My name is Volker Musahi, I’m Associate Professor of Orthopedic Surgery here at the University of Pittsburgh. This morning I will be talking about management of meniscus tears. I have no conflict of interest with this presentation.

I would like to start this morning with a typical case presentation. This is a 30 year old gentleman who is a business person, he is active in playing racquetball, he sustained a twisting injury and came to see us with this radial split tear of his lateral meniscus, complained of lateral joint line pain and swelling. So when we look at his intraoperative findings here you see very much of a pristine joint with intact reticular cartilage on the lateral femur here, on the lateral tibia but a very complex lateral meniscus tear consisting of this vertical split tear in the anterior horn and then a large radial split tear. So this is a very difficult decision as we know that there is limited blood supply to the lateral meniscus in this area, however if we resect this, this would mean a subtotal meniscectomy. So in this case what was done is an outside-in repair for the anterior horn, an inside-out repair here for the radial split tear with a total of 5 sutures and then we used a fibrin clot to augment the healing. So I’m going to go through some of the details in how we get there and I will also share with you some outcomes on this type of repair because you probably are asking yourself whether this would ever have a chance of healing.

So we take a step back, we go back to anatomy, the meniscus is crescent shaped as you can see on the picture on the right, the vascular supply comes from the medial and lateral geniculate arteries.
The median meniscus as you can see on this anatomic slide here is C shaped, the lateral meniscus is semicircular. And only about a fourth of the lateral meniscus has vascular supply. The function of the meniscus is that it deepens the tibial surface, it’s a secondary stabilizer, it provides nutrition to the joint and lubrication. And the secondary restraint to anterior/posterior translation is the posterior horn of the medial meniscus.

Meniscus essentially consists of Type I collagen, there are longitudinal and radial fibers. The longitudinal fibers are the most important ones and provide hoop stresses. So when we do a repair we would like to capture those fibers which is best done with a vertical mattress. Medial versus lateral, there is a big difference in that the medial compartment is essentially stable, the medial tib plateau is concave and the medial femur is convex so there is bony constraint and additionally the medial meniscus has a firm capsular attachment. However on the lateral side it’s a more dynamic situation. Here the tibial plateau is smaller and convex, and the lateral femur is convex as well so the meniscus is what provides stability and the meniscus on the lateral side is much more mobile.

Here again this slide, this is (inaudible) doing a meniscus allograft procedure and you can see very nice this lateral meniscus semicircular and on the medial meniscus note the large posterior horn compared to the lateral meniscus.
As far as classification there are MRI classifications we sometimes like to use. The image on the right would be a type III tear which connects to the tibial surface and as far as diagnostics it’s sometimes difficult to differentiate between grade 1, 2 and 3 which are intrameniscal signals. The tear pattern, the most classic tear is the bucket handle tear which is shown on image A. This is a tear that usually goes to the red/red zone meaning there is vascular supply and therefore can be repaired. B would be a paired big type tear which is in the avascular zone and very difficult to repair and difficult to heal. And then C is a radial split as I showed in this first case, D is a horizontal cleavage tear which is a more degenerative type tear and so is E, which is a complex tear.

Discoid meniscus we see commonly in young people and you can see this with subtle findings but the radiograph shows squaring of the lateral condyle and a hypoplastic tibial spine and also compared to the contralateral side shows joint space widening. And on the MRIs you can see consecutive images with this bowtie appearance.

This is a typical vignette as would be asked in CME type questions. A 21 year old Division II running back sustained a twisting injury during a game, he had immediate swelling and pain. On exam two days later had an effusion, range of motion 10 to 100 degrees, he has medial joint line tenderness, he is stable on his ligament exam and what is the preferred treatment? So this would be a bucket handle medial meniscus tear as you can see on this image. In this case going through the red/white zone and the preferred treatment would be a fixation and gold standard is inside-out
meniscus repair. So I’m going to talk a little bit about the different treatment options in the next couple of slides.

The meniscus tears are the most common injury to the knee, higher risk in the ACL deficient knee to be seeing a meniscus tear, and for all comers we see most commonly medial meniscus tears and for ACL injuries it would be the posterior horn of the lateral meniscus where you should look for a tear. In young patients it would be a traumatic history, the tear is peripheral and is associated with an ACL commonly. In older people it’s a degenerative type tear, horizontal cleavage tear and involves the posterior horn of the medial meniscus. Our treatment options are observation, total or partial meniscectomy, meniscus repair and I’m also going to talk a little bit about meniscus reconstruction with allograft.

Observation would be the appropriate treatment for small tears that are partial thickness, nondisplaced and less than 5 mm in length. We can see these tears in traumatic situations and often associated with ACL and they are best treated with observation.

And total or partial meniscectomy would be for irreparable tears, especially those that involve the avascular zones or degenerative type tears. Stay away from thermal treatment which injures the cartilage. Total meniscectomy has detrimental effects on the joint, the contact area of the femur and tibia are decreased by 75% and in return the contact stresses increase by more than 400%, therefore
after total meniscectomy degenerative changes occur, reticular cartilage will wear and eventually the joint will go into arthritis. Partial meniscectomy is shown to have less of an effect with decrease of contact area 10% and contact stresses only increase by 60%. So classic literature, if we look at what happens in long term follow-up these are all studies, 15 year follow-up and longer you can see in the bold font 80 to 90% at 15 years have arthritic changes in their joint. And patients or athletes will come back and complain of this very commonly and you will find medial joint space narrowing and our treatment options then are very limited. And partial meniscectomy is really the treatment of choice, arthroscopy has been used for the past 30 years and we try to preserve as much meniscus as possible, and so when we look at the literature for partial meniscectomy we can see that degenerative changes only occur in about 40 to 50% following partial meniscectomy.

I’m going to talk a little bit about what factors factor in for meniscus repair. So age of the patient is very important, the younger age more favorable for repair and healing. The location of the tear is very important in that the more peripheral the tear is the more amenable it is for repair and healing. Acute tears also more amenable for healing and the status of the articular cartilage is very important, if you have grade 3 or 4 changes in that joint a meniscus repair is not going to work. Concomitant injuries are important, if the knee is unstable it needs to be stabilized at the time of meniscus repair or else this is going to fail. And then of course what type of sport or job, is this a work injury, all these factors factor in as well, as well as experience of the surgeon.
Here is another image of typical tears. The Type I tear seen on the upper right is the most common tear that we fix, a vertical split tear and then in the lateral meniscus this radial split tear you can see as number II, it’s a very difficult tear to treat but if that gets resected it usually means a total meniscectomy and later a meniscus transplant, so any effort should be made in repairing this. So the ideal indication for a meniscus repair is an acute tear, a vertical split in the periphery of the meniscus in a young patient that has a stable knee, or even better concomitant with ACL reconstruction will have shown to increase healing chances.

So technical details about inside-out meniscus repair, this would be for a lateral meniscus repair, the image on the right shows the approach which is between the biceps, femoris and the IT band. And the protection here has to be of the perineal nerve, it has to be protected posteriorly usually by a Henning retractor or by an Army/Navy retractor. On the medial side we worry about the infrapatellar branch of the saphenous nerve, this usually courses proximal to the joint line right on the sartorius fascia and the sartorius fascia is what needs to be split to get to the posterior medial meniscus.

This is a typical video, I chose this video. This happens to be from a medial meniscus transplant, what I would like to show here is a vertical mattress inside-out suture. So this is the first passage of a suture through the periphery of the meniscus and here comes the second passage which goes through the capsule and this gives a nice vertical mattress repair capturing the circumferential fibers.
of the meniscus. And here is a second suture going in and for a meniscus transplant like this we usually use about 10 inside-out sutures for peripheral capsule repair. Henning has showed almost 100% successful outcome with inside-out repairs, 98% successful in acute tears and also propagated for rasping and fibrin plug whenever possible in this inside-out technique.

The outside-in technique was described by Warren in New York and is a nice technique that can be used for more anterior tears both in the media and in the lateral compartment. These tears are not good, this technique is not good for posterior tears. The technical details is that percutaneous spinal needles are passed times two through the meniscus and then typically a PDS suture gets passed through the meniscus and then a small stab incision in the skin you can tie the knot over the capsule anteriorly when you are done with the case. The outside-in technique is a suture technique and again the vertical mattress is the strongest and horizontal mattress and mulberry knots are weaker.

Morgan has done a nice follow-up study on this in ’91, 74 second look arthroscopies that showed essentially 85% healing or partial healing and the failure cases were just about 15%, in which case a partial medial meniscectomy was performed concomitant with the ACL tear. The outside-in technique is not recommended in the posterior region of the meniscus.

A couple of words about all inside techniques, this is very common, started in the ‘90s, we are now in the third generation of this. These devices that are on this picture here, arrows and darts that we
usually don’t use these days anymore and a lot of complications with chondral injuries and dislodging and also their biomechanical properties are not favorable and I have a slide on this. But the advantages of these devices are they are very simple to use, they are fast and a suture fixation is possible with the third generation type of devices. However disadvantages are that this is not a foolproof procedure and the suture can break, the tear can sometimes be very difficult to reduce if a vertical mattress is not passed. The devices are not resolvable, so you have to be careful of this. Cost is an issue especially with new healthcare coming in, so problems are there. The risks are also skin penetration if these devices are pushed in too far you can penetrate the skin. The vertical mattress is usually difficult to achieve because these devices are not as sturdy as the inside-out zone specific cannulas. Premature dislodging of these plastic teeth can happen and also foreign body granulomas have been observed, cartilage defects like I said.

This slide shows just an overview in biomechanical properties and you can see these darts and arrows on the top have very low pullout forces and then on the lower you see the double vertical mattress suture which is the preferable technique has almost a 3 times higher pullout strength compared to the arrow.

Some results. I think you can see on this slide that results of this are not as good as inside-out repairs, but 66% good outcome but 28% failures in the Siebold study, and Barber showed 87% success with the rapid loc device.
A couple of words about biology, we like to use fibrin clots to enhance our repairs, Arnoczky and Warren described this in the ‘80s, this has been used in many, many cases, there are good outcome papers that this works, it’s a very cheap technique. You harvest 50 cc of the patient’s own blood, you take a stir rod and a beaker and obtain this fibrin clot that you can see on the right, this can either be threaded into your suture before you do the repair or it can also be placed into the repair after sutures are passed and before they are tied. This is an intraoperative picture showing a horizontal cleavage tear with a fibrin clot in place and the sutures prior to capturing the clot. Success rate for isolated medial meniscus repair 60 to 80%, lateral meniscus 90% and notice that combined with ACL reconstruction you have improved healing rates.

So I’d like to show you this case, this is a young 14 year old young patient who plays basketball, had pain after a play, swelling and pain and tenderness on the lateral joint line, had an effusion, ligament exam was stable. The MRI shows open physis and also shows this radial split lateral meniscus tear. So you can see here in this video the radial split tear, we use a shaver and a rasp to freshen up the tear edges, and if you would resect this tear this is essentially 75% of the lateral meniscus that would be resected. So in this case we performed horizontal mattress sutures which in a radial tear the only sutures that would work, we placed 3 of these suture. You usually go about 1 cm posterior and anterior form the actual tear to capture healthy meniscus. And then once all sutures are placed so commonly between anywhere between 3 and 6 horizontal mattress sutures get passed, then the fibrin clot is prepared and through a 7 mm cannula once the portal is dilated you can put the fibrin clot into
the joint and with a probe try to maneuver the clot into the tear site. And then the sutures can be tied over the capsule which will capture the fibrin clot.

And finally I would like to talk about meniscus transplant which is the bail out that we have for young patients after total meniscectomies being performed. So the indications here are very tight, and it would be for a prior subtotal or total meniscectomies in young patients, the articular cartilage status has to be less than grade III or IV chondrosis so no full thickness chondrosis can be accepted because that will lead to early failure of this very complex procedure. Then at the same time the joint has to be in neutral alignment, so for a medial meniscus transplant a concomitant varus needs to be treated with an osteotomy and we have very aggressive indications here. And the same goes for a lateral meniscus transplant with a distal femur osteotomy. This can be done concomitantly or two stage. And secondly ligament status, so a meniscus transplant in a knee that is ACL deficient will not work either, so ACL reconstruction should be done concomitantly. On the lateral side usually a bone bridge is used, there is the picture on the top right and on the medial side either bone plugs or a suture technique as described by Freddie Fu.

We use fresh frozen allograft, the number one issue with allograft use is actually sizing. This is done on a lateral x-ray to appropriately match the dimensions of the meniscus. There is really low immune response, the graft is acellular and it does not matter as far as outcome whether this is fresh frozen, fresh or cryo preserved. There is a risk of disease transmission, this needs to be discussed
with the patient ahead of time. The risk is low, it’s less than 1 in 250,000 for HIV and hepatitis but these are issues that need to be discussed.

Chris Harner her at Pitt has done an outcome study on this, those are 31 patients, you see the average age is very young 28 years, this is a short term follow-up. Two-thirds of these patients had combined ligament instabilities and that is typically how we see these patients. In the knee outcome survey they have 86 score and IKDC you can see that basically 30 of them, so almost all, have either very good or good outcome. This is short term, and there was no joint space narrowing over time. It however needs to be noted that this is not a procedure for returning back to high impact athletics, but rather to treat pain on the joint line and preserve the joint and prevent progression of arthritis. Postoperative management after meniscus transplant would be brace for 6 weeks, motion with CPM for the first 4 weeks from 0 to 90, then go from partial to full weight bearing over the first 4 weeks, return to activities of daily living at about 2 months and return to sports or more higher level activities at about one year. So it’s a long rehabilitation.

I’d like to share with you this case, this is a 19 year old worker that fell out of a 7 foot scaffold. He had an ACL reconstruction done as a result of this injury, one and a half years prior to seeing us, and at the same time had done a subtotal medial meniscectomy. He continued to have medial-sided pain and also instability. So it was a very difficult problem to treat. These images here go from upper left to lower right and show his vertical and posterior ACL in place that is loose and essentially not
functioning. With this graft in place examination under anesthesia showed a grade III pivot shift. And then the picture on the upper right shows after debridement of this graft you can see here in the high noon position the previous tunnel position and then the – all that we used here depicts the correct anatomic spot, low on the lateral femoral condyle. And then the tibial tunnel is anterior just adjacent to the anterior horn of the lateral meniscus and not anterior to the PCL. And then the lower right shows the anatomic ACL reconstruction.

We then used in the same setting a medial meniscus plateau, you have seen this image before, the technique that we prefer is the suture technique described by Freddie Fu, two number 5 Ethibond sutures are placed, one each into the anterior and posterior root of the meniscus then four number 2 Ethibond sutures are placed in the posterior horn and as I said before after the meniscus is inserted about 10 inside-out sutures are placed in addition to this.

So this is his joint, you can see medial femoral condyle and plateau have preserved cartilage, grade 1 to 2 changes. The meniscus was almost entire resected so we completed that to a bleeding capsule. Here we used an ACL tip guide, this image is for the anterior root footprint of the medial meniscus, we drill a tunnel from an anterior medial skin incision. This next image here shows the posterior root and then through a posterior medial capsulotomy the meniscus gets inserted, the sutures of the roots get transferred into the tunnels through use in suture passes, the meniscus then is pushed in digitally and once in place and an adequate tension on the root sutures we then in this case used
FAST-FIX All-inside device to do the capsule repair and then anteriorly used outside-in sutures. This is the final product. You can see this nicely fits into his media compartment.

This is 3 months status post, still has a little bit of motion deficit but overall very good motion, very stable knee. You can see on the radiograph the low and lateral position of the ACL, we prefer EndoButton and suture post technique.

So in summary, repair the meniscus whenever possible, especially the lateral meniscus which is in a dynamic situation and you can see very early arthritic changes if a meniscectomy is done here. The ideal indication for the repair is an acute tear vertical in the periphery in a young patient concomitant with ACL reconstruction. Remember Fairbanks changes, those are radiographic signs of arthritis, joint space narrowing, subchondral sclerosis, osteophytes and squaring of the condyles. At long term follow-up if partial meniscectomy about half of your patients will have these changes. The gold standard for meniscus repair is an inside-out repair, vertical mattress, new devices are simple and fast but beware of complications, chondral injury and of course cost.

For meniscus transplant the indication is for young patients status post meniscectomy, no high grade chondrosis, the alignment and ligament status as discussed have to be neutral. We use fresh-frozen and the lateral x-ray for sizing. Save the meniscus. All right, thank you very much.