's a lot out there in operationalize how you do this. And there's even reliability studies. So you can measure strength. You can do it, and you can get objective numbers. And this is very relevant in our athletes, where handheld-- or excuse me, manual muscle testing sometimes just doesn't do it, sorry.

And when we look at the recommendation for clinical tests, now, again, we're often performing in the rehabilitation domain performing clinical tests to either raise suspicion because we don't have imaging often. If we do, even all are better, but if we're seeing them before a specialist may see them.

So raise suspicion of a potential condition being there. As we'll note, most of these tests are better screening tools than making a specific diagnosis. But to me, sometimes it does change my threshold and where I may send somebody if they're not doing well in rehabilitation to a specialist. So again, there is utility here.

And we make B-level recommendation, again, as you can see why we would make that recommendation. And also, I'm not going to go over all of these. We'll speak a little more to joint-specific testing. Many of these are based around FAIS diagnosis.

But the extra-articular tests are relevant because, as mentioned, the peri-articular issues that we see in these individuals with version issues, is definitely it's a real thing. And we often have to deal with that.

OK, just making some of the results from an umbrella review by Fernandez that looked at FAIS and all the different tests that are out there, as you can see. I know Dr. Ranawat and a number of other individuals on this call were involved with a number of these studies.

By far and away, we look at the FADIR tests the most, Flexion Abduction Internal Rotation is shown on the right. It's symptom provocation test. Again, the evidence leans to that as being-- leans towards that being-- more than leans, it does establish that as a better screening tool due to the sensitivity versus a somewhat lower inconsistent specificity. So basically a negative test will probably give you more information than a positive test in trying to rule out FAIS.

A number of other tests that, for lack of a better term, they're the test for capsule ligamentous structure. Some of these are looking at mobility. Many of them are looking for symptom provocation. The log roll test has been described in the literature.

But what about the effect of version or other structural variation? So you see in the upper left of the screen, we show what would be a positive log roll test. If the individual is symptomatic on the right, and they have increased external rotation, we often would attribute that to increased laxity of the structures that provide anterior stability iliofemoral, ligament, capsule, et cetera.

However, if someone has a version issue at that hip, and it's unilateral, or a tibial issue, too, as was mentioned, that test may not be valid, again. We have to at least consider that. There's a number of micro-instability tests that are out there tend to have higher specificity versus sensitivity. So they are not the greatest screening examination techniques.

And you'll see several variations, I won't get into too much detail, in the lower part of the screen. Most of these, basically, attempt to create anterior translation of the femoral head, and then looking for pain or apprehension and attributing that to the condition of micro-instability. And then also ligamentum Teres test has been described, as well.

I mention these, primarily, because again, as relocation clinicians, these may not be the crux of our examination. They don't guide treatment, so to speak. But to me, again, they change my threshold sometimes of referral, or at least give me an idea of if someone isn't improving, maybe there's an underlying anatomical construct that I can't affect.

OK, just some data on or literature on the three tests that were shown in the previous slide for micro-instability. Again, they tend to be-- but they do show a great ability to predict. They tend to be more specific than sensitive. So negative tests may not mean much in regard to determining the diagnosis.

And if you want a little more information on micro-instability, again, another elusive term, so you pair that with version, and it becomes very complicated, we do have a Delphi study that was published, I think, last year. I can't see there. Yeah, last year, last year, yeah, 2022. So this gives you a general idea what the clinical picture may look like.

And I put what I noted here were some of the agreed upon, if you will, factors that physical therapists can pick out. History is large here, right? And the examination techniques that we have available to us, to at least get an idea of maybe someone has falls into this category, it wouldn't be unthought of or it wouldn't be unreasonable to think that this category could overlap with version issues.

OK, Craig's test, we talk about it all the time. We teach it in the entry-level course. What does it mean? And it's important to remember that Craig's test is-- it's basically a measurement of rotation. And you're trying your best to estimate without, particularly in our environment, where we don't have imaging or some of the more accurate measurements available, it's a way of estimating version by using range of motion and palpation.

To that end, those are two clinical measurements that, inherently, have a certain amount of error or margin of error associated with them. But it's the best we have, at least in our environment.

So again, it may be a review for some people, but basically, we'll have the individual in prone palpating the greater trochanter. We'll internally externally rotate the [INAUDIBLE] into the point where the greater trochanter becomes most prominent. We're trying to get parallel to the table. We then measure the amount of rotation.

Now, typically, it's going to be accepted-- unless it's very retroverted hip, you will probably see some degree of internal rotation. It's how much. And you can see, again, the literature does vary, but we have the normal value of approximately 8 to 15 degrees, depending on the references that you look at. Again, children's going to be different if they're not skeletally mature yet.

Greater than 15 degrees of internal rotation is generally moving towards femoral anteversion, potentially. Or less than 8 degrees is moving towards a retroversion type of presentation.

Again, the study already referenced, Uding found that Craig's test to be valid as significant difference between patients with MRI-identified femoral anteversion normal and femoral retroversion. You can see the values there that fall within the values above.

So it does have clinical utility for us. Again, it's a way to estimate femoral [INAUDIBLE] version. Obviously, there's plenty of room for error there. And it should be considered in the context of other clinical findings. Again, it doesn't always drive our rehabilitation plan of care, but you put it in the larger clinical picture and decisions that may be made if someone isn't improving.

Spend a little more time on physical performance measures. Again, these are things that we could affect, quality and movement. Give a level B recommendation, which is much better. We didn't have the recommendation at all in 2014. It's a preponderance of level II and III studies.

And we basically make a recommendation that you should measure function and postural control at baseline and at follow up, as well. And now it's been operationalized that we can actually describe this a little bit better. Not only what we're looking for, but how to note improvement and what that means.

Common tests, so it's not an all-inclusive list, include the squat, the overhead squat or double-leg squat, step-down test, single-leg squat test. The SEBT, the Star Excursion Balance Test and a number of other functional measures. We'll speak to two or three of those for time's sake.

What about the squat? It's a big conversation, right? Patients ask about this all the time. And then I'm not getting into treatment, that someone else is doing that today. But this is a conversation that often has to take place.

And what we basically-- the take-home message is that traditional performance-based optimization of the squat, may not be ideal for rehabilitation purposes. So when someone comes to the clinic, no doubt we will have them squat.

And you can see two different potential versions or two different scenarios on your right of the screen. You see a squat with the feet straight forward. You can see it very wide apart. Some people have chosen to do this based on what people have told them to do, other people, because it's their more comfortable position.

And often, what you may run into, is an issue where someone has told them to change this. That may be great in the performance world. It may actually be a very valid recommendation, even in the rehab world. But we have to realize that sometimes people are squatting this way because of their bony mechanics.

Someone with a large amount of retroversion, that squat on your right, that almost Sumo-style squat with external rotation, a bit of abduction, that may be the preferable way if they're going to squat to do it versus someone who maybe [INAUDIBLE] on your left. We don't know why they're doing this. But if we make the observation, our physical examination should help determine why they're doing this.

I don't have a name for this test, but if you hang someone upside down in yoga ropes in a patient's yoga studio, you can see on your left, the way someone with an anteverted hips may handle that. Someone with greatly retroverted hips may handle it a different way, on your

Right. I don't, again, have a name for this test. I guess it's a non-weight bearing version preference test. But if you flip it around, it doesn't look much different than what we talk about with the squat conversation. So my daughter does this much more gracefully. I look like a frog that is about to be dissected in high school anatomy.

What about single-leg tests? It's important that we do single-leg tests. I don't know if this is really big news to anyone in the room today, but there's reasons for this. One, in the literature, we have much more on single-leg tasks step down and single-leg squat in the non-arthritis hip population to speak to a differences that we see and also treatment related-- a way of measuring the effects of treatment, as well.

And some of our colleagues, Malloy being one of them, found differences in hip function were much more prominent during single-leg squat tests versus double-leg squat tests. Put someone on one leg, it makes a big difference in the demands that are induced.

Additionally, I would say that it's valuable to look both at the single step down and the single-leg squat. Because in the sagittal plane, the single-leg squat, you may be able to pick up more-- you may be able to pick up some variation of what occurs at the pelvis, which you won't see in the step down test.

And primarily, that's pelvic tilt. And Lewis and colleagues found that individuals with symptomatic or FAIS, symptomatic FAI-related hip groin and groin pain, showed an increase anterior pelvic tilt. Some of this may also come back to what happens at the spine. So we, at minimally, for the more active individuals recommend performing these tests and assessing quality of movement during these tests at the beginning and at the end of treatment. There's a reason for that we'll discuss.

OK, the star excursion balance test not new to anybody. But this test has been often described in literature for a number of lower-extremity conditions. Kivlan and Martin found that it was related to be they found in non-symptomatic individuals to be correlated with hip abductor strength. But in symptomatic individuals, individuals with AIS, Johansen looked at individuals with bilateral FAI but unilateral FAIS, symptomatic on one side.

And they found the posterolateral is marked here with the yellow dots and the posterioromedial directions there were deficits in the symptomatic individuals. So they were correlated with performance. And this performance is also correlated-- on this test, is correlated with if it was lacking, or there was a deficit, it was correlated with HAGOS subscale with scores on the HAGOS subscales as well, in terms of symptoms and pain intensity.

OK, but what about version considerations for these individuals? And they are there. Position of the stance leg is a concern, as you would see in the picture here. Often, when we define these tests, we actually define them by having somebody starting with their foot relatively in a forward position, if you will, close to neutral in the transverse plane.

However, this puts individuals, particularly with retroversion, at a true disadvantage. You're already putting them in a mechanically disadvantaged position. We don't much to really say about that. No one has changed these tests or at least operationalized them so that you can perform if you have retroversion or inversion.

So when you're put at this disadvantage, the only thing to say, if you do allow that individual on the stance leg to adapt a more, to them, really where it's more of a neutral position from a performance perspective, you should do that on both sides. So at least you have reliability in how you perform the test and interpret the findings. But it's a real issue that we have to discuss for these individuals when we take them through these tests.

And then, again, why do these tests? Not only because it picks up movement variation that we may see or movement deficits, which we want to treat, depending on what the-- remember, the cause can be numerous, can be neuromuscular, control, strength, mobility. We can determine that through the rest of our physical evaluation.

But our group out of Texas, and along with Rob Martin here in Pittsburgh and Ben Kivlan looked at conservative management of these individuals and used as an outcome, the performance on the step down and single-leg squat test and found that when individuals improve their performance on these two tests, it was correlated with reports of less pain and greater functional ability in ADL and sport-related activities as evidenced by performance on the HOS subscales for ADLs and sport-related activities.

So a bottom line there in these types of individuals that if you can improve their movement quality, you can improve their pain and reported quality of life. Now, how they got to that point is more of a multimodal approach, which the evidence does show. That's there. And I won't get into that too much with intervention. Someone else is covering that. That's where the preponderance of evidence lies.

So the improved movement quality, how they did it, was some combination of strength, potentially range of motion, just doing the test as an activity, so neuromuscular control. But this just speaks more to improving the overall quality, what you observe, and what the clinical outcomes that are correlated with that look like. So teach to the test at times.

As we get closer to our summary, and again, I do mention here, I list some of the levels of recommendation we make in the upcoming clinical practice guideline, assuming no other edits are there, it's in the final stage, but looking at the evaluation, determining the history. Is it consistent with non-OA hip conditions? Is there a pediatric history that we may not be treating right now that is very relevant?

Confirmed symptom description and distribution, is it multi-regional, which we often see, a combination of intra-articular and extra-articular issues. The impairment evaluation, strength and range of motion, we have a lot of evidence to support you should do that. You always feel like that's pretty straightforward. Sometimes people forego that.

Functional performance measures as just discussed. Clinical tests to rule in or out change your threshold of referral, your suspicion. Patient-reported outcome measures. We didn't speak to that too much. This is more about physical evaluation, but of course, you should be using validated patient-reported outcome measures for these individuals who are often much more active than other populations.

Then we have to put this all together to determine the relationship with these clinical evaluation findings. Maybe we have additional medical information that's been provided if you've seen one of our colleagues beforehand. That's very useful. If not, we may need that and have to determine when that referral should take place to not do the patient a disservice.

And then I won't speak to intervention, but again, just for the sake of completeness, I listed the evidence levels and a recommendation for the intervention, the conservative intervention for individuals with non-arthritis hip pain.

**ANDREW
CURLEY:**

So this is an outline of the talk that we'll go through today starting with background, then talking about standard radiographs, and finishing up with CT cross-sectional imaging. So some background about version.

Acetabular femoral version has come increasingly into the limelight, over the past couple of years, when evaluating patients with non-arthritis hip pain, specifically the young-adult patient population. Recently, a study by Lerch et al out of the Bernese group, found a high prevalence of acetabular version abnormalities in their cohort of 538 hips that came through their institution with hip pain.

Interestingly, this study also found a high rate of femoral version abnormalities with one in six patients or 17% of patients having severe femoral version abnormalities highlighting the importance of, not just looking at the acetabular version but also looking at the femoral version, as well.

So when evaluating a patient coming into the office, typically, we start with plain radiographs, which includes a pelvis X-ray series. Some of the traditional metrics that we can use on a plain AP pelvis to evaluate for acetabular version, include the crossover sign, ischial spine sign, and posterior wall sign. In combination, the three of these signs, traditionally, was taught to be indicative of global acetabular retroversion, as you see here.

Additionally, the anterior posterior wall can be evaluated in isolation, and the anterior wall indices or posterior wall indices, which is the length of the anterior wall or posterior wall divided by the radius of the femoral head, can be calculated, which will give you a relative metric for anterior and posterior wall coverage.

Taken together, the anterior and posterior wall can be used to calculate the PA ratio as described by Matsuyama and et al several years ago. And in their radiographic metric, they describe the PA ratio, which involves taking the posterior wall and dividing it by the anterior wall.

And they compared this to cross-sectional imaging at the hip center. And they found that there is good correlation between the PA ratio and acetabular version on CT scan suggesting that X-rays are a good screening tool for looking at acetabular version.

More recently, another study has questioned the accuracy of using plain X-rays for evaluating acetabular coverage. In this study, from 2020, these authors looked at plain x-rays and compared it to CT scan. And they found that during their comparison X-ray and CT scans, poorly correlated when evaluating anterior and posterior wall indices.

So in conclusion, X-ray is a good screening tool to give you a bird's eye view of acetabular version, but currently, it's not considered the gold standard. When we want to be more accurate looking at acetabular version, most people will reference a CT scan or some form of cross-sectional imaging.

Whenever we talk about obtaining a CT scan in this patient population, one of the things that we have to consider is the X-ray-- I'm sorry. The radiation exposure that these young adults are being exposed to. And Wylie et al, in their 2018 study, noted that a standard pelvic CT for young adults increases the relative risk of malignancy 5 to 17 times in this patient population.

So more recently, several studies have come out describing a low-dose CT scan protocol in which the pelvic CT radiation is similar to that of a standard three-view X-ray pelvis series that we typically obtain in this patient population anyways.

This is an example of one such protocol that we published at Pittsburgh. You can see the various specifications of the CT scan are listed here. There's other protocols that are also published in the literature that can reduce the radiation dosage, as well.

And more recently, several authors have started investigating whether or not MRI can be used to supplant CT scan when evaluating version on the acetabular or femoral side. Oftentimes, we're getting MRIs to evaluate for soft-tissue pathology in this patient population anyways.

And as MRI techniques continue to evolve and advance, the accuracy of evaluating the bony morphology continues to improve. And in the future, it may be possible that MRI supplants CT for evaluating acetabular and femoral version.

So when we talk about evaluating acetabular version on CT or cross-sectional imaging, one of the first things that we have to consider is the terminology for acetabular version. Are we talking about cranial acetabular version, or are we talking about central acetabular version?

And within these terms, there's also several different definitions. So you can see cranial acetabular version central version shown here on the right. If you critically evaluate the literature, several studies describe cranial acetabular version as a location at the 1 to 2 o'clock position on the acetabular clock face. Whereas, other studies will describe a position that's 5 millimeters below the acetabular roof. So if you're doing 1.25mm slices on a pelvic CT, that'd be about four slices below the roof of the acetabulum.

Even central version has different definitions in the literature. Some studies describe the 3 o'clock position on the acetabular clock face as the central version location. Whereas, other studies utilize the center of the femoral head and use that axial CT slice to measure central version.

So where do these definitions come from? When we look back through the literature, the definition of 5 millimeters below the acetabular roof, the site that's most often cited is this study from the Bernese group, from several years ago, in which they were looking at the validity of the cross-over sign. And in their study, they described cranial acetabular version as below 5 millimeters from the acetabular roof.

Interestingly, while the main results of their study have been somewhat disputed or debated with more recent studies, this definition of cranial acetabular version has seemed to stick over the years and is now referenced in future studies.

What about the center of the femoral head? Well, this comes from a study back in the early 1990s by Tonus et al. And in their study, they described the center of the femoral head as the site at which they measured acetabular version. And many of the more recent studies go back and they referenced this study by Tonus et al when describing central acetabular version.

So it's important to keep in mind the location that you're considering when you're talking about central or cranial version because based on the definition that you use, that can vary your version measurement pretty significantly.

What about femoral version? So when evaluating femoral version with CT or cross-sectional imaging, there's multiple techniques that have been described in the literature, as you can see here. All of these techniques, more or less, involve some measurement of establishing an axis on the posterior aspect of the femoral condyles.

One of the more commonly referenced techniques is the technique of Murphy et al, where an additional slice is taken through the center of the femoral head, and a line is connected through a separate slice just above the lesser trochanter and connecting a point at the center of the femoral neck at that axial slice.

Obviously, this can be somewhat finicky, as you're taking multiple slices and picking the central point on the femur just above the lesser trochanter sometimes can be non-reproducible. An alternative method, as described by Jared et al, uses an axial oblique slice through the center of the femoral neck.

I personally found this technique to be a little bit more reliable in picking the center of the femoral neck. And additionally, you have the benefit of using the same slice for the center of the femoral head and center of the femoral neck compared to two separate axial slices. So I feel that this technique, at least when I've used it, has been more reproducible.

So how do these techniques stack up when we compare them against each other? This study from the Bernese group, in 2019, compared these different femoral version measurements on CT scan. And interestingly, they found a wide range of femoral version discrepancies based on the measurement utilized.

So for example, the technique by Lee et al gave an average version of 11 degrees. Whereas, Murphy et al gave an average version of 28 degrees. So you can imagine this difference between the two techniques, if not appropriately identified, could inaccurately guide management.

So some other metrics to consider when we're evaluating version in a young patient coming in with hip pain, are functional femoral antetorsion and McKibben index. So starting with functional femoral antetorsion. This is a term that was coined by the Bernese group back in 2018.

And in this study, they essentially discuss that no study had evaluated or described the position of the greater troch in the axial plane. Specifically, where does the greater troch lie normally? For instance, if the greater troch lied further anterior, then you would have a different pull of the hip abductor muscles versus a patient where the greater troch lid more posteriorly. And I have a picture describing this later on.

So they defined the term functional antetorsion. And how that's measured, is by taking a slice through the center of the femoral head and then a slice through the center of the femoral neck, as you can see here. And then on a separate slice, you can take the anterior and posterior aspect of the greater troch find the midpoint.

So this blue line would be more of the functional version. Whereas, the red dotted line here would be more of the anatomic version. You can see how this varies between the blue and red line. And I have an example here.

So once again, you have your femoral neck axis. And in this patient, the center of the greater troch is in line with the femoral neck axis. So the trochanteric axis and femoral neck axis are aligned.

But what happens if the greater troch is shifted anterior relative to the femoral neck, just based off the patient's natural anatomy? Well, in this patient, their trochanteric axis would be more anterior. So the hip abductors would have a different vector pull in the axial plane.

And likewise, the greater troch could be shifted more posteriorly, and once again, the trochanteric axis would differ from the femoral neck axis in giving you a different pull of the hip abductors in the axial plane. So further work is needed to evaluate the clinical significance of functional femoral antetorsion, but it's an interesting concept to consider.

And lastly, we'll finish up with the McKibben index. So the McKibben index is the sum of femoral version and central acetabular version. And these two metrics, in combination, can be utilized to identify the McKibben index, as you see here to the right.

So interestingly, based off the combination of the femoral version central acetabular version, these combinations, you could have an aggravated combination. So for example, a patient with increased femoral version and increased acetabular version, they'd be more likely to impinge posteriorly or be unstable anteriorly. And conversely, if a patient is retroverted on the acetabulum and femur, these two alignment abnormalities in combination increases the risk of anterior impingement.

Interestingly, these two metrics can also compensate for each other. So for example, a patient can have increased femoral version, but they're compensated by decreasing their retroverted acetabulum. So in this case, their McKibben index would lie within the normal range. And then vice versa with the decreased femoral version and increased acetabular version.

Lerch et al, from the Bernese group, evaluated 384 patients with symptomatic hip pain at their institution and evaluated their McKibben index. And interestingly, they found in their cohort, as you can see here to the right, 28% of patients had an abnormal McKibben index, which is described as less than 20 degrees or greater than 50 degrees. So essentially, a quarter of the patients had an abnormal McKibben index.

And interestingly, a lot of these patients would not have been identified had the femoral version or acetabular version been evaluated in isolation. So it's useful to look at femoral version and acetabular version as a complete picture together.

So some take-home points from this presentation. Acetabular version, you can use X-ray or CT scan to evaluate. CT or cross-sectional imaging is currently considered more of the gold standard.

When you're using cross-sectional imaging, consider where version is being measured. Is it being measured at the cranial position versus the central position? And also, what is the definition of cranial or central version that you're utilizing?

For femoral version, CT or MRI is needed to evaluate femoral version with cross-sectional imaging. The version measurement, based off of the type of method utilized, can vary significantly. So keep in mind which type of method you're using for evaluating femoral version so that it's reproducible and reliable.

And lastly, future directions. So in the future, as MRI techniques continue to advance and evolve, will this eventually supplant CT scan for evaluating version of the acetabulum and femur? Additionally, functional femoral version and combined version or McKibben index, keep an eye out for these in the future as we continue to better understand the hip and understand the clinical significance of these version metrics.

DAVE SPAEDER: So I'm going to talk about hip pain rehab in the presence of femoral/acetabular version, femoral and acetabular version. So why is this important? It's one of those things where understanding version can be critical with making-- or can be critical because it can change the mechanics of the joint.

So it's going to increase, potentially, joint-reaction forces. And we also know that oftentimes, version can affect outcomes post-hip arthroscopy but also during regular treatment of any patient with hip pathology.

So Keelan really went through all this clinical assessment really well, and Andrew talked about some of the imaging. So I won't touch too much on this. Just highlighting a few things.

Craig's test for femoral version is always important for us to as a quick physical exam on top of everything else that we're doing. Watching the patient walk is also important. It just gives a better insight as to mechanically how they're functioning.

But talking about the things that we can really address. We can modify. strength testing number one, isolating hip and lower extremity current strength levels and making sure that we have a good assessment of that. But also, flexibility and joint mobility can be very critical, as well. Again, going through the Craig's test, watching them walk, functionally watching them move.

So a typical presentation that we find generally femoral anteversion, you see a toe-in standing, walking, anterior pelvic tilt. They're walking falling into the femoral internal position, falling into a lordotic lumbar spine, a lot of times, excessive internal rotation of the hip, and that limited hip external rotation.

Retroversion, a lot of times just the opposite. So you're seeing toe-out standing, walking, neutral, or even slightly into a posterior pelvic tilt, femoral external rotation, and excessive external rotation with limited hip IR.

I think where we can really help the patient, as a clinician, is making sure that we have a very solid history. What positions are they most comfortable in? What positions do they have the most pain with? Where do they feel like they're most challenged?

Do these patients, do they trip a lot? Oftentimes, you'll hear people with anteversion they say to you, oh, I always catch my toe on my other foot. Or I'm constantly tripping on that side. And so these are different clues to steer you down a certain path.

Can you check different shoe wear patterns? Do they have preferred foot position during squatting? Are they comfortable in certain sitting positions? Do they have to constantly adjust or change their sitting position? Different places to start with.

Get a movement assessment, building on what Keelan was talking about. A good way is just to assess a squat. A lot of times we'll have patients, just have them stand up and just without any cuing, have them squat down as deep as they can and really just watch what their preferred position is.

Do they tend to keep their legs more of in a neutral internal rotated or even an anteverted position? Do they tend to flare out into an external rotated position? Do they really struggle with a single-leg squat? A lot of times, they're at a biomechanical disadvantage if they are in a more of a retroverted position. Static standing posture, like I talked about, and even some ambulation can be good tools for you to start assessing this.

So what are some rehab considerations? I think number one, we want to start with treating the impairments. We want to optimize soft-tissue mobility, so joint mobilization stretching soft tissue work. However, with those, we have to understand that anyone who's going to fall more in that anteverted or retroverted position, they're not going to have the same length tension relationships, oftentimes.

So will we normalize a range of motion? That's hard to say, sometimes. And a lot of times, we want to be very mindful that we're stretching, mobilizing, or even doing some of the soft-tissue work in not having them feel joint symptoms but is more of a soft tissue, a symptom that they're feeling.

So anything that's deep, pinching, reproducing that dull achiness that's deep near the joint, that's something we really don't want to push into too much. Again, we want to optimize their movement. We don't necessarily want to normalize their movement. On top of that, whatever you tease out by diametric measurements, manual muscle testing, functional mobility that can steer us towards more of that isolated targeted strengthening.

Quadruped rocking is an exercise I often will use with patients, just to get them some early mobility, especially if they seem to be a little more flared up. This is a really good starting place to even help them realize, like, I can adjust my position, and I can clear some of these symptoms.

We want to really back off or reduce the irritable level of that hip and reduce that irritation. And just helping them work through some of these movement positions and help them learn, oh, if I actually rotate a little bit, or if I stay neutral with my hips, I can reduce that pinching sensation that I'm getting. So it just helps them to feel the right movements to feel the right symptoms when they're moving back through the hips, in a relatively easy, low-impact manner.

Isolated strengthening for peri-hip, core, and lower extremity musculature is really a must have. You may have to adjust the range of motion a little bit based on their presentation or based on positions that will become symptomatic. Targeted stretching hip flexors, hamstrings, quads, glutes, and even the joint mobility like I talked about.

Do you want to be careful, again, just based on we want more of a soft-tissue limitation with these. We don't want to push them into their joint symptoms or that familiar symptom for them.

Some anteversion considerations, generally speaking, these are patients that are going to present with-- if they are anteverted, they're going to present with soft-tissue limitations, including some hip flexor tightness, lengthened glutes, paraspinal erector tightness, lengthened anterior core. Almost mimicking that lower-cross syndrome.

Now it may not be the clinical picture of a lower-cross syndrome, but it's a way that we want to make sure we're pulling them back into that normal position as best as we can. Will we see a physical change? Maybe not, but again, we're giving them the support from a soft-tissue perspective.

Bony limitations, oftentimes, hip extension is going to be limited. They're going to run into a greater chance of that history of femoral impingement, and care must be taken to really monitor excessive hip extension. These are the patients-- you're starting to get into runners, who they're putting in a lot of mileage or volume. They tend to extend a lot. And that's when you can start to run into more of that long-term stress type injury. They're also going to be limited with hip external rotation.

This is just a good model to just show you the length tension relationships, and how that lateral hip is going to change as the version changes. Again, just a picture of lower-cross syndrome.

So how can we address anteversion exercise selection? I think this, as clinicians, especially PTs, ATs, this is where we can really make sure we're optimizing our outcomes. It's not really complex. And the goals are still the same.

We want these patients to squat. We want these patients to hinge. We want to work on core stability. We want to work on lower-extremity strength and force development of motor control. But slightly cuing these exercises away from positions that we know can be aggravating, can be really helpful with making sure they're tolerating from a session-to-session basis but also just building the movement pattern a little bit more.

So generally with anteverted patients, femoral anteverted patients, squatting with a more narrow stance is going to be appropriate for them. Have them self select that. We don't want to force them into a position where they're starting to get really wide. Doing a Lateral Lunge here, may not be appropriate for them right away because it might stress them a little bit too much into that external rotated position.

These are patients that do pretty well with progressing from a double leg to single-leg options with a squat. So forcing a step up, forcing single-leg squats, pistol squats, even the star balance can be a good option here. Hinging patterns, conventional deadlifts or even trap-bar deadlifts are going to be good for these patients because they're staying in line. They're staying within that position that they're most comfortable. We're not stressing the joint at it's end range. You can also progress with double and single-leg RDLs to, again, to try to force that hinging pattern.

Core considerations, while we want to develop a complete core strength, anti-extension exercises are going to be critical for these patients. The picture on the bottom is a simple example of anti-extension. I start very early on with hips, hip arthroscopies, or really any patient that has an irritable hip in that we want to work on that pelvic stability.

Here, we're just really forcing that posterior pelvic tilt making sure that they're stable through their core as they just start to advance overhead with a weight stressing that wanting to pull them into an extended position. Progressions with this, you can get fairly creative. Planking is a good option, even just switching up where we're having them hold the weight during certain exercises squatting, deadlifting, can really challenge them in different ways.

Retroverted considerations, soft-tissue limitations, typically, you're going to see tightness of the hip external rotators, hip extensors. Tightness through the anterior core and the obliques. Bony limitations are going to be more through hip flexion, hip internal rotation.

Same thing, we want these patients to squat, hinge, work on core strength. This is how we're going to develop that, again, that dynamic ability to load and progress into athletic events. So squatting these patients may favor a wider stance reduce depth of their squatting.

Considerations would be a sumo squat, working into a lateral lunge, making sure we're just allowing that hip to travel through the range of motion that it feels best with or it's not producing that more deep joint symptom.

Hinging can be challenging for these patients at first because they want to be externally rotated. It's hard to sit back through the hips appropriately. So they're going to start compensating a little bit more through the lower back. An easy, better entry point would be maybe through hip thrusting. So you can start working through hip thrusting, load it up, start to transition the weight, repetitions.

Again, this allows for them to better select or self select the position that's going to be most comfortable for them, whether that's falling into a little more externally rotated position or staying in a neutral position where they tolerate. Then you can start working in a more sumo deadlift or a wider stance deadlift. And then also working into RDLs.

Again, these are a challenging position for these patients to get into. So consideration with some progressions, including B stance, which I'll have a picture of, and then progressing into single leg. It's going to be a harder transition into that single leg. But it's a worthwhile transition to move towards a single leg so that they can get back into more athletic activities. And core, one consideration is we want to focus on a little bit more anti-rotation activities.

So here's a wider stance sumo squat or sumo deadlift. Middle picture is a B stance, so we're still allowing them to self select that front leg where they feel most comfortable but give them that prop or that kickstand on the back leg so that they can stay in a position that's most appropriate for their hip, as we continue to load that and get the motor patterns ingrained with them.

This is just a quick example of, when we're looking at dynamic loading, how do we see different loading patterns or preferences? So the picture on the left, you can see how he wants to rotate or internally rotate on that back leg to load to be able to produce that force as he goes down the hill. He tends to probably be a little bit more anteverted.

Where the picture on the right, now he wants to favor more of that externally rotated back position. He tends to drive the ground back. He doesn't have as much internal rotation on pelvis on femur on that back side.

| I think the take-home message here is that there is no cookie-cutter approach for these patients. We want to find the positions that they're most comfortable in and that they feel explosive and they feel strong within. If they're starting to feel pain, or if they're really struggling, you see a lot of compensation patterns, maybe we want to switch up how they're loading.

And this is just one example, athletically, but even when we start talking about patients getting back into cutting, jumping, everything like that we may want to work with footwork patterns with them to make sure that they're in the right position. And we're not trying to force different agility drills on them that they're just not comfortable with or isn't a good strategy for them.

Dynamic progression, we want to, number one, have good control through that full available range. Develop strategies, like I just said, with foot placement during explosive, dynamic loading. And then we also want to have that slow progression with optimized load. Ensure that tolerance, especially when they start working towards those vulnerable positions as they start getting back to return to sport and back into return to functional activities.

Thank you very much for the opportunity. If you have any questions, let me know.

**DANIEL
LUEDERS:**

It's really impressive to see the connections between Dr. Ranawat and Dr. Moreau and the history here in Pittsburgh. It's pretty amazing to consider, as well, that Dr. Ryan, who we'll hear from next and I go back about 20 years or so, when we used to meet in Breckenridge every year to discuss and deliberate the complexities of the hip and to do a little skiing.

And it really is amazing to see all that Dr. Ryan has published in this topic, in this field and all the amazing things ahead of him. And I wanted to thank him for his great contribution today.

We've discussed the posterior hip in this conference before. We had Hal Martin several years ago and his expertise. Dr. Moreau asked me to discuss the imaging and use of ultrasound in the evaluation of the ischiofemoral impingement, and its dynamic nature in the posterior hip.

So this slide shows us the gross anatomy of the posterior hip. What we see, specifically, is medially, the ischial tuberosity, laterally, the sorry-- medially, the ischial tuberosity, laterally the lesser trochanter of the femur, and then the deep-hip external rotators that emerge from the pelvis and insert to femur and the sciatic nerve that courses over the top of those.

In cross section-- if I can get this to advance --what this appears as, it's a particularly potentially vulnerable space between the ischial tuberosity and the lesser trochanter seen in this cross section between the two blue lines. And what is relatively a confined space on this static anatomic evaluation that changes dynamically throughout hip motion in each plane.

An illustration here, demonstrates that sciatic nerve coursing over the quadratus femoris in the ischiofemoral interval in purple, the tuberosity medially and laterally, the lesser trochanter of the femur. And what gets impinged in this process, we believe, is the quadratus femoris, as the hip moves dynamically.

And it's thought that this process involves-- I need to get this to advance. --hip adduction, which narrows that interval between the lesser tuberosity and the ischium, hip extension, which brings that lesser trochanter posteriorly, and femoral external rotation.

And then certainly, as Dr. Ranawat had discussed earlier, and Dave did as well, as well as Keelan, we have to consider femoral version in this, as well, in that excessive femoral retroversion or even loss of anteversion places that femoral neck more posteriorly, which we would reason increases contact pressure and narrows the interval between the ischium and the femur posteriorly.

So classically, and most in the literature, MRIs are used to describe this issue of femoral interval to assess the quadratus femoris. And what's described is the narrowest point between the ischium and the lesser trochanter and the qualitative assessment of the quadratus femoris, as well.

There's been a range of values described indicating pathology in this issue of femoral interval, as well as what normal values could be. And I think that largely gets to variations or lack of standards in the femoral positioning, during the MRI, whether that be a neutral or whether that be a maximal femoral external rotation. There's quite a range there.

But roughly, asymptomatic individuals seem to have at least 2 centimeters or 20 millimeters of space in the ischiofemoral interval on MR imaging, symptomatic individuals, less than that. So those values have been described as little as 12 millimeters, 13 millimeters in that space.

What's also helpful in MRI, is the qualitative assessment of the ischiofemoral space and the quadratus femoris, where the T2 signal and edema in the quadratus femoris is suggestive of impingement and pathology. Extent of tearing can also be visualized, as well as more chronic fibrofatty replacement and atrophy in advanced cases.

What MRI also contributes is cross-sectional imaging assessing bony integrity for concomitant bone injuries, other musculotendinous pathologies in the posterior hip that might mimic or overlap with this, including hamstring tendinopathies and tears and insertional piriformis and gluteus medius tears and pathology. This is just a correlating image of a coronal view of that quadratus femoris and the ischiofemoral interval variant dimittis.

MRI does have limitations in this evaluation, though. We all know the basics with MRI, and that there's greater expense associated with it. It's not available at the point of care, and then any ferro-metallic implants prohibit the use of MRI in evaluation.

There can also be inconsistencies and variabilities in positioning of the femur. This was illustrated in the study, in a case report described by Dr. Jon Finnoff in 2015, in which they demonstrated in MRI evaluation of the hip in the same patient done six months apart, differences in the measured ischiofemoral interval, without any specific intervention for the lesser trochanter or decompression of that issue of femoral space.

So in August, this space was measured at 2.8 millimeters, and then again, without any intervention, but perhaps lack of standardization or consistency in the femoral positioning and rotation on the MRI, in May of the next year, it was measured at 11.4 millimeters.

So again, the limitation with the MRI is also that it's static in that we can't dynamically move the hip and move the pelvis. And as we've already discussed, the hip is a very dynamic joint that changes its position of the femur of the acetabulum throughout the arc of motion, which can cause pathologies and can cause pain. An MRI gives you a static assessment of that.

And therein lies the benefit of ultrasound, which gives us an analogous image of the ischiofemoral interval. So in these comparison images, we have medial to the right, lateral to the left. We see the ischial tuberosity on the right of the ultrasound images are bright or hyperechoic projection superficially.

To the far left of that image, we see the lesser trochanter of the femur, as indicated by the ampersand and the long axis, or longitudinal quadratus femoris coursing through the ischiofemoral interval between the ischium and postiofemur.

And demonstrated here on the right, is the dynamic visualization of the ischiofemoral interval and the quadratus femoris throughout the arc of internal external range of motion. This is of great benefit in the clinic because it's available at the point of care. It can correlate location of patient's pain. And the femur can be moved through a range of adduction, abduction, and internal-external rotation to demonstrate narrowing in that ischiofemoral interval and potential for impingement.

Dr. Finnoff did publish a study in 2015, correlating MRI with ultrasound in the assessment of the ischiofemoral interval. Essentially, what was done, is 10 patients were placed on an MRI table. Their thigh and leg were secured, they were taped down, to stabilize them in a neutral position.

And so the same position, they were put through an MRI. And immediately, either before or following that, which was randomized, that same issue of femoral interval was assessed with ultrasound. And so they were assessed in the same exact position.

And what they demonstrated was a high degree of correlation between the measurements taken between the two imaging modality, essentially, that there was some variation, which measured about 1.1 millimeters, to 1.3 millimeters, but grossly, the intervals measured and obtained between ultrasound and MRI, were very close in range and had a high degree of correlation.

A similar type of study was done in China with 25 patients with quadratus femoris edema and ischiofemoral interval narrowing, compared to 19 controls, where no statistically significant difference was seen in the measurement of the ischiofemoral space between ultrasound and MRI.

There was a decreased ischiofemoral space distance measured in the ischiofemoral impingement hips compared with the controls. And interestingly, they showed about 3 millimeters of difference in the measured issue of femoral interval on MRI and with ultrasound but didn't describe a statistical significance to that.

And so as I said before, femoral rotation matters in the evaluation of this. And that can vary without standardization on MRI or your testing. And Dr. Finnoff assessed and demonstrated this, as well, where they took 10 patients and evaluated the ischiofemoral interval in a range of pelvis hip positions in internal and external rotation and abduction and adduction.

This is demonstrated in these two images, where on the left, the hip is put into 15 degrees of adduction, A-D deduction, and 30 degrees of pelvis external rotation demonstrating the narrowest interval of the ischiofemoral space. And on the right, the same patient was put into 15 degrees of abduction, 30 degrees of internal rotation. And that space widened to over centimeters. So the position really does matter with this.

And this is, again, correlated with a study from China that showed that same abducted internal rotated position was widest. Adduction externally, rotation is narrowest. And this is shown in graph form from Dr. Finnoff's study, which on the bottom left, demonstrates an abducted externally rotated position on the top right and abducted externally rotated position.

And so that widest position was measured at greater than 5 centimeters in this study. The narrowest position at just over 3 centimeters. And you can see that there's a statistically significant difference between those ranges in evaluating the ischiofemoral interval. Again, suggesting that pelvis positioning and the dynamic nature of this impingement process is really important.

Ultrasound certainly has its limitations. It's not able to image structures deep to bone or intrinsic to bone. So any concomitant pathologies deep to the ischium can't be evaluated. Without a full extent of evaluation of bone, version can't be determined or assessed significantly.

And relative to MRI, the edematous changes within quadratus femoris are less sensitive on ultrasound, which those edema changes can certainly be pathognomonic and very supportive for this diagnosis and are important to understand.

Another benefit of the use of ultrasound, particularly at the point of care and in clinic, is the direction of injections, whether for therapeutic or diagnostic utility. Returning to this cross-sectional imaging, we have lateral to the right, medial to the left, posterior at the bottom of the screen.

And the arrow indicates the approach that's taken to do an ischiofemoral interval or quadratus femoris injection going just inside the lesser trochanter of the femur, both superficial. And then deep to quadratus femoris to really get diffuse coverage of that, either anesthetic or corticosteroid, or in some cases, even botulinum toxin into that muscle for symptom palliation. Taking care certainly to understand the location and ensure the safety of the sciatic nerve, which is indicated in the star in that image.

I won't go through an exhaustive discussion of the effectiveness of the injections but just to say that the lidocaine can be quite effective and give you a bit of a diagnostic step in assessing pain, both before and then after an anesthetic injection. Corticosteroid injection might provide more prolonged benefit, but it's really only reported in case series and case reports. So there's no larger randomized studies there.

Dextrose is described, as well. And then, again, there's a few cases described with botulinum toxin, to perhaps decrease an overactive or spastic quadratus femoris contributing to symptom improvement, as well.

So in summary, the normal ischiofemoral space, both on ultrasound and on MRI, is probably greater than 2 centimeters. That can widen in a femoral internally rotated in abducted position. And pathologic narrowing of the ischiofemoral interval, is probably between 1 and 2 centimeters and narrowest in a femoral adducted and externally rotated position.

So the use of MRI and ultrasound really seem to be complementary in this evaluation. Ultrasound, for its dynamic evaluation and assessment at the point of care. MRI with its sensitivity for edema in the quadratus femoris and coinciding or complicating bony pathologies and assessment of femoral version.