Management of Patellofemoral Pain Syndrome
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Presenter: David Nolan, PT, DPT, MS, OCS, SCS, CSCS
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Well, we are pleased to have David Nolan back with us again today. Dr. Nolan is an Associate Clinical Professor at Northeastern University, in the Department of Physical Therapy and Movement and Rehabilitation Sciences, as well as a graduate lecturer in the College of Professional Studies and the Transitional Doctor of Physical Therapy Program at Northeastern University. David is also a Clinical Specialist at the Mass General Sports Physical Therapy Service and a Director of the MGH Northeastern University Sports Physical Therapy Residency Program. Dr. Nolan is a board-certified orthopedic clinical specialist and a sports clinical specialist through the American Board of Physical Therapy Specialties, and a certified strength and conditioning specialist through the NSCA. He's a past recipient of the Excellence in Clinical Teaching Award from the New England Consortium of Academic Coordinators of Clinical Education, as well as an award for outstanding achievement in clinical practice by the Massachusetts Chapter of the APTA. And most recently, Dr. Nolan was presented with the 2019 Lynn Wallace Clinical Educator Award from the American Academy of Sports Physical Therapy. Thank you so much for presenting, again, for us today, Dr. Nolan, and at this time I'm going to transfer the mike over to you.

Great, thank you very much Calista for the kind introduction and welcome everybody. I'm looking forward to presenting. So we'll get started talking about management of patellofemoral pain. When I go through the learning outcomes first, so, after the course, participants will be able to list three contributing factors associated with developing anterior knee pain. Identify at least two proximal mechanical influences contributing to patellofemoral pain syndrome. And design an evidence-based rehabilitation program for the patient with patellofemoral pain syndrome. So we'll start with a little bit of an overview first, so this is one of the most common knee disorders. Makes up about 25% of all knee diagnoses that are gonna be seen. Tends to be more common in females than in males. Not to say that men won't have patellofemoral pain, but we do see it more often in females. It's a common complaint after ACL or meniscal injury and we'll see discomfort there, even after surgery as well. One of the most
frequent injuries in runners. Certainly knee injuries in runners is very common and then general anterior knee pain. A lot of the mechanical things that we'll talk about today, we can see in our active population. It's an interesting pathology because we can see it in sedentary folks that have issues. We can see it in very active folks, like runners or other endurance athletes as well. A little bit on etiology. So tends to be associated with repetitive micro trauma. So some of the things to consider. General posture and alignment. Things that have been talked about in the past. Looking at Q-angle, which is thinking about envisioning a line from ASIS to mid-patella and mid-patella to tibial tubercle. It is essentially thinking about a valgus angle at the knee. Foot pronation has been talked about as well. We'll touch in more detail on a few of these things. Again, foot pronation can change the orientation of the tibia, and then have influence on the knee as well. In general, lower extremity biomechanics that can be driven by either muscle imbalances, tightness, et cetera, hip internal rotation, contributing to knee valgus. We see greater amounts of patellofemoral joint stresses as well. And then certainly, what many of us are focused on, with clinical practice every day, thinking about a lot of the neuromuscular factors which are what we're often working on, trying to modify in our patients.

So thinking about glute strength as well as quadriceps strength, general quad timing as well. Especially in folks that have any kind of swelling. Reviewing a little bit of the anatomy, starting with the bony anatomy. So the lateral femoral condyle actually provides a bit of a buttress. So, again, if we see instability it tends to be lateral in nature. There is a design there, a far as that lateral femoral condyle providing a bit of a buttress to control things. The trochlear groove may be more shallow proximally, so as, we're gonna have less bony stability in extension. As we move into flexion, we actually start to have more contact area and things become a little bit more stable. So certainly patients can have, I would say that the vast majority of people that we see are gonna have modifiable things that we're gonna be focusing on, but certainly understanding that many patients will, in fact, have some of these underlying structural changes as far
as having something like a shallow trochlear groove. It’s just gonna make the patella less stable. Also thinking about the general shape. So this is something that you may see in a radiograph report or other reports. Just a general classification. So you’re essentially looking as though it’s a sunrise view of the patella, which is generally taken with the knee in 30 or 40 degrees of flexion, sort of coming from behind, so as though you’re looking at the superior portion of the patella, as it engages in the trochlear groove. So a normal patella is number one, so you sort of see the normal shape and sort of displacement variation there. And then you can see some variations in the shape of the patella, as well as the position of the patella. You can start to see things become a little bit more lateral.

If we look at contact surface of the patellofemoral joint, again, remembering that there’s hyaline cartilage there, so on undersurface or retro surface of the patella, that’s gonna be the articulation with the femur. If you look at the medial facet, that’s broken down further into superior, middle, inferior and odd. Lateral facet’s broken down into superior, middle and inferior. And, again, I include these, just to understand that there’s variations in the articular surface. So you can encounter some of these things, if people do have patellofemoral joint degenerative disease. If they have cartilage wear they may have chondral defects, things like that. That it’s not just a pure, sort of flat surface that is, you can sort of see the general shape of the patella there as well. And as far as contact surface, as we think about range of motion or different positions. So at zero degrees there’s very little contact, so that’s when there’s the most amount of mobility or freedom of motion of the patella moving within the trochlear groove, which is part of the reason why, generally, when we’re assessing position and mobility of the patella, it’s gonna be done at zero degrees. As we start to move into flexion, there starts to become a greater amount of the patella that’s in contact with the trochlear groove, and you can also see different portions of the patella tend to have greater contact in different angles. Where this can be impactful is thinking about, obviously, as you get into higher degrees, there’s a larger surface area of contact. But also the specific area
of the patella starts to change. So if people have a chondral defect, or degenerative changes, and if they have symptoms from that, you know, the typical crepitus or catching or locking or just generally pain, the range that that's happening can give you a little bit of information as far as where that damage might be happening on the patella, and then that sometimes can guide us when we're giving recommendations for either activities to avoid or positions to avoid, or that might even be as simple as how deep they're moving into knee flexion with different activities, if they can control some of the things that they're doing, so that we're not potentially driving more symptoms with some folks. If we think about patellofemoral alignment. So this is a systematic review of 15 studies, I looked at six alignment measures. And I listed them there, as far as what they looked at.

So they looked at sulcus angle, femoral trochlear depth, patellar tilt angle, lateral patellofemoral angle, lateral femoral trochlear inclination and then tibial tubercle, the trochlear groove distance. And the whole point of putting this in is that what they found from this review is that patellofemoral alignment in a healthy knee is extremely variable. Again, I looked at normal subjects. So there's tremendous variability as far as the, quote unquote, normal anatomy or the normal variations that we might see.

So even though we talked about some of the variations that we might see, in patellar shape and other things like that, just realizing that it's a really wide spectrum. That it becomes difficult to attach any one of these things to somebody that maybe has symptoms at the knee, as far as here's the mechanical reason or the structural reason why that's happening. That there's a tremendous amount of variability across the board. Move away from the bony anatomy and talk a little bit about soft tissue. So we have passive stabilizers. In that category it's gonna include the patellar tendon. Remembering that the patellar tendon has more of a lateral orientation, from proximal to distal. That's part of the challenge that can create a laterally directed force on the patella. The lateral capsule is there as well. So within the capsule we have superficial
and deep fibers. The superficial run obliquely. They tend to be fairly thin and run from the IT band to the patella. The deep fibers originate from the IT band as well, and they run a little bit more transverse. You can see those in the picture that's there. Some will feel that the restrictions in those fibers can be part of what contributes to when we see folks that have a lateral shift or a lateral tilt in the patella, can be that lateral capsule and potentially the retinaculum that can be creating some of that. So considering the soft tissue structures. The medial capsule. So we’ve got the medial patellofemoral ligament, so the percentages that are there is the amount of the overall stability on the medial side, that these individual structures are contributing.

So you can see the bulk of the medial stability is from the medial patellofemoral ligament. And we’ll talk a little bit about the MPFL at the end, today. I’ll review some of the surgical options which are, you know, a little bit of a spoiler alert, the vast majority of patients are gonna do far better without surgery generally. It’s a smaller group of people that will ultimately have surgery with patellofemoral pain, but MPFL reconstruction is one of the procedures that may be available to some patients. There’s also a medial meniscal patella ligament, medial retinaculum, and then the medial patellotibial ligament as well. And, again, you can see that outside of the MPFL the other structures are providing smaller percentages of the overall stability. When we think about active stabilizers, obviously our quadriceps is critical, and when we think about the quads we’re remembering that there’s rectus femoris, vastus lateralis.

There have been some authors that have described as vastus lateralis oblique, or VLO. Certainly most of us have all heard about the vastus medialis oblique, that’s with the VMO, which is very important as well. And then the intermedius. Again, quads are functioning as a unit but, ideally, we wanna see activation of all the muscles and good timing there. So one of the things that we can see, that plays a role in this population, is oftentimes there can be inhibition of the VMO and oftentimes that will be driven by low-level effusion, some swelling in the knee that will inhibit some of those fibers. So
once that changes, now the overall activation of the quads is gonna be influenced. So, in that study that’s obviously old now but, I think, still is important to remember, that as little as 20 to 30 cc’s of fluid, of effusion, can inhibit a quad. So, you know, that's not a tremendous amount of fluid and I would argue that that may even be, there may even be an amount that may be difficult to appreciate, through palpation or observation, and maybe even with girth measurements, that often can be enough to create inhibition of some of the muscles. And I think, for many people, because of where the fluid ends up being, the VMO seems to take a big brunt of that, as far as the area that’s inhibited. So part of that problem is now you’re gonna alter, ultimately, the forces acting on the patella, when the quads contract. So this is looking at sort of just a schematic of the active musculature, so as we break down the quad the direction of force, when those individual muscles are working.

So the resulting force is a superiorly directed force on the patella. Because part of that is you can see the angle of the lateralis versus medialis versus VMO. So when they all work together we actually have, you know, a relatively symmetrical force. But you can start to envision that if there is portions of that, so if we just think about the VMO being inhibited, potentially, from that swelling, ultimately, now, the resultant force that the quads are putting on the patella becomes more lateral in nature. Which can contribute to sort of orientation, it can contribute to symptoms, et cetera. So which is where, you know, a lot of the discussions and things have come for a long time, as far as the tracking, and what’s influencing the patella. So there’s a number of things to consider. And certainly quad strength, quad activation, can be part of that. Important to note the VMO is originating off the adductor magnus, and we’ll talk about some, you know, potential misconceptions that we’ve seen with intentional interventions, to try to address the VMO specifically. But in that angle that it’s inserting, that oblique angle between 45 and 65 degrees, so, again, it’s giving some active stabilization on the medial side of the patellofemoral joint. So, again, if the VMO isn’t working well or doing its job, we’re relying much more heavily on the medial passive structures, like MPFL
and some of the others, to try to keep things in a good place. A little bit on biomechanics here. So the primary function of patella is to facilitate knee extension. It basically creates a lever system that allows it to be more mechanically efficient. So the patella, and you can see in the schematic there, increases the lever arm of the extensor mechanism. So the force of the extensor mechanism is increased by as much as 50%, by the presence of the patella. In other words, if somebody were to have their patella removed then you're losing that mechanical advantage.

So you're essentially losing some of the typical force that's gonna be generated there. And I've practiced long enough that I've actually had two patients, over the years, that ultimately had such significant pain and didn't respond to conservative treatment, had had multiple surgical interventions, that had a patellectomy, they had their patella removed. Which is really not a procedure that I think should be considered for most people. And both people that I saw had had significant challenges from that. 'Cause, essentially, we know that knee strength and quad strength is important, so taking a patella out actually makes it far more difficult for the quad to do its job. Both of the folks that I had seen had had really significant structural changes in degeneration to the articulation, the chondral surface area of the patella, and that's part of where the decision came from.

But just keep in mind, I'm not sure if other folks have seen that as well. It's not a super-common procedure but the patella is there for a reason, for sure. Again, normal kinematics. It's what's referred to as a lateral C, so the, because of the shape of the patella and the shape of the trochlear, the glide is slightly lateral throughout the range, and that's typical. It moves medial 45 to 18 degrees, and laterally from 18 to zero, and that's typical. Again, we're trying to avoid or identify folks that are gonna be much more significantly lateral, that may be at risk of subluxing. Similarly, with tilt, it's slightly lateral at rest, and then moves medially about five degrees, as the knee extends. So if we think about pathomechanics, so some of the things that we're talking about in
abnormalities, we can envision or think about greater or higher joint stresses, and that can lead to cartilage wear. So one of the things to consider is remembering that cartilage is not innervated, so there are no nerve endings. Because it's aneural, we need to think about so why does it hurt, right. So you think about this component where we're getting more load at the joint. That may be advancing the wear and tear to the cartilage, and certainly can be responsible for some of the mechanical symptoms, but if there's no nerve endings there then that shouldn't be painful. But obviously these folks can have significant pain.

So what often will happen is, as the cartilage wear becomes significant enough and you're actually getting low to the subchondral bone, the subchondral bone has significant nerve innervation. Significant nerve endings. And that's often where the pain comes from. So, for me, one of this is, one of the critical things that I'll explore with patients is when I either hear or feel crepitus or when they complain about it. Again, crepitus is our word for it. Patients will complain about snapping, cracking, popping, and things like that. So any of that noisy component, the first question I usually ask is is there pain with it. Because painless crepitus, in general, is generally a little bit less concerning to me than painful crepitus. That may be a sign that you are starting to get some wear and tear within the joint, but it also gives you a little bit of a sense of how significant that it might be. That if there's pain then you've likely worn at least portions of that down to the subchondral bone, or there's at least fissures there where the subchondral bone is being loaded, and it's that load to the subchondral bone and the irritation to the nerve endings that are there, that will create some of that discomfort, okay.

As far as traumatic required, so if there hasn't been trauma, certainly thinking about presentations being bilateral. Oftentimes, especially as we look at the typical presentation within patellofemoral pain, one side may be worse than the other and one side may be symptomatic, but if you look you'll often have findings on both sides, as
far as imbalances or other components. So something that we wanna think about exploring and assessing both limbs, as we're looking at patients. So if we look at predisposing factors, some of the things they talked about in different studies. So gender. 13% of women between 18 and 35 will experience, at least from this one paper, will experience patellofemoral pain syndrome. So, as I mentioned earlier, we definitely tend to see this more frequently in females, and certainly in our younger females. Not that it's an exclusive club but it's generally a common population. Body weight can play a role as well. Obviously we're thinking about something happening at a joint, so as there's more load there's potentially more load on tissues as well. Thinking about activity level and then the activity itself. So activity itself is, is it an activity that's putting more load on the knee, more joint compression forces. Is there impact involved? And then the activity level. Thinking about, maybe the activity is running but are they running two or three miles or are they running 20 miles. Are they biking five miles or 50 miles?

Same thing, playing a sport. Are we talking every day versus periodically. Because I think, for many people, with a lot of the pathologies that we see, certainly in the lower extremities, thinking about just overall volume of activity, that rarely is it the activity just by itself, right. There's not many activities, even though people might think about, have negative thoughts towards running, there really hasn't been things that have shown that running, alone, is what leads to joint breakdown. It's usually other injuries that then perpetuate. But thinking about just the level of competition, the level and the overall volume. Biomechanical alignment as well, and we'll explore a little bit throughout the talk today, factors throughout the entire kinetic chain that can sort of change mechanics, change walking mechanics, change how we're moving, going up and down stairs, et cetera, that can potentially start to put excessive load on tissues, and then that can start to create discomfort in folks. So if we look at risk factors, some of the bigger things that have been talked about, for many years. So excessive foot pronation has been discussed, so Dave Tiberio was one of the first people, in the 80s, to start
talking about this. So with foot pronation we see tibial internal rotation, which will typically lead to femoral internal rotation. So as we’re getting those components, the femur is moving underneath the patella, so that can start to change the orientation. That may change how load is distributed, et cetera, at the patellofemoral joint. Muscle imbalances. So the VMO, we’ve talked about a little bit already, but the VMO gets a lot of press and has for many years. I think one thing that’s important to remember is that the quads are functioning as a unit, right. We’re not trying to isolate individual muscles. We want there to be balance.

And if you think about the schematic that I showed as far as the resultant force, and things like that, and we see that in other areas. We see that with rotator cuff and other parts of the body where those force couples become important. All the portions of the quad working as a unit, together, is what creates the normal mechanics at the patellofemoral joint. So if that’s impacted in a negative way, you know, by alteration of activation or something else, then you can start to have changes. So, again, looking at having that balance and the timing. I think one of the things that I see, fairly often, is when, again, people have some of that underlying irritation or swelling, and that swelling inhibits the VMO.

Yet when people are contracting their quads they may still have good strength, but the medial side of the quad, the VMO, may be delayed in activation, or it’s firing a little bit later. So I think that can be the challenge. So oftentimes it’s not so much that a specific muscle is weak and has to get stronger in isolation. But we need to address the underlying cause of the swelling that’s potentially creating some of that inhibition. Decreased knee flexion angle. So we see this a lot, especially with endurance athletes. So runners, in particular. So that’s gonna have, it’s gonna lead to a decreased contact area of the patella. So that can, by itself, sort of impact general forces and how things might be progressing. Other risk factors. So this was a prospective study that looked at 3D motion analysis of female runners. They then followed those runners for two years.
and then they pulled out the group that developed patellofemoral pain syndrome, and what they saw in that group was they had four degrees more peak hip adduction compared to the matched controls. So, in other words, you know, that dynamic valgus that we all see and appreciate, as the hip is internally rotating and sort of adducting and we’re getting more of that load, that’s certainly gonna be something that will potentially lead to anterior knee pain. And if, even just looking at that picture, if you can kind of just envision the patella that’s just sort of floating on the top or above the trochlear, so as the femur starts to move oftentimes the patella is gonna end up some place that it’s not really designed to be.

And obviously one of the biggest things that we’ve seen in literature, over the last decade plus, has been hip muscle imbalance. And certainly with patellofemoral pain, but certainly other knee disorders, I would even say it really, it should be a consideration for almost anything that we see, as far as disfunction in the lower kinetic chain. Again, thinking back to general lumbopelvic core and hip and glute stability, to control the position, right. It’s this concept that, I think, we kind of forget about a little bit in the lower extremity, but, you know, it applies in the upper and lower extremity, that we need proximal stability for distal mobility. For us to do things with our hand and wrist, we need stability at our shoulder, right.

Otherwise things can’t function very well. Same thing, for us to have distal function, as far as what our foot and ankle and knee is doing, we need to have proximal control. So some of that is in through, again, midsection core, lumbopelvic strength, but then glutes as well. So many authors have published on this, and this is just a small sample, as far as the importance of looking at gluteal strength, in particular. So hip abductor, external rotator strength, as far as that’s gonna play a role, oftentimes, in patients that we see. And just to talk about a couple of studies that have looked at that. This was a paper that looked at naval cadets, and they were exploring risk factors for developing patellofemoral pain. Among the things that they found, which have been included or
discussed in other studies as well, so decreased knee flexion angle, increased hip internal rotation during a jump-land task. In other words, when they're landing from a jump, that you're seeing more of that dynamic valgus. As the hip internally rotates you're usually seeing adduction with it as well. Decreased quad strength. So they saw as much as 12% less strength in the patellofemoral pain syndrome group. And, again, I think we spent a lot of time thinking about glutes and proximal control, but important to remember that knee strength, quad strength is critical as well. That we're not sort of ignoring the knee and just focusing on hip and glutes. Hip abductor weakness was actually not predictive. It was 3% less in the patellofemoral pain syndrome group, which is interesting, 'cause that’s variable. We certainly see that reported differently in some studies.

So some of that may be population as well. So just thinking about, you know, sex differences, potentially, that can be a factor, and making sure that we're assessing all of them, right. Not just assuming that it's only gonna be one thing. Increased navicular drop was something that they mentioned as well. Again, that navicular drop is giving us, is really a measurement of how much pronation somebody has, for folks who are less familiar with it. So the greater the navicular drop, usually, the more pronation. As we talked earlier, the more pronation that you’re seeing, you’re gonna get more tibial internal rotation, which now is gonna create, generally, more internal rotation of the femur as well.

So whether that's been driven from the ground up or the top down, I think there's opportunity for that to have influence at the knee. One of the things I say to my patients very often is that the knee often pays the price for faulty mechanics at the hip or at the foot. And part of that is if you think about the knee, it moves really well in sagittal plane. There’s some rotation, there's some frontal plane movement there, but predominately the knee moves in sagittal plane. Whereas if you think of your hip, or you think of your foot and ankle complex, those joints above and below the knee move really well in
sagittal plane, in frontal plane, in transverse plane. So if you end up having a problem at the hip, or at the foot and ankle complex, that’s in the frontal or transverse plane, it's difficult for the knee to do anything effectively to compensate for that, so I think, for me, in my mind, that's where I think a lot of the challenges come from, is the knee can't do much with or accommodate for some of the typical things that we'll see go wrong at the hip or at the foot and ankle, because it's outside of the sagittal plane, okay. So their conclusion, which I think is an important one, is that there’s a number of modifiable risk factors that are gonna contribute to patellofemoral pain syndrome, and that's really what we should be thinking about. Whether it's a prevention program, or obviously, as we get into rehabilitation as well.

Another paper that looked at runners with patellofemoral pain, and then they had matched uninjured runners. The variables that they explored were hip abduction, external rotation strength before and after the run. They looked at arch height before the run. They looked at lower extremity kinematic data, both before and after the run. The results that they found, so both groups displayed diminished strength at the end of the run, which isn’t terribly surprising. You would expect that, probably just from fatigue. Patellofemoral pain syndrome group had significantly less hip abduction strength, right, which I think is important, and a little bit different from what we saw in the last study.

But certainly, a number of other papers have talked about abductor weakness. And hip abductor weakness was associated with greater peak hip adduction angle, right. So if your adductors are weak, you’re now gonna have a tougher time controlling adduction. What was interesting here is arch height did not differ between the two groups. So part of my rationale for selecting the handful of studies that I’m including here is it’s obviously not exhaustive and there are others, but really just to highlight some of the differences or variabilities within the literature really show that, there’s papers that show that there’s contributing factors distally. There’s papers that show that there’s
contributing factors proximally. And what I hope, at the end of this, that, you know, one of the things that I can help get across is I think we need to be looking at the entire lower kinetic chain, when we're thinking about these folks. Because in one patient you may see more proximal, one patient you may see more distal, another patient you may see things going wrong everywhere. And in order to be successful I think that it all has to be identified and addressed, right. So they found that runners with patellofemoral pain syndrome group displayed weaker hip abductor muscles, which became more pronounced at the end of the run.

Which, if anyone is similar to me and I'd see a fair number of runners, this is an important thing to think about because, in a clinical setting, we're identifying potentially weakness, but important to remember that that's as strong as they're going to get. Or the strongest, not as they're going to get, the strongest they're going to be in that moment, right. So, in other words, if they were to go out and go for a run, over the course of that activity they're gradually gonna get weaker because they're gonna fatigue. So if we're seeing subtle weakness, in a clinical setting, and you've got somebody who's, you know, a half marathoner, is running, eight, 10, 12 miles, right, it may be that that weakness that's subtle, when we're testing them, gets far more pronounced as they're getting deeper into their activity.

So things to consider from an endurance standpoint as well. If we take a look at a few other risk factors. So Chris Powers at USC, his group researched extensively with patellofemoral pain syndrome. So they looked at females with patellofemoral pain and then they had pain-free controls as well. And what they found in the PFP group was greater amounts of hip internal rotation, which we've seen in other studies, decreased hip strength, and the way they measured that was general performance of hip extension, as far as number of repetitions, and they saw less pelvic drop repetitions. So essentially doing prone hip extension exercise and then hip hike exercise, one with fatigue setting in. They also saw greater amounts of femoral inclination. Now
remembering that that’s a bony change that we’re not gonna modify, so, again, most of the things that we’re focused on are things that we can modify, but understand that there will be folks that are gonna have changes in bone structure, that may be putting them at higher risk. That femoral inclination certainly impacts how the hip and the knee are functioning. It also likely changes the orientation of the glute musculature as well, which actually may be part of what’s contributing to that. And then this was a study looking at the difference of males and females.

So, again, I’ve shared a few of them with you, but there’s lots of studies that look, specifically looking at females and identifying glute weakness, and particular gluteus medius or hip abductor weakness, being related to patellofemoral pain. And so the question was, well is that true for everybody, right. Do we see that in men as well? And so the answer was not exactly, right. So this group that looked at that found that they didn’t see that hip abductor or external rotator weakness in the male subjects. They did see hip extensor weakness. So, again, I think it’s important to test, and I can certainly say, anecdotally, that I’ve absolutely had males with anterior knee pain that have had glute weakness. But it’s not sort of necessarily as pronounced or as common as we’ll see with females.

But, again, another piece, just to make sure that we’re thinking about all the potential contributing factors when we’re thinking about folks. It’s not quite just so simple as just giving everybody glutes need strengthening. This is a paper that was published recently in British Journal of Sports Medicine. They looked at 18 studies, so they, with all those studies that were lumped together, they had a pretty big number of participants that they essentially were able to include and they were exploring the risk factors to develop future patellofemoral pain. So some of the things they found, so quad weakness in the military population, in particular, 'cause there's been a number of studies looking at naval cadets, and people in boot camp, et cetera. Things that they didn’t actually see that were tied together were age, height, weight, BMI, body fat,
Q-angle, things like that, or hip weakness. Again, so this is an important thing, is that not every patient with glute weakness will develop patellofemoral pain. Certainly people that have patellofemoral pain may have glute weakness, but there's multiple contributing factors. So patient presentation, how are they coming in to see us. What's the typical presentation again. Far more common to see this in females than in males. Generally it's an insidious onset, so there may be a precipitating event that, sort of the straw that breaks the camel's back so to speak, but more often it's something that comes on and gradually progresses.

So the patient might talk about, well, you know, I started to feel it, you know, a few months ago, or even maybe a year ago, and as I've kind of continued to be active or keep doing things, it's gradually gotten worse. It tends to be fairly diffuse pain. It's not as often that it's a pinpoint localized spot. So more general peripatellar pain. Obviously, with most of our patients, the people come to see us because they've got limitations in function. They can't do things or things hurt, and that's what often drives patients to seek all of us out. And then quad or considering VMO weakness. Again, certainly we know that glute strength can be related. We know that quad strength, in general, knee strength, can be problematic. Again, my own views as far as VMO is thinking about some of that inhibition from the underlying effusion that can be there, that's now contributing to just general quad deficit. Again, thinking about that diffuse anterior knee pain.

Oftentimes people will complain about pain with prolonged sitting. So some people may have heard of or call this moviegoer sign, so, when people are sitting for a prolonged time, like anything about the length of a movie, or I would say that even when people are sitting at work or whatever it might be, for a long period of time, and the knee is just in a singular position, and then they go to stand up or move and then it's symptomatic again. I think some of that can be the amount of knee flexion that they're in. And the loading mechanics and sort of where their contact pressures are. So
generally increased pain going up and down stairs, getting up from a chair, especially if you've been sitting for a long time. There may be joint crepitus. Again, some of that wear and tear to the articular surface and sort of creating some of those snap, crackles and pops that our patients will talk about. Pseudo giving way. So really just means that they'll complain of a sensation of instability or they'll complain that it feels like it's gonna buckle or it doesn't feel stable underneath me. And I think, for many people, that's related to the mild swelling.

So lower level effusion that is gonna inhibit the musculature, may now correlate with it feeling like it's gonna buckle, or it's not stable, right. Which is different from having a true instability from ligamentous damage. It's more that the dynamic stabilizers aren't able to work. In the picture that you see there is really more just to kind of illustrate a point, right. We think about patellofemoral pain and anterior knee pain and that's just, it almost doesn't even matter what all of the things listed are, but they're all various pathologies or problems or diagnoses, that can create symptoms in the front of the knee. So there's no shortage of structural things that can happen that can contribute to pain. So the upside for us is that regardless of what it's being called, anterior knee pain, patellofemoral pain, we're often looking at the same things, right.

So what we're gonna call it at the end of the day may vary a little bit, patient to patient, but we're generally trying to explore and make sure that we're looking at very similar things. So within our examination now, some of the things that are gonna be relatively common. So I touched on Q-angle a little bit earlier. So that can be one piece. I will say, myself, Q-angle is not something that I routinely measure, at least not anymore. And that's not a pitch that if you do that, to force you to stop. For folks that are less familiar, Q-angle measurement is essentially going from ASIS to mid-patella, and then mid-patella to tibial tubercle, and the inner section of those two lines is giving you an angle. And obviously females are gonna normally be higher than males, mostly because of the width of the pelvis. So it's really more that as you're getting beyond
those sort of ranges, is when it’s abnormal. Because it’s creating more of a valgus moment at the knee, which can now have a negative impact to what the patella needs to do during normal function. For me, the reason that I’ve gotten away from measuring it is it’s a static measurement. The patient is typically laying on the table. So I will say that it’s not uncommon to find somebody that may have a static Q-angle measurement that would be considered within a reasonable range, but when you look at them move dynamically, like doing a single leg squat or a step down or descending stairs, that you see this really significant medial collapse. This combined hip internal rotation and adduction.

So, for me, I have gotten away from measuring static Q-angle but I will absolutely look at a, I think of it as a dynamic Q-angle, with one of those activities. Either watching them do a single step down or a single leg squat, something to sort of look at that. Admittedly, I’m not getting a number from that because I don’t have, at my disposal within the clinic, the technology to be able to capture that with cameras or 3D motion, things like that. But anecdotally I can look to see how significant that is and compare it side to side, and also see if there’s symptoms with it. Again, something to consider.

And it’s just making sure that if you are measuring it statically, that you probably wanna look at it dynamically as well because there’s an opportunity that somebody may not look terrible statically, but now when you watch them move, because of underlying muscle imbalances, you may see a more significant problem. Genu valgum, again, just in general.

So what we’re talking about is essentially dynamic valgus, because they can’t control. People can have genu valgum just as a structural change. Femoral anteversion. Some more of the internal rotation or internally rotated position of the femur. Tibial torsion is essentially the torsion or rotational deformity of the tib and fib. Some folks will call that malleolar torsion or malleolar position. It’s really all referring to the same thing. It’s just really sort of preference on name. Because, in truth, we’re not just looking at the tibia,
we're looking at tib and fib. So you can talk about tibial torsion. People talk about fibular migration and tibiofibular torsion, or malleolar position. All those things are kind of looking at the same thing. Is the lower leg distal to the knee, rotated? So do they have an in toe or an out toe kind of gait pattern? Also a lateral tibial tubercle. So the more lateral the tibial tubercle is, that's where the quads are attaching, right. So if it's more lateral, now you're gonna have a more laterally directed force on the patella, when the quads activate, or when the quads fire, right.

Again, so potentially thinking about all these pieces, but, you know, the one consideration that hopefully I'm able to articulate is looking at things dynamically, right. And I think what you do is gonna vary a little bit on what you have available in your setting, as well as what's reasonable for the patient, right. So I don't certainly have everybody do a single leg squat. I may have them do a shallow step down or look at them on the stairs. I think depending on what their symptom level is and what they might describe, as far as what's difficult for them. But I think looking at how they're moving dynamically is very important. Other exam findings, so restrictions in musculature. So muscle imbalances, in general, I think, are very common.

So looking at muscle tightness as well as muscle weakness. So assessing hip flexor length. Assessing hamstrings and quad length, et cetera. They can all have a contribution. Quad strength, again we've talked about that. So making sure that we're measuring, again, we'll talk a fair amount about glutes today but don't forget about the quads as well. And then the delay in the VMO firing. And, again, I think that that, for me, is how I think of that more often than having to do some isolatory exercise to try to strengthen the VMO. Oftentimes the quads are working but then everything's not firing together. So if there's a delay in the VMO, that now changes that, at least for part of the time, that resultant vector, of what the quads are doing to the patella. And Barton has done a lot of work. He's somebody that looks extensively at this population, and this was a paper in JOSPT a number of years ago, but looking at things at the foot and
ankle. So a couple of things that they’ve talked about, that other papers have looked at as well, is greater amounts of pronation and just, in general, greater amounts of foot mobility. Which, I think, for many patients, those two things go hand and hand. If you think, in general, of your hyperpronatory foot types, they tend to be more mobile, more loose and floppy, versus your supinatory foot types, or your higher arch foot types, tend to be a little bit more stiff and rigid, right. So I think that some of that pronation, you can see the picture there, a patient of mine, that you'll often see these things happening together.

So she’s got a fair amount of foot pronation, wider base of support, genu valgus. Some hip internal rotation as well. Again, a lot of the things that we're talking about sort of travel together in packs. So you'll often see this as part of the presentation. Another structural piece to look at is gonna be the patella position. So we can identify a position alta or a baja. Patella alta refers to a high-riding patella, and patella baja refers to a low-riding patella. So the quick clinical measurement of this, because we're not gonna have x-rays on every patient, is if you envision the distance from the superior pole of the patella to the inferior pole of the patella, compared to the distance from the inferior pole of the patella to the tibial tubercle, that should be a one to one ratio.

And you can see the differences there that, you know, if it's, the patella is significantly higher or away from the tibial tubercle, it's high-riding, and if it's closer to the tibial tubercle it's gonna be low-riding. From a functional standpoint, a high-riding patella is gonna be less stable, because the patient has to get into a relatively deeper amount of flexion, before the patella is actually seated well in the groove. So it's gonna be less stable for a longer period of time or deeper through the range of motion. Whereas the opposite will happen in a patella baja. Because it's sitting lower it's gonna take smaller amounts of flexion to actually have, potentially, more compressive forces. So, again, not something that we're gonna change, there would need to be a surgical intervention of some kind to change this significantly, but something to sort of understand. Again,
baja are folks that may be at a higher risk for joint compressive things, or patellofemoral joint load or maybe chondral wear. And patella alta are probably gonna be at a higher risk for subluxations or dislocations, because it's just generally less stable. I think it's important that consider differential diagnosis as well. Again, that one slide that I showed with the huge list on both sides of the knee of all the stuff that can go wrong. You know, some of the more common things that should be at least in your mind, at some point, as you're going through your examination, when we're kind of teasing some of this out.

So tendon pathology, so acutely tendinitis or more chronic presentation will be tendinosis or tendinopathy. Both are gonna be activity-induced, as far as comparing this to patellofemoral pain. So I think palpation is key. Again, if the tendon is damaged or if there's pathologic portions of the tendon, often we'll tease that out with palpatations. So if you're feeling areas that might be greater density, et cetera, that may be something to look at the tendon a little bit more, more significantly.

Osgood-Schlatters is a bony deformity at the tibial tubercle. So usually in our adolescence. Again, so differentiating with palpation. Again, is it patellar tendon or is it truly at the tibial tubercle. Is the tibial tubercle elevated? Certainly, if folks have had x-rays this can be seen on radiographs for sure.

Again, sort of thinking about that growth spurt in our younger adolescent patients, something to consider. ITB friction syndrome. So, you know, if they have more anterior and lateral knee pain, they could have some discomfort or irritation of the ITB insertion. Again, what I'll say, when you look at literature and you think about patellofemoral pain and IT band, is the abnormal or faulty mechanics that typically contribute is very similar between the two. So looking at components of proximal strength, muscle imbalance, et cetera. And, again, I think many people will kind of lump PFP, patellofemoral pain syndrome, IT band friction syndrome, just into a, almost like an ICF of anterior knee pain, right. So the true anatomic component may not necessarily be as critical as far as
helping people to get better. Meniscal or ligament pathology, typically we’re gonna try to rule out with special testing. Or also the mechanism, right. So if they have a traumatic mechanism, not just this insidious gradual onset, we need to think a little bit more about some of the damage to the meniscus or potentially ligaments. Certainly the special testing for meniscus isn’t great, but we can be fairly accurate with our ligament testing. If you’re thinking about ACL, Lachman, anterior drawer, et cetera. And then if we’re not able to reproduce things at the knee, with knee testing, is remembering that, you know, referred pain from L3-L4 is gonna send symptoms to the lateral part of the thigh.

So kind of this interior lateral knee distal thigh pain certainly can be related to the lumbar spine as well. So talking a little bit about each of these, so patellar tendinopathy. I think it’s important to differentiate between itis and osis. Itis, there’s an underlying inflammation that’s more acute in nature. So these are folks that will respond to anti-inflammatory medications, potentially iontophoresis and ice. They generally will do well, relatively quickly, as long as you modify the activity and fix the underlying impairments. So work on range of motion, flexibility, strength, et cetera, and very often people with true tendinitis get better pretty quick. I will say, in my own clinical practice, that I probably see true tendinitis less often. I think there’s probably multiple factors at work there but, for many patients, they develop an itis some place, and not just patellar tendon, just in general, and they think well, you know, I flared something up, I’ll take it easy.

Maybe I’ll take some medications. And oh it’s still bothersome, they see a physician, and maybe they get prescription medicines, and then now it’s a few weeks or months later and they’re still having symptoms. Well by the time many patients get in to see any of us, well maybe it’s not acute anymore. Maybe it’s more chronic. And as you transition out of that acute presentation, there’s a consideration for tendinosis. When you actually get more degeneration or microtrauma to the tissue itself that then, now
you're dealing with scar tissue and just a poorer quality, which is gonna be a different management. So more of an active warm up to try to stimulate blood flow. Potentially friction massage to break up some of those scar tissue formations. Certainly addressing impairments and stretching things like that, but then, with tendinopathy, one of the things that we see, not just at the knee, but in other areas of the body as well, is how critical eccentric strengthening is going to be to try to remodel that tissue. Osgood-Schlatters, again, they will present with anterior knee pain. It’s generally worse with running, jumping et cetera, and it’s more about the demographics of the patient. So we see it in adolescents, generally more often in boys than girls, and you can obviously see some of these are easy to see.

Certainly on imaging you can see it. But then even without imaging, if you see that pronunciation of the tibial tubercle. But, again, looking for this kind of thing. So is it actually around the patellar that hurts. Is it patellar tendon versus the tibial tubercle itself. I think that one of the things that I've, you know, throughout the years of my career, have worked hard to try to get better at all the time, is improving my palpation skills. So not just poking around to see what hurts but really thinking about what am I palpating. Am I just creating pain or am I palpating a different feeling within the tissue? Is it dense, is there swelling there, whatever that might be?

So I think, you know, the advice here is just try to be as deliberate as you can with your palpation, as you’re doing it, to try to tease out some of the subtle differential diagnosis pieces. IT band, again, all this is kind of in this anterior portion, anterior lateral portion of knee discomfort. Main functions of the IT band, stabilize the lateral hip and knee. It’s in a position to resist hip adduction and knee internal rotation. Important to remember that there’s both femoral and tibial attachments, which means that, theoretically at least, that if there’s abnormal things happening at the foot or at the hip, that can have an impact to the IT band. So, again, thinking about both proximal and distal contributing factors. IT band's been shown to be a very common cause or related
problem, with knee pain in runners and cyclists, and a lot of that stems from hip abductor weakness. Again, what I see with this population, so runners and cyclists are predominately sagittal plane functioning individuals, right. That’s most of what their activity is. So they tend to have bigger issues with frontal and transverse plane. So if you have somebody that’s essentially only doing sagittal plane activity, like all they do is run or all they do is bike, and they don’t do much in the way of cross-training, you may see imbalances, weaknesses, et cetera, in other planes, that can contribute to some of this. So, again, underlying hip abductor weakness. If the gluteus medius can’t do its job TFL will often compensate. And remembering, TFL is kind of now transitioning into our IT band.

So if TFL is working harder you’re likely gonna get influence or impact or tension into the IT band as well. And in folks that are endurance athletes, you know, any kind of abrupt increase in weekly mileage can have a negative influence as well. So asking subjective questions about has your training schedule changed. You see that in the northeast, where I am, the weather starts to get nice and people go from doing very little, and being stuck inside all the time, to now being outdoors and not having much of a wrap up, or people decide, well, I’m gonna train for this event, and now they start wrapping things up quickly. So, again, the subjective piece of our history becomes important to get some of those factors teased out. Some of the literature that’s looking specifically at IT band syndrome.

Again, we see very similar things to what I touched on already, with patellofemoral pain. So this is a paper that looked at running mechanics of females with IT band syndrome, compared to healthy females. The IT band syndrome group exhibited significantly greater hip adduction and knee internal rotation, which results in an increased ITB strain and compression against the lateral femoral condyle. So, again, their recommendations give treatment focusing on controlling secondary plane motions. Again, you can see the patient there that’s coming into that. You see a little bit of a
pelvic drop and then dynamic valgus, that hip adduction and internal rotation. So, again, identifying why is that happening, right, and for many people it’s gonna be some of the challenges with controlling things proximally. JOSPT in 2010, IT band syndrome group significantly greater hip adduction, angle and knee internal rotation angle. Again, so what are the pieces that we can think about driving that again. Very often that’s gonna be considerations for proximal weakness. As far as distal mechanism, and I’ve touched on this with, you know, throughout the discussion so far. This is where the literature’s a little bit more mixed, but I wanted to include this, just to give, you know, a little bit of background, and hopefully influence the way that you’re thinking about these patients, at least a little bit.

So different paper, so one, greater rearfoot inversion angle and heel strike. So if your heel is hitting the ground in an inverted position, typically, now, once you hit the ground, it everts further, which is gonna be more pronation, okay. We talked about the influence of more pronation. Greater tibial internal rotation throughout stance phase. Again, as we have more tibial internal rotation, that’s gonna be coupled with more pronation as well. Increased peak rearfoot eversion, that’s just referring to the amount of eversion that’s happening. Eversion’s always gonna be a component of pronation. But another paper looked at and found decreased peak rearfoot eversion, right.

So we’ll often see some conflicting evidence within this population, as well. And the last one kind of, with all that under consideration, I wanted to mention, because they found decreased eversion in the IT band syndrome group as a whole. But they identified a subgroup of patients that had excessive eversion, as well as high tibial knee internal rotation. So my purpose of putting this in, and what I hope that you take from this, is that does every person that have knee pain have a foot and ankle problem, or need a foot orthosis. And the answer is absolutely not. However, there is likely a sub-population of patients that have anterior knee pain, that may have contributing factors at their foot, right. So, again, this is part of my rationale for making sure that
we're looking, you know, somebody comes in with anterior knee pain, we're thinking about what's happening at the hip, the knee, as well as the foot and ankle complex, because very often we're gonna identify issues at all three areas, and I would argue in order for our patients to get all the way better, we probably need to not only identify it but address each of those, okay. Thinking about location of pain can play a role as well. So superior to the patella, typically quad tendinitis. Inferior, thinking about patellar tendon as well as infrapatellar fat pad. Remember that infrapatellar fat pad is sort of spanning the space on either side of the patellar tendon.

So, again, I think your palpation becomes very critical as well. Not just poking around but is there density and discomfort and fibers of the patella tendon, versus is it the rich nerve ending fat pad, which can be highly innervated and highly reactive. Lateral, so you can have changes in the lateral retinaculum. We talked about tight lateral musculature as well. You can have changes to the IT band. On the medial side we can have excessive stretching to that medial retinaculum, think about MPFL. Again, we'll talk about MPFL reconstruction at the end, but it's not just about the lateral side being tight or restrictive, but the medial side may not be doing its job. And you may not have stability on the medial side.

Retro, so symptoms sort of deep to the knee or behind the knee, so may have chondromalacia patella, which, I think it's diagnosed a lot but important to remember that to be able to truly diagnose chondromalacia patella, that's defined as a softening of the undersurface of the cartilage. So really it requires that it's being probed. So during arthroscopy. So I think we make some leaps when people have mechanical findings and crepitus and things like that, that there's likely some chondromalacia patella. Which may be the case, but just realizing that there may be other factors creating discomfort in and around that region. Subchondral bone stress. Again, if you have cartilage wear, and you're getting load to the subchondral bone, that may create pain, because there's a large number of nerve endings in that area and on imaging you
may actually see edema or swelling within the bone, because of that irritation. Especially if you see impact athletes, runners et cetera. So now that we’ve got some background we’ll start thinking a little bit more about treatment considerations. So conservative things that we’ll touch on, so exercise, bracing, taping, orthotic therapy, stretching, soft tissue work, activity modification. Again, all of these things have been discussed in the literature. We’ll review a little bit about that but, you know, I think the take home that I would try to put out there to you is that we have to really think about the cause, and not just the symptoms, right.

So people can have shifting pain all the time, they might come in today and it’s uncomfortable here, tomorrow it’s uncomfortable a little bit in different spot. But thinking what are the underlying contributing factors. And, again, thinking about the entire kinetic chain when we’re making those considerations. So I think being accurate with what we’re examining and what we're identifying. Oftentimes we're controlling or modifying activity. So I'm personally not a big proponent of eliminating things completely, unless it’s absolutely necessary or they’re gonna potentially cause greater damage to something. But modifying activity, you know. So controlling load, in the short term, as we're progressing or addressing impairments. Either if they’re weak or stiff or limitations in muscle length, et cetera.

And education as well. Making sure patients understand what’s happening and understand why something at their foot, potentially, or their hip, may be the bigger part of what’s related to their knee pain, right. It’s not uncommon that we'll have patients with knee pain that were working or doing very little directly at the knee. It may be sort of aimed at different areas, just because of what’s driving it. So I think it's important to make sure that we’re going through that, so patients understand. So when we think about, again, the recommendation, in short, is gonna be this comprehensive individualized approach, but as we kind of talk through some of the specific things that we’re thinking about, is in general, so strengthening but quad balance as well. And
thinking about VMO and VL firing simultaneously. I talked earlier about it’s not uncommon to see some of that delay, and I think a lot of that delay in patients is coming from underlying low-level effusion because of irritation, things like that, that’s now gonna be enough to inhibit portions of the quad. And it may not be so much that it’s creating lots of appreciable weakness, but it may just be the quality of the contraction, the timing of the contraction. So the VMO, as I mentioned already, has gotten a lot of press for a very long time, and there was a period where there was a lot of attention paid to the knee to strengthen the VMO, to isolate the VMO, so I wanted to take a minute just to review some of that work, because I do think that we still see some of these things being done.

And hopefully talking through a few of these things will give you some things to consider or give you some pause when you’re doing some of this. So there was actually higher VMO activity in this one study, in PT Journal with quad set, than any other open kinetic chain exercise. So, again, some of the things that we see, and you can see them in the pictures there. So people doing straight leg raises with leg and external rotation, to try to bias VMO. I mentioned earlier that the VMO fibers come off of the adductor. So there have been folks that have advocated for firing the adductor. So, in the picture to the right, squeezing a ball of fired adductors and then doing a squat, to try to bias VMO as well. Again, another paper VMO activity during quad set was greater than a straight leg raise. Other folks have looked at dynamic activities like doing step ups in various positions.

Again, that same principle is what you see with the straight leg raise, that well, if we externally rotate the limb then we'll get more VMO activation. This paper in PT Journal, again, some of this work is older but I think it gets missed a lot and people often perpetuate some of these things. No difference in VMO to VL ratio by doing step ups with different degrees of rotation. VMO to VL ratio during squat leg press. Knee
extension with and without simultaneous hip adduction. No difference was noted. And with the thing specific to firing adductors, you know, I would make the argument that even if that did help turn on VMO, the problem with that, if you think about that from a faulty position standpoint. As you're squeezing something between your knees you're encouraging a valgus angle, and that's part of what we've been talking about that is often the underlying problem with so many folks.

So I think it's important that we're trying to be thoughtful with what pieces that we're actually integrating. And also that there's probably not a great need, even if we could, I think one of the things I talk to patients about, is even if we could isolate the VMO, which some of those papers that we just went through, I would say, have shown that that's not the case, I'm not sure that we need to or want to, right. We need the quads to be strong as a unit. We're not trying to bias the VMO. There's not a specific range that the VMO is 100% responsible for. I think, if anything, it's a component of if there's effusion. Again, I know that I've said this multiple times. If there's effusion, you may have this inhibition because of that fluid. So it's probably more of a sign that we need to address that component, so to make sure that the entirety of the quads are working and functioning appropriately. From a stretching opponent, so certainly rectus femoris. IT band. IT band, by itself, isn't gonna lengthen, but IT band is attaching to portions of the lateral retinaculum.

So as IT band is taut or pulled, because I would argue because TFL is working harder to make up for gluteus medius not working hard enough, that can create some tension or tugging at the lateral soft tissue structures around the patella femoral joint. Hamstrings. So thinking about knee flexion contractures. As we're deeper in a knee flexion, patella's engaged in a trochlea so that may distribute or put more load into different angles, potentially more load to the cartilage, more wear and tear to the cartilage. Gastroc-soleus as well. So we've talked about foot pronation as being a factor, and tibial internal rotation. So when the gastroc-soleus group is restricted that
limits ankle dorsiflexion, which a common compensation will be to pronate excessively through the midfoot. So, again, that pronation, which is a compensation for tight calf restriction in the gastroc-soleus complex, may be leading to alterations at the patellofemoral joint as well. So, again, another advocacy point to think about the entire lower kinetic chain. Biofeedback has been discussed and used, again, to try to target and restore the balance between VMO and VL. So, you know, the biofeedback can give you their visual and or auditory feedback, as far as the level of firing. So from a retraining standpoint, that can potentially be helpful for patients. Bracing and orthotics. There’s countless braces and things on the market and I have no relationship or information to disclose relative to the company Breg.

Nor is this an endorsement for the product either, but more just an example that there are several different braces available, and you’ll see things as simple as a neoprene sleeve or a neoprene sleeve with a cutout for the patella. The brace that you see there has a lateral buttress, where it’s trying to control the position. Again, I think, oftentimes the braces are trying to keep the patella at home. And I think that for some people, that may be a structural problem that maybe helps with the brace. But I would say, in my own personal experience, that many people, this is a dynamic issue that's not related to the bony structure. But rather a dynamic issue that the brace isn't gonna fix. So I think keeping that in mind.

So the take home is I don't think every patient needs a knee brace. And foot orthosis, I don’t think everybody needs a foot orthotic either. I think that foot pronation may be a contributing factor in a sub-population of patients, but even if that's the case, I don’t know that it's ever gonna be the problem, right. I think people are gonna have other things. They're gonna have quad weakness, they're gonna have muscle imbalances. They're gonna have core or glute weakness, et cetera. So, again, it’s not, I think many studies look for the silver bullet. Like oh, anterior knee pain, everybody gets an orthosis, or everybody gets a knee brace. We need to be a little bit more nimble and
more dynamic with our approach, and far more individualized as well. A few things as far as treatment. So Dave Lake published this paper where they looked at ice, ultrasound, phonophoresis, iontophoresis, EMG biofeedback, NMES, as well as standard E-Stim and laser. They found 12 randomized control trials that met their inclusion criteria within the review, and this is directly from the paper and none of the therapeutic modalities reviewed had sound scientific justification for the treatment of PFPS, when used alone. Now that's an important piece. That's not a statement saying throw away all your modalities. I would say it is a statement that, if you're gonna use modalities that shouldn't be all that's happening, right.

So there needs to be a specific thing that you're trying to achieve. And then realizing that you're doing other things on top of that. So I think we need to be careful when we're utilizing modalities in isolation, and looking a little bit broader than that. Thinking about regional interdependence, lumbopelvic manipulation. There's not a tremendous amount of work that's been done here, but they had 50 subjects, a mix of men and women. 45% of the folks had a successful outcome. And what they found, hip internal rotation, range of motion, assymetry greater than 14 degrees, the success improved to 80%. Again, this is not a validated clinical prediction rule. It's more the early stage of a paper, a far as looking at making, checking the validity of a clinical prediction rule. But, again, there may be a component as far as lumbar spine being related.

So if you're seeing some of that assymetry of rotation range of motion, certainly look at the lumbopelvic region to see if there's other contributing factors. Patellar taping has been utilized and talked about for a very long time, in literature. Again the goal of this is that it's an individual approach, and you're trying to correct the worst symptom first. So for those that might be less familiar, this is presuming that on examination we can identify a lateral shift or a lateral tilt or rotation of patella, which, in some patients, at least for me, can be challenging, if they have a lot of adipose tissue or if they have some swelling, can be a little bit tougher. But if we're doing a taping technique to try to
correct for something or control for something, ideally that taping should improve symptoms relatively quickly. It's not something that's gonna take several days or weeks to sort of kick in. Jenny McConnell, who's done a lot of work in that area, talks about an asterisk sign or basically reproducing the symptom. So let's say that somebody has pain with stairs or doing a step down. Well then you would do the technique, the taping technique, and then have them do that activity again, and ideally you wanna see that maybe not eliminate pain but make it significantly less, to determine if you've been successful or not. A few papers that have looked at this. Radiographs to determine impact of tape on patellar position. So x-rays are done before taping, after taping and then after exercise. They did see medialization of the patella, after it was taped, but that position was not maintained after exercise.

Another paper, no change in patellar congruency post-taping. Patients did note a 50% reduction in pain with taping. So the initial premise, with taping, was that we're changing the position of the patella, so this must be a good thing. And that must be what's happening, because people feel better. What imaging has shown, with many of these studies, is that yes, people feel better. But we're actually, the patella's not staying where we're trying to put it or where we think we're putting it. But yet people feel better, so there's a component to that. So it still may be a consideration. This paper looked at a standardized exercise program and then exercise and taping. Looked at torque, EMG activity, and then severity of pain. Both groups got better. No significant difference between the two groups, as far as folks that were taped versus were not taped. This was another early stage clinical prediction rule, as far as who can we identify that's gonna benefit from taping. They did a medial glide technique, which is essentially trying to move the patellar from a lateral position to more of a natural or, you know, more medializing it. Their criteria was immediate 50% reduction in pain or moderate improvement on the global rating of change, or the GROC. That was what was considered a success. Two exam items that predicted success with taping was a positive patellar tilt test, which is really assessing the restriction in the lateral
retinaculum. So do they actually have a patellar tilt, in other words, the lateral portion is more approximated to the tibia than the medial side. And tibial varium greater than five degrees. So when they factored those two things in, probability of success went from 52 to 83%. So something to consider. Again, I would say that probably not every patient needs to be taped, and there may be some of this literature that can help guide us, as far as who should be. Foot orthoses.

Some of the literature that looks specifically here with patellofemoral pain syndrome. Custom orthoses that were fabricated with rearfoot and or forefoot posting, that was determined by the exam. So this first study found that foot orthoses were effective in relieving PFPS in young patients. Another study that was in JOSPT, small sample but they all had calcaneal eversion in bilateral weight bearing. Custom foot orthoses. They followed up at two weeks and three months. They found the improvement in pain, stiffness, physical function for patient with PFPS, that demonstrated excessive pronation. Again, so does everybody have a problem with their foot that needs an orthosis, probably not. But, again, I think it’s something that we need to look at to make sure that we're catching the patient, that that's a contributing factor.

This group looked at, again, trying to think about clinical prediction. 50% reduction was what their foundation for a success was. Best predictors of improvement, forefoot valgus greater than or equal to two degrees. Great toe extension less than 78. And navicular drop less than three millimeters. Again, this is not sort of progressed through the vetting process or extensive study process, to be a validated clinical prediction rule. But, again, thinking about these components and that we probably should be looking at, at the foot. We'll spend a little bit more time talking about proximal considerations. There's probably been far more literature, as far as in support, where I think that almost across the board, this is something that we need to think about. This was in JOSPT that looked at hip strength on sedentary females, with and without patellofemoral pain. So what I want you to focus on, you know, is just in general. So
what you have is the muscles that they’re looking at and then the strength with the
range or standard deviation for controls. Unilateral patellofemoral pain. Bilateral
patellofemoral pain. If you look at the abductors, the strength and the controls, 14.6.
Unilateral PFPS, 11.7. Bilateral down to 9.6. Again, you know, this is a common finding
you’ll see in other papers, that people with patellofemoral pain syndrome often will
have hip abductor weakness. So certainly consideration is something to think about, as
being part of our exam, and then likely something that we wanna include within our
treatment interventions as well. This is a paper that looked at adding hip strengthening
exercises to knee strengthening and stretching.

And they found that to be successful. The subjects had better LAFS scores, so lower
extremity functional scale and decreased pain. And they focused on external rotation
and abduction. This paper in AJSM, so eight week rehab program focused on the hip
and the core. Significant improvements in pain, functional ability, external rotation and
abduction strength. So there’s no shortage of literature sort of looking at integrating hip
glute core strength with this population, especially in females. Another study here, they
had an exercise group, and then a control group that did not do exercise. They did hip
abductor and external rotation strength three times a week for eight weeks.

Strength group decreased pain, improved WOMAC score, so Western Ontario and
McMaster’s. So it’s a knee function self-report measure that you see with knee pain.
And increased bilateral hip strength with handheld dynamometer as well. This paper, I
thought, was good. It looked at a lot of exercises and I’ve teased out just a few in the
was a side plank, with abduction, dominant leg down, you can see the percent and the
IC, and then the ranking there. So I just, I included the top three exercises here. And
then side plank abduction with a dominant leg up. So that's obviously a very
challenging exercise, either way, right. So they're in a side plank and then abducting
the leg that's on top. So that's likely a progression, right, so many of our patients aren't
starting with that. And then a single limb squat provided pretty significant glute activation as well. One important thing to remember is that the subjects in this study were healthy, so they didn't have any knee pain. And they were young as well, right. So, again, keep that in mind when we're looking at some of this literature, that just because there's an activity that has high glute activation doesn't mean it's gonna be an appropriate activity for our patients. We have to make sure they're doing the activity correctly. Ideally, hopefully, with little to no pain, and that they're doing it with proper form as well. Looking at hip extension or glute, the importance of hip extension with glute med firing.

So they included four different types or variations to a clam shell exercise. So what I wanted to show, and this is kind of in reverse order. So just a standard clam shell exercise, so sideline, hip and knee flexion, and just externally rotating, was not highly ranked. There was a lot of exercises and it was, in fact, below the 50% threshold, which is usually what's identified as kind of the bare minimum, to be able to, quote unquote, be working on strength. Reverse clam. They’re in that same position but moving through internal and external rotation. And then progression from that. Their third position was the limb is abducted, so basically holding in abduction and then externally rotating there, and that you start to see an increase now in the IC. So that knocks involuntary isometric contraction. And then in abduction and extension was the highest, right.

So now, if you imagine the patient lying, side lying, the limb is abducted and extended back. So the reason I include this is that I would put forward that the position of the limb, in sagittal plane, becomes important for muscle activation. When the hip is in flexion, oftentimes we’ll see activation of TFL. When we come into more extension, I think we can get a better bias of gluteus medius, and that’s, I think, part of what’s being seen here is that as the MVIC is increasing, you’re seeing decreasing amounts of hip flexion. So just keep that in mind. I think some of this I included, really just to kind
of make sure that we’re thinking about form in general. That same paper looked at glute max as well. So looking at high performers for glute max, right. So glute med gets a lot of well deserved attention but glute max is important as well. So front plank doing hip extension was a high performer. Again, that’s another challenging exercise. But if you look at what came in second place, a glute squeeze, right. So just an isometric contraction. So, again, when you’re thinking about your patient, certainly the temptation is to have everybody do the highest performing exercise, but remember what might be second may still be very effective in building strength, and may be more appropriate for the level that our patient is on. And then you see side plank and single limb squat were effective in helping glute max as well. We saw those in glute med but you see it with glute max as well.

And that’s the take home of this last slide, is looking at exercises, can we identify exercises that can give us more bang for our buck. In other words, do we have things that will do a good job of glute med and glute max together. Right, so and that’s what’s listed here. So front plank with hip extension. Side plank with abduction, regardless of the dominant leg being up or down, and then single limb squat, all had relatively high MVIC numbers for glute med and glute max. I think as long as there’s appropriate exercises for your patient, I think this can be helpful because now, you know, rather than picking the three best glute knee exercises or three best glute max exercises, and people having six, seven, eight, nine, 10 exercises to do, you know, if we can try to trim that down and give them a smaller amount of things that are gonna be very focused, that can get more bang for your buck, so to speak, that you’re getting multiple regions or multiple muscle groups that are important to you, as a clinician, without having to, you know, carve out huge chunks of time during the day. For me, that’s been something I think has been helpful in improving patient compliance with home program. And Dave Selkowitz is a PT and a researcher who’s faculty at Mass General Hospital’s Institute of Health Professions, and has done a lot of really, in my opinion, really nice work, and nice papers that have been published, looking at muscle
activation and looking at it with PFP patients as well. So they’re looking at glute med and superior glute max and, again, I think in important work here, while trying to minimize TFL. 'Cause, remember, that TFL and glute med are in a position to abduct the leg, so if you’re just looking at abduction it’s hard to know how much of that’s glute med versus TFL, and I would argue that ideally we want a bias glute med. So he did fine-wire EMG, looked at 11 different exercises, and they’ve calculated a glute to TFL index for each exercise. In other words, not just looking at max MVIC, but what were the exercises that preferentially activated glutes and preferentially minimized the activation of TFL. So if we look at the top performers for that glute to TFL activation.

So the clam shell, and they did a standard clam, but important to note, I think, that it did have resistance. They did it with TheraBand. They did a sidestep exercise that had resistance as well. So a band loop around the ankles. And then unilateral bridge and then two exercises in quadruped, so hip extension, one with the knee extended, one with the knee flexed, okay. So if we look at glute med, we’re basically looking at exercises that other studies have talked about. So, again, these were exercises that were not their top performers. So side lying hip abduction and hip hike, right, which other papers have talked about as far as hip abduction being a great exercise for glute med, and hip hike being a great exercise for glute med, which, if you look, they are. So if you look at just the activation, let’s see if I can get my, try and get my arrow, there we go.

So if you look at the glute med numbers, right, for both of those, they’re actually quite high, right. But the downside with both of them is that they had high TFL activation as well. So, again, for me, this isn’t a rationale to get rid of those exercises. For me, I think, it’s important that we look at the position. So they did their hip abduction with the leg against the wall, so they’re trying to stay in a neutral position so not flexing. I typically advocate the patients to move into a little bit of extension, to try to minimize the TFL activation. Hip hike, same thing. If you don’t control for the position of the
trunk and the patient’s leaning forward, then I think you can get some bias there as well. So, again, the take home is that these exercises, I think, can be very good for glute med. We can see that in the MVIC numbers. And I think there can be form or positional things that we can focus on, to try to minimize that TFL activation that arguably would be helpful. You know, I think that this is a great study, and one of the first ones that really looked at, especially with fine-wire, that looked at the influence of TFL as well. So a great study and I would encourage you to read it if you haven’t seen it, but they looked at healthy subjects so it’s hard for us to know would people with knee pain, or PFP, or other problems, sort of function the same way. Clam and sidestep both use elastic resistance, so that may have increased the EMG amplitudes a little bit, so that may be throwing the numbers off some.

And they didn’t look at glute min, they looked at super glute max, glute med. You know, glute min is smaller, obviously, but it does make up 20% of the abductor cross-sectional area. So that may be something to think about for future studies as well. Looking at the clamshell exercise in general. So this is a paper in JOSPT that healthy subjects, surface EMG. They looked at the position of doing it. Essentially looking at the pelvic position. So basically looking at the pelvis being in neutral, versus being in a rotated position. They found better glute activation when the pelvis was in neutral. Better glute med activation with 60 degrees of flexion.

And important to note that TFL activation was relatively low across the board, which we saw in Dave Selkowitz’s study, that the clamshell exercise, there was relatively low TFL activation there as well. Barton Bishop looked at glute to TFL muscle activation as well. So clam with resistance and clam without resistance were some of the higher performers. So you can see glute max, glute med and TFL. Again, so this ends up being, you know, I think a great exercise to introduce, thinking that we wanna try to maximize glutes and minimize TFL. Other papers that have looked at proximal strength. So where we put the band, if we’re doing resisted work, is important. So this was a
group that looked at bands being around the knee, around the ankle and then around the forefoot. As we move the band more distal, with a sidestepping exercise, we get better glutes versus TFL. At the forefoot, in particular, because that’s now likely encouraging some external rotation, that helps bias glutes and get less TFL as well. Again, so some consideration, again, and that may not be appropriate for some patients because obviously the more distal it is the longer the lever arm, it may be difficult. Or you may need to think about a lighter band if you’re gonna do that. But if we’re trying to diminish TFL activation and increase the deep external rotators, then having it around the forefoot, I think, can be helpful. And this was a paper that looked at different positions as well.

So resisted sidestepping in an upright position, as well as in squat positions. They looked at EMG of glute med, glute max and TFL. EMG was greatest in the stance limb, which I think we see that with standing hip abduction as well, ‘cause the muscles are working to stabilize the pelvis. Glute activity was better than TFL activity in a squat position, which is probably a little bit more functional as well. Again, with that squat position, that’s probably a little bit closer to what we see with some of the clamshell exercises as well. This was a paper that looked at surface EMG of glute max and glute med. They did weightbearing and non-weightbearing exercises. Weightbearing, they did a forward step up and a lateral step up.

Non-weightbearing, so 10 rep max, prone hip extension and side lying hip abduction. And they found, oops sorry, I’m gonna jump back. They found relatively high activation, higher activation in the non-weightbearing exercises. So part of the reason that I include this is that oftentimes we sort of have this thought that, well, so we start with open chain or start with, you know, table exercises, and then we sort of get away from that. Which, from a functional standpoint, I think is important, but from a muscle activation and sort of, you know, working on pure strength gains, the non-weightbearing sort of standard exercises, open kinetic chain things that we can
do, again, this study did prone hip extension, side lying hip abduction for glute med and glute max, I think still continue to have a place. So I think that’s important to consider as well. So it’s not that we have to do one or the other. You know, I think that from my personal practice, I’m trying to integrate open chain and closed chain things throughout, as long as the patient’s able to tolerate it. I wanted to include this as well, thinking about form and posture. I think that becomes very important. This was a study that looked at glute max and hamstring activation, doing a prone hip extension exercise, in various degrees of abduction.

So patient’s prone and the knee is flexed to try to minimize hamstring, and they’re extending the thigh, extending the femur. So what you see is glute max activation increases and hamstring activation decreases, as the abduction angle is greater. And I think part of that, and why the picture that’s there is there, is as we come into 20 or 30 degrees of abduction, the limb is in line with the glute max fibers, which is probably preferential over the hamstring. Flexing the knee helps deactivate or diminish the power that the hamstring has. So, again, if we’re trying to work on glute max, thinking about that we’re trying to not allow the compensatory hamstring activation to happen. So flexing the hip and abducting the leg can be one thing that will help us achieve that. I think that can be important as well. This group, in 2018, looked at hip strengthening with and without knee strengthening. So systematic review with meta analysis. They looked at randomized trials or control trials. They ended up with 14 that met criteria. Hip and knee strengthening was found to be effective in superior to knee strengthening alone, right.

So integrating both hip and knee strengthening is not sort of a ground breaking take home. What was interesting is that they found decreased pain improved activity, but there was no concurrent change in strength. So they did strengthening exercises at the knee, at the hip, but they actually didn’t see a significant change in their strength. So the take home, or the assumption there, is that this is likely having an impact on the
patient’s motor control, or their overall movement pattern, which is gonna be important as well. I wanted to touch on blood flow restriction, because I think it’s gaining a lot of influence and notoriety. Obviously there’s more work being done and more papers that are coming out all the time. This is a, in the British Journal of Sports Medicine, randomized control trial. They had 69 subjects, so standard group and a BFR group. They did eight weeks of leg press and leg extensions. So the standard group, they exercise at a 70% of one rep max. The BFR group, 30% of one rep max.

So very briefly, for those that are less familiar with blood flow restriction, is it’s a tourniquet that’s restricting blood flow and it’s, the goal is to try to increase strength, making significant strength gains with less load, so less weight or less resistance. The BFR group had a 93% greater decrease in pain with ADLS, at eight weeks. Similar improvement between groups of VAS, as far as their overall worst pain. And there was no difference between interventions at six months. So, from this paper, BFR may be helpful at controlling pain early on. I think that, for many folks that have a difficulty with load management, BFR can be a nice adjunct to get them doing, sort of, loaded strengthening, without having to have as significant a load to be able to actually make some changes. So just a quick summary of that section.

So, you know, I think glute strengthening has been shown to be critical in lower extremity function. We’ve seen a lot, and talked about a lot of the papers that have been published, kind of looking at the influence of glute strength with PFP as well. You always have to think about the quality of tissue, phase of healing and baseline strength, to make your determination of what exercise is gonna be best. And making sure that we’re not doing something that’s too high level for the patient in front of us. Also I think it’s important to think about what muscle do we wanna activate. What muscle do we wanna try to minimize, right? So if we're trying to get glute max, many patients are trying to minimize hamstrings. If we're trying to get glute med we're trying to minimize TFL. So think about typical compensatory patterns, and not only making sure that
we’re getting the muscles we want, but that we’re not getting muscles that are already overcompensating in the scenario. And important to realize, too, that with a lot of the EMG studies, they’re healthy, asymptomatic patients that are young. We don’t necessarily know if the activation, that type of thing, would carry over to patients with symptoms. We’ve seen some of that work, those studies come out, I’ve seen more often in the shoulder than in lower extremity. But, again, important to keep in mind. But I think the EMG work can be very helpful. And then this was a consensus statement in BJSM, from a treatment summary.

So the things that they were in favor of. So hip and knee focused exercise. Foot orthoses, and I would argue that foot orthoses are gonna be appropriate for selected patients, not for every patient. There was not evidence or background for electrophysical agents or modalities in isolation. Again, in conjunction with other things, potentially. Patellofemoral knee or lumbar mobilization in isolation wasn’t found to be effective either, and, again, I don’t know that not everybody is gonna be stiff. So that may not necessarily be helpful. But if you identify a restriction then certainly doing it. And really, from the consensus statement, there really wasn’t enough information or high-level research, to make a determination on taping, bracing, dry needling, soft tissue mobilization and BFR. I think, in the coming years, we’re gonna see more and more coming out, especially dry needling and BFR. That there will be much more literature available to make more convincing statements.

So, if we go through just kind of general guidelines in the acute phase, again oftentimes the acuity, we’re gonna see some of that increase in effusion. So potentially doing things to try to control or decrease swelling, whether that’s soft tissue, whether that’s stem. You know, certainly activating quads and getting the muscle pump to help, I think, can be helpful. ’Cause, again, that fluid is going to ultimately inhibit the VMO and alter the function of the quads. Sub-acute. If people are restricted, if they have self-immobilized or things like that, you may need to do patellar mobilizations. Lateral
structures. Again, if there’s influence from the IT band, lateral retinaculum, potentially addressing that as well. Strengthening, we’ve talked a lot about that as far as glute and quad. Depending on symptoms, avoiding deeper flexion because of the compressive forces of the patella, I think, can be an important consideration. For me it’s not, I’m not trying to force patients through lots of pain. For some people, biofeedback can be helpful if they have difficulty finding ways to fire muscles, and the feedback can help them with that. In endurance training as well. These are muscles that are working all the time, with every step, with every stair that we go, et cetera. So rebuilding that strength and then focusing on endurance as well. Chronic phase, so gradually progressing hip and quad strength.

Getting off the table, doing things functionally, doing things in closed chain, working on movement patterns and motor control. And that’s not to say that there doesn’t continue to be a place for open chain exercise, from an isolation standpoint. I’ll often have people doing specific exercises to try to, almost as a dynamic warm up, to make sure that they’re activating muscles that are gonna be important. Glute med, glute max, quads, et cetera. So, again, when we’re thinking about these patients I think it’s critical to think about the cause of the symptoms, and not just chase symptoms. Very often we need to tie in pieces of activity modification, which doesn’t always mean eliminating 100% of the activity, but making modifications, decreasing volume, spreading things out.

Maybe holding back until they can improve in their impairments. Again, specific individualized treatment approach. We talked about a lot of interventions that have varying amounts of evidence to support or not support. At the end of the day, every patient will be unique. There will be a lot of overlaps. Your quad and hip strength is likely gonna be across the board, but looking at other specific things, that’s often gonna vary a little bit. So thinking about the faulty mechanics, abnormal movement patterns, what’s driving that, what are the pieces that we need to do with the individual
patient in front of us. And making sure that we're trying to identify all those contributing factors throughout the entirety of the lower kinetic chain. So I wanna talk, briefly, a little bit about surgical considerations. And, again, this is really just to make sure everyone's familiar with it. You know, I would say that the vast majority of patients, conservative management, you know, working with a rehab professional, is likely gonna be the best option in most cases. Certainly the first option, and it may be, if they fail, we can look at surgery. I think that the vast majority of folks will do quite well. But there are certainly people that ultimately don’t, that might need to consider surgery. So some of the options that are here that we’ll touch on today, so lateral release, distal realignment.

There's a few different variations there. MPFL reconstruction, medial patellofemoral ligament. Patellofemoral arthroplasty and patellectomy are talked about as well. Lateral release was something that was done very frequently, 80s and 90s, and probably a little bit less so now. Certainly not done in isolation very much but still can be done. Indications, so anterior knee pain due to excessive lateral pressure. So if the lateral structures are compressing the patella into the lateral portion of the trochlea, clinically we'll see a lateral tilt with that. And, again, anybody who's thinking about surgery, really they should’ve exhausted conservative care.

So, in other words, they've failed, you know, a meaningful stint of conservative care and physical therapy. Contraindications, so if there’s hypermobility we should not be cutting through lateral structures. And should not be done in isolation for recurrent lateral patellar dislocations. Because many studies have shown deterioration of results over time, and that’s partly from, you know, in the 80s and 90s, when this procedure was being done a lot, and then seeing those folks, over time, not necessarily have the best outcomes. Rehab is starting relatively quickly, usually within a couple of days. You’re incising something, you wanna make sure you get the kind of things moving so that you’re not just allowing for an environment for lots of scar tissue. Distal realignment. So indications here. Tolerance ability due to an increased Q-angle or tibial
tubercle malalignment. So, again, an actual anatomical structural abnormality. Patellar tilt and subluxation that cannot be corrected by the MPFL ligament alone. So, in other words, it's not just that the medial structures are insufficient, but there's an actual bony change. The upside here is that that corrects for the subluxation and tilt radiographically. So you're changing the anatomy. It allows for more aggressive rehab because you're changing the bone but then things are screwed down.

So people are starting right away, it's essentially like a fixated fracture, essentially, and working towards full range of motion. Downside is it's a bony procedure, it's an osteotomy, so it doesn't address the MPFL. So if the MPFL is lax or torn, it's not doing anything with that, unless they do a reconstruction in conjunction with. You also can't do this before skeletal maturity. So if you have a young patient that's still growing, that has some of these, then you're not able to do this until they're done growing. MPFL reconstruction is something that, I think, is, you know, at least with certain surgeons that I work with we'll see this a lot more often now than we used to.

I think people used to think the MPFL was a little bit less significant than it probably is. Indications to lateral patellar instability due to laxity of proximal medial restraints. Again, it's a procedure for instability. So by reconstructing the passive structures on the medial side of the knee. Contraindications, so not performed for malalignment, arthrosis or pain. So, again, you're doing this because the medial structure, it's no different from you doing ACL reconstruction because the ACL is torn, right. You're doing medial patellofemoral ligament reconstructing, because the MPFL is either torn or it's locked enough that it's essentially insufficient and it's not functioning or not doing its job, okay. So, again, a lot of these procedures that we've talked about, you know, it's not an end result that oh you still have pain so let's do this, right. You're looking at other findings. There's specific findings relative to either the MPFL or the bony alignment that are being changed. It's not just like okay, we've done everything else and it's still hurts, let's try this. Return to play, so this was a systematic review that
was just in AJSM late last year. They looked at, 53 studies met their inclusion criteria and that were ultimately reviewed. As far as people getting back to athletic activity. Weightbearing restrictions were in over 90% of the guidelines. Range of motion restrictions in almost 85%. Timeline for return to play or return to full activity, so, in other words, just using time as a criteria, which I would suggest to everybody is a problem, and was over about 2/3. Again, that’s similar to basically saying that if you had an ACL reconstructing at six months you can do whatever you want. I think we’ve, for the most part, gotten away from that. That it’s more milestone criteria but we’re still seeing timelines in many of these.

And then the most concerning part, subjective or objective criteria to determine return to activity was less than 20%. In other words, getting data like strength, like specific range of motion data. Quad girth, you know. Any kind of hop testing or hand-held dynamometry, things like that. Some of the things that we look at with other pathologies weren’t utilized, right. So for a return to play, which isn’t the specific focus of what we’re talking about today, but after some of these or, in general, you know, I would advocate for higher level objective testing to make sure that people are getting back to a reasonable percentage compared to the other side, at minimum, before we’re allowing them to do challenging activity.

So just, I guess, to summarize or to wrap up a little bit about surgical considerations, is, again, those really aren’t considerations for, okay, you have patellofemoral pain, you tried PT, it still hurts, so let’s choose a surgery. Again, people will typically have conservative management first, and if they’re still symptomatic and they have inclusion criteria, again if they have a bony abnormality then you can address it with an osteotomy. If they have a ligament problem, laxity or damage, then that can be fixed with a reconstruction. But they’re not necessarily done just because somebody continues to have symptoms necessarily. And I think that is probably, you know, my own opinion or experience was in the period when lateral releases were done very
frequently, it was more, okay, you have patellofemoral pain, you tried PT, you still have pain, let’s do a lateral release. But it was just okay, we’ve exhausted all other options, let’s incise the lateral structures and see how you do. And I think that the inclusion criteria and clinical decision-making for going down the path of surgery, I think, is better now. But keeping in mind that those are considerations that should be being discussed and evaluated before it’s determined that somebody’s gonna actually have surgery.

So I thought now we’d take a little bit of time to go through a case study, and this was a young lady that was a patient of mine. I have a couple of video clips to share as well. I think she encompasses, you know, a number of the things that we’ll often see with patients that have anterior knee pain. She’s a 15 year old, female basketball player. When I had seen her she was playing on four different teams. So at least, in my area in the northeast, this is a change that we’ve seen sort of getting more and more, I guess, significant, or getting worse, if you wanna think of it that way, that we’re seeing much more sports specialization in far younger athletes. That the days of people playing different sports each season seems to be less and less, and you have younger athletes focusing on a single sport and doing things year round. And when they’re in specific seasons, maybe even playing on multiple teams, like this lady was.

She had had a recent onset of bilateral anterior knee pain that was worse with playing basketball and worse with going up and down stairs. And Dad was with her and, at the time, one of his things was, he said "I'm worried about how she runs. "When I see her at practice, when I see her at games, "the way that she's running doesn't look good. "Makes me worry." It was his wording. So we’ll show a couple of videos. The first one is just gonna be her walking on the treadmill. So generally I'll have people, a self-selected pace, so this was just her self-selected normal walking speed. And I'll typically try to look at people barefoot as well, so I can see what the feet are doing. And we can look at this more than one time through but, you know, a few things that
you can see with her. Fair amount of toe out on both sides. You can see valgus and
some hip internal rotation as well. This is just with her walking. So if we play this again.
If you look at her pelvis. Even just with walking, there's a fair amount of frontal plane
pelvic drop. If you look at, her medial knees are essentially touching or rubbing
together, her feet are apart, so there's a good amount of valgus. Some toe out, you can
see some compensatory pronation as well. Right, so a lot of the factors that we talked
about sort of over the last couple of hours, we're seeing with her. Head to the next
slide. So a few quick things, again, not all the data, but some of the data. So she had
some muscle length limitations. Hip flexure, quad, gastroc-soleus and hamstrings.

Again, she was young and hit a growth spurt so part of her success in basketball, she
was quite a bit taller than a lot of the other athletes her age. So because of that she
had a lot of muscle tightness as well. But very significant limitations and strength. Quad
and hamstrings were four out of five. Glute med and glute max were three plus out of
five. So, again, things that we've talked about in other areas. So muscle restrictions
and then strength restrictions at the hip and the knee. So we saw her walking, now let's
take a look at her running as well. So looking from behind, this is a self-selected jog
speed. And you can see a fair amount of pelvic motion as well, both frontal plane and
transverse plane. If you look at her knees, as she's moving through, right, so she kind
of has to work pretty hard just to get one around the other, right. Because of all that
dynamic valgus and medial collapse, you know, as she comes through she's almost
sort of rubbing medial side there. She stays toed out, sort of the entirety of the time as
well.

And, again, one of the things that I mentioned earlier when we were talking about
strength testing, is that, you know, in a clinical setting, that's as strong as they'll be.
Like you think about now, okay, she goes out for a run or goes to basketball practice,
she's likely gonna fatigue and then things are gonna get worse. So she's only been
jogging here for 30 or 60 seconds, and you're seeing some difficulty or some
concerning things with her form now. Imagine her at the end of practice, or at the end of a game. How much more pronounced some of these things might get. Which is likely what Dad was seeing, right. So seeing some of these concerns, or how she's gonna be moving when she's on the court. We'll go to the next one now. So now, if we take a look at her, again, just from the side, one thing I wanna point out is how far forward she is. So one of the difficulties, so now, as her, and this is, I'll play this a couple of times. Because of her, this isn't helping her knee pain, obviously, 'cause as she comes further forward then she's increasing the load. In addition to that, part of the reason that she's coming forward is because she's lacking hip extension, right.

So if you think about what's happening here, I'll pause it for a moment. If you don't have hip extension, remember during walking, running, we need, you know, 10, 15, 20 degrees of hip extension. So if it's not there, you've either gotta drastically shorten your stride or anteriorly rotate the pelvis and bring the trunk forward, so you can essentially try to cheat and get some relative hip extension that way, right. So if you look at the further she gets back is even with the rest of her trunk. So, again, that's creating some challenges with her form and, I would argue, probably making it more challenging for her to actually engage her glutes when she's running, which may be part of why you're seeing so much collapse.

Because she's in a flex position all the time because she's so tight with her hip flexors that she can't actually extend her hips. So with somebody like her, and we'll go to the next slide, I think that making those considerations and addressing the muscle length limitations becomes very very important. For some reason, there we go. So just got two videos of different heights. If we take a look at her just doing a box jump, so as she's coming down, again, you can see just how much valgus that she's coming into. And I've got one more video, it's gonna look very similar. It's just a slightly higher box. We can take a look at her jumping here. Right, you can see when she lands, I mean, she looks unsure of herself, for sure, and as she comes down, you just see all that
collapse, right. So lots of difficulties with controlling up above. Right, so, head to the next one. Right, so these are the videos that we took a look at. So treatment for her, as far as what we focused on, and, again, some of the things that I talked to as we looked at the videos. So muscle flexibility in general, but hip flexors were probably her biggest. So we focused on, you know, we looked at quads, at hamstrings, at gastroc-soleus, at hip flexors, and I think one of the biggest things for her, her hip flexor tightness made it difficult for her to have hip extension during her walking and running gait. So she's lacking extension.

And it's also gonna make it far more difficult for her to be into an extended hip position to try to bias gluteus medius and potentially less TFL. So really critical for her to have glute activation exercises. So she's got lots of compensation. So some of the things that I touched on earlier, that, you know, if we're doing a glute max exercise, watching that she's not just trying to get all hamstrings. Glute med that she's not getting all TFL. So one of the things that I see with somebody like her, so I think she's a great example. So if you think back to that Boren study that we talked about, is, you know, the likelihood of her doing a side plank with hip abduction, with good form, is probably zero, right. So she's gonna have to start with lower level things, even though she's a healthy, young, active, motivated woman. We have to find activation exercises, muscle strengthening exercises that are appropriate, that she can do with good form, so that she's just not doing the same faulty movement patterns and going into the compensations again.

And I'll try to spend time explaining that rationale to patients, because oftentimes we're doing something that may be lower level or seem easier, compared to what they'd been doing on their own. But explaining the rationale for that. That we're trying to build the foundation and not encourage the same faulty movement pattern. And then as the strength gets better, it just, I would argue, just doesn't magically correct everything by itself. It's starting to work on balance and neuro re-ed, some more dynamic things,
getting her doing squat activities. Getting her doing step downs and sort of dynamic movements, jumping and landing, so that she can focus on that in a controlled environment, in the clinic, that then we can hopefully get better carry over when she’s doing things dynamically and playing basketball. Ultimately, she did very very well and I’ll tell you that when I saw her and met with Dad, I was actually more concerned about the risk of ACL injury with her, than other things. Thankfully she’s doing very well and still playing basketball, and has been maintaining with her hip strength and quad strength, and that’s a big part of what we focused on. So hopefully that helps kind of tie a few things together and seeing some of the things we might find with the examination, how that impacts gait.

So just to summarize a few additional things. So patellofemoral pain is a multifactorial condition. We talked about all the different contributing factors that’s gonna need an individually tailored multimodal approach. We have to think about lots of contributing factors. Immediate pain relief, I think, is a priority to try to gain patient's trust. You know, I think that not that it has to be everything, but making sure that we can show that we can influence their symptoms, I think, is important and, again, this is from the BJSM paper. Patient empowerment, by emphasizing active over passive interventions. Again, there’s not a lot of literature to support modalities anyway, but making sure that we get patients to understand that this isn’t me doing stuff to you. This is me helping to teach you what you need to do for yourself, is a conversation I have with patients quite a bit. So that patient education and activity modification, I think, is critical, for people to be successful long-term. So thank you very much everyone, it was a pleasure to be with you today and hopefully give you some things to consider when you're working with these patients, and I’m certainly happy to try to answer any questions that might come up.

- [Calista] All right, well thank you so much Dr. Nolan. We currently don't have any questions in the question and answer pod, but if you do have any questions go ahead
and place those in before we close out today's course. All right. I'm gonna go ahead and close out today's course. Thank you everyone for attending, and thank you, again, Dr. Nolan, for such an excellent course.

- [David] Thank you very much for having me.