Anatomic Double-Bundle ACL Reconstruction

Patient Information Handout / Frequently Asked Questions

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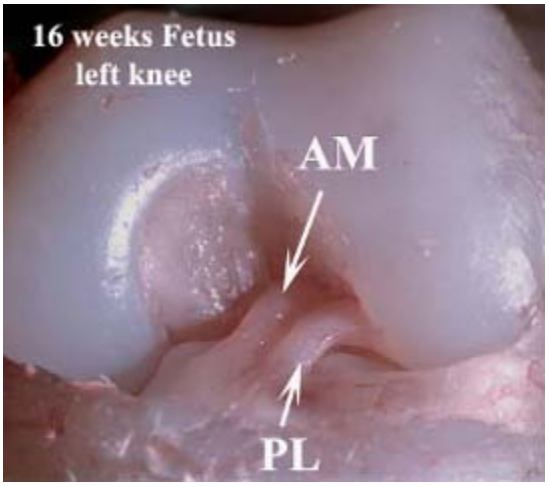
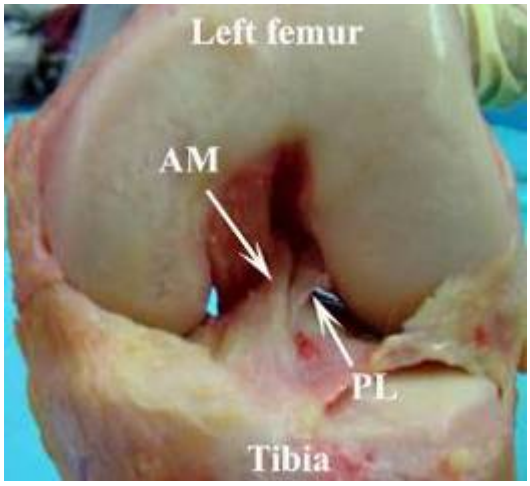
What is the ACL and what does it do?

- The anterior cruciate ligament (ACL) is a ligament that connects the femur to the tibia in the center of the knee joint.
- When athletes "blow out" their knees – this is the ligament that is commonly torn.
- The ACL is <u>important</u> during daily activities but absolutely <u>critical</u> to the stability of the knee during sports.

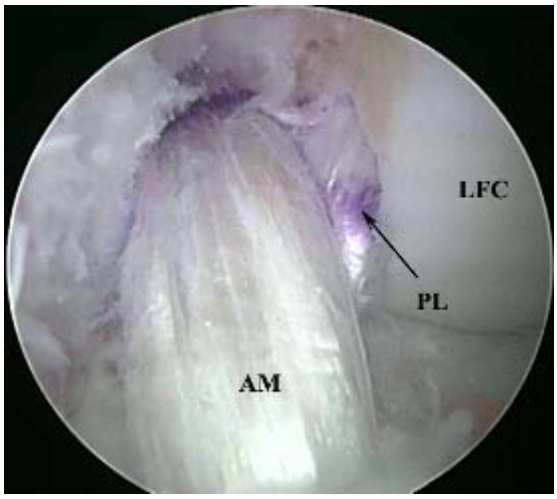
What is the native anatomy of the ACL?

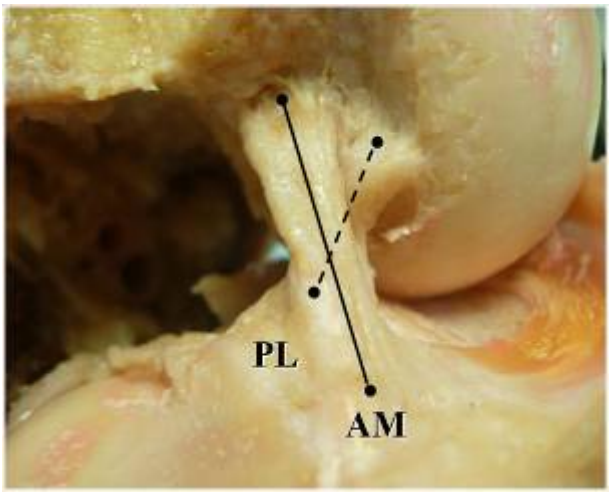
- The ACL is made up of two functional bundles of tissue, the anteromedial (AM) and posterolateral (PL) bundles. These bundles are first seen during fetal development and persist throughout life. [1]



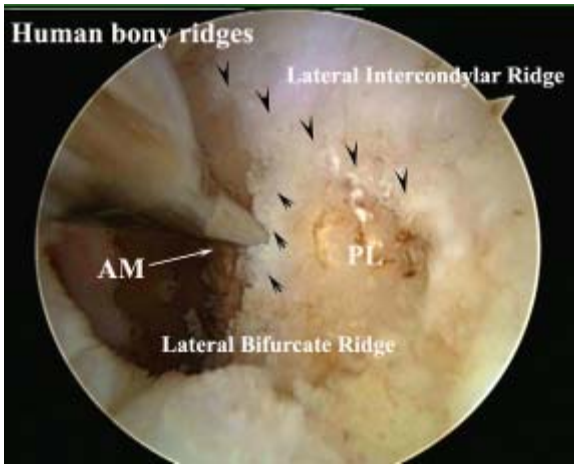


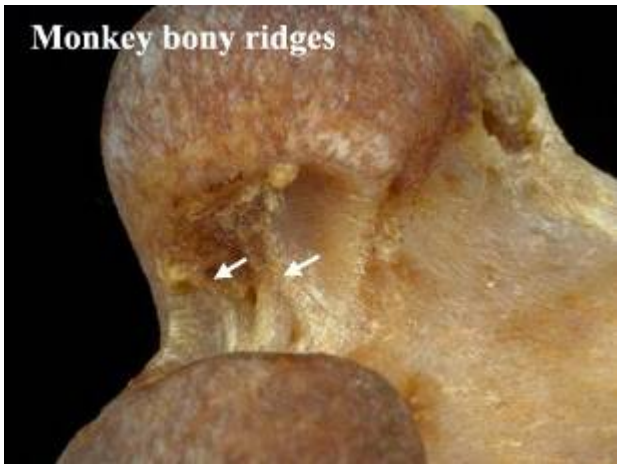
- The AM bundle of the ACL primarily controls anterior (forward) movement of the tibia underneath the femur, and the PL bundle controls rotational stability of the knee, such as in pivoting, twisting, running, and jumping. [9,10]
- In other words, each bundle has a different function, and this is reflected in the anatomy. When the knee is straight the AM and PL bundles are parallel. As the knee is flexed, the two bundles cross each other:





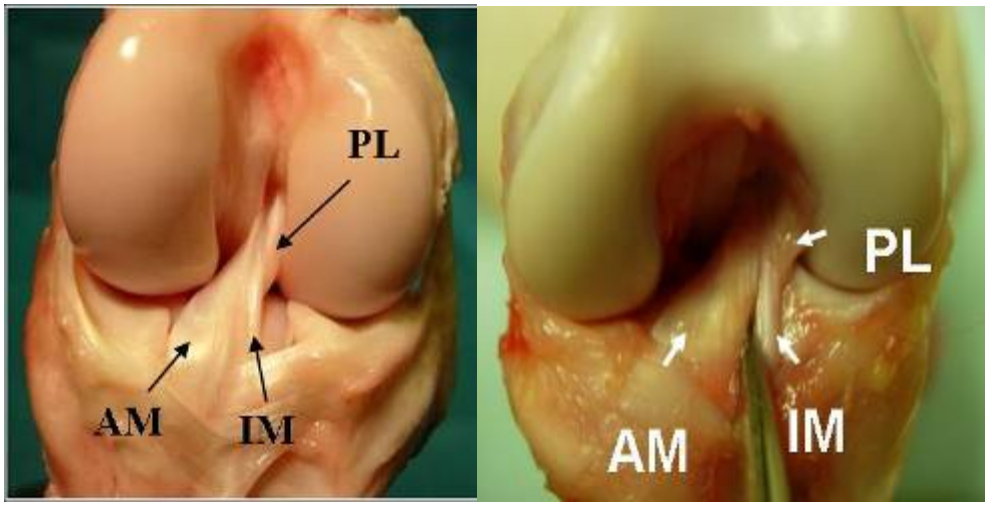
- Here is a closer look at the femoral attachment sites – we can see the upper margin of the ACL attachment site (intercondylar ridge) and the bifurcate ridge (probe on ridge) which separates the insertion sites of both the AM and PL bundles.



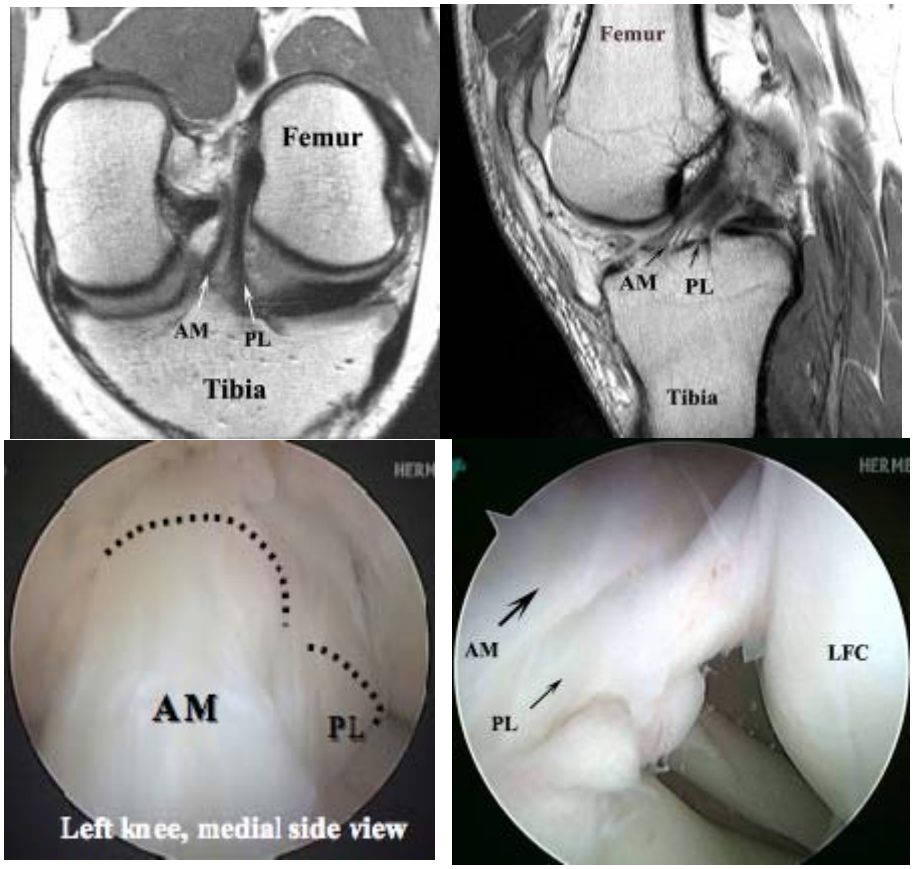


- Interestingly – different animals have different numbers of ACL bundles – likely a reflection of Darwinian selection.
- This is seen in both the bone and soft tissues. Above is a comparison of the human bony ridge (left) for ACL insertion, on the right is the bony ridge of the ACL in monkeys – reflecting different ACL bundles.

- Here is a goat with 3 bundles on the left, and a rhesus monkey also with 3 bundles on the right.



- Here are some normal human knees showing both the AM and PL bundles of the ACL - on MRI scan and during arthroscopy:



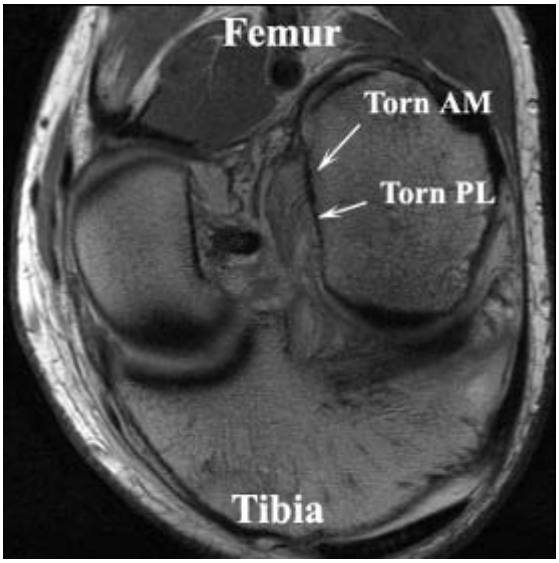
Are ACL tears common?

- ACL tears are very common. Over 200,000 ACL tears occur each year in the United States. The highest incidence is in individuals between 15 to 25 years of age, who participate in

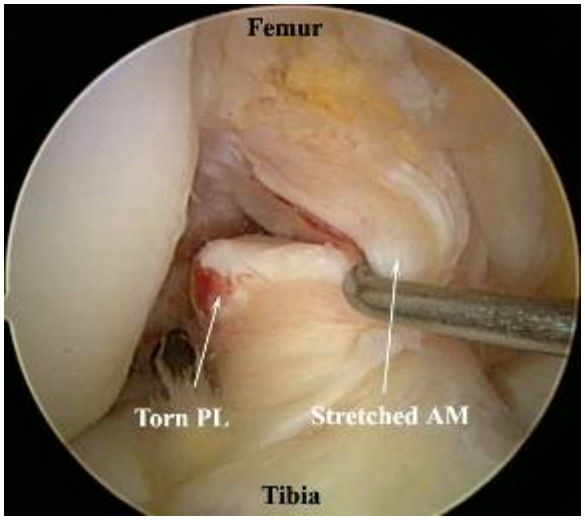
pivoting sports (like soccer and football), but ACL tears can occur at all ages and in all sporting activities. [18]

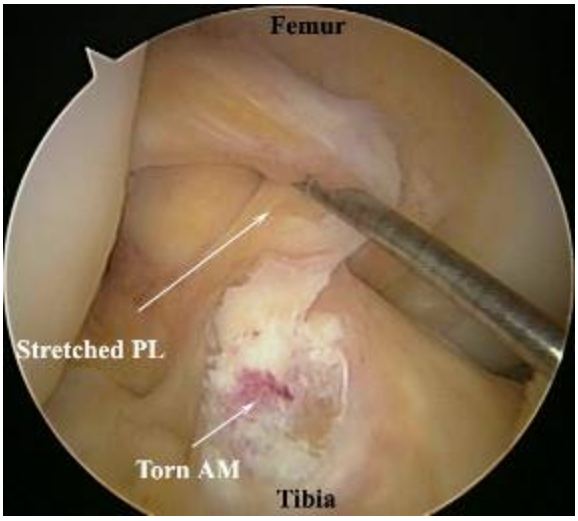
How is an ACL tear diagnosed?

- Tear of the ACL can be diagnosed by a history of trauma to the knee (contact or non-contact) and physical examination. MRI scan can confirm the diagnosis:



- At the time of arthroscopic surgery, severe stretch-out or complete tear of the AM and PL bundles of the ACL can be seen, as pictured below:





Is surgery absolutely necessary for my ACL tear?

- No. There are some patients who are able to function without an intact ACL. These patients modify their activity, by eliminating pivoting and cutting movements and sports, in order to

minimize subluxation, or "giving away" episodes. However, sometimes during regular activities the ACL-deficient knee can subluxate, resulting in painful episodes with swelling.

- Importantly, there is a risk for damage to the menisci (cartilage shock absorbers) and articular coating cartilage inside the knee joint with each subluxation event. This damage can lead to degenerative arthritis.
- Because of these concerns, a majority of active patients elect to undergo ACL surgery when the ligament tears.

Can the ACL be repaired or does it have to be reconstructed?

In general, the fibers of the ACL cannot be sewn back together again (repaired). This is due to severe stretch-out and irreversible damage to the ligament sustained at the time of injury. Therefore, the damaged ligament must be removed and replaced with a new one.

I just tore my ACL—when will I be ready for surgery?

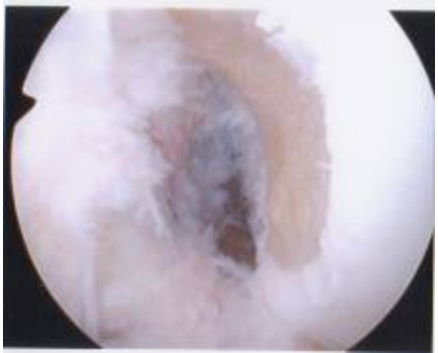
- In general, there are three criteria that must be met before the ACL can be surgically reconstructed:
    1) Swelling in the knee must go down to near-normal
    2) Range-of-motion (flexion and extension) of the injured knee must be nearly equal to the uninjured knee
    3) Good Quadriceps muscle control must be present (able to do a straight-leg raise)
- Usually it takes a couple of weeks after injury before ACL reconstruction can be performed.
- The presence of any associated injuries to the knee joint involving cartilage, meniscus, or other ligaments may change the time-frame for surgery.

What are the key variables to consider when thinking about ACL reconstruction (what do we mean by anatomic reconstruction, and what is double bundle reconstruction)?

- Anatomic reconstruction - everybody has different anatomy – therefore in order to truly reconstruct the ACL – it is important to approximate each individuals native anatomy - both in tunnel size and location
- Single vs. Double bundle ACL surgery – (see below)

What is the surgical technique for ACL reconstruction?

- In the majority of North America, only one bundle of the ACL is typically reconstructed at the time of surgery. This is known as "Single-Bundle" reconstruction. However, this form of reconstruction is non-anatomic because it does not reproduce a person's normal or "native" anatomy.
- Usually, the surgeon will perform a notchplasty first to chip off a piece of bone in the joint (see below), which Dr. Fu believes is unnecessary. Then a drill guide will be used to drill one tunnel each on the tibial and femoral side, followed by passing through one graft.




- This standardized technique does historically provide good results. Dr. Fu has performed over 5000 Single-Bundle ACL reconstructions in this manner at UPMC from 1982-2003 (21 year experience).
- However, many feel that we can make improvements. More importantly, Dr. Fu believes that the surgery should be individualized to each patient because everyone has a different native anatomy.
- At UPMC, and in many medical centers around the world, "Double-Bundle" ACL reconstruction is now performed. Dr. Fu has performed over 500 Double-Bundle reconstructions since 2003, with excellent results.
- Double-Bundle surgery reconstructs both the AM and the PL bundles. [20]

Why is Anatomic Double-Bundle ACL reconstruction performed instead of Single-Bundle?

The answer to this question is based on a significant amount of scientific evidence:

- The ACL is composed of two functional bundles, the anteromedial (AM) bundle and the posterolateral (PL) bundle, not just one. [1]
- Between 10% and 30% of patients complain of pain and residual instability following Single-Bundle ACL reconstruction. [2-7]
- Arthritis has been observed on x-rays in up to 90% of patients at long-term follow-up after Single-Bundle ACL reconstruction. [8]
- Single-Bundle ACL reconstruction does not adequately restore normal knee stability, particularly tibial rotation [11-16]
- Anatomic Double-Bundle reconstruction better restores knee stability compared to Single-Bundle reconstruction. [12,14,16,17]

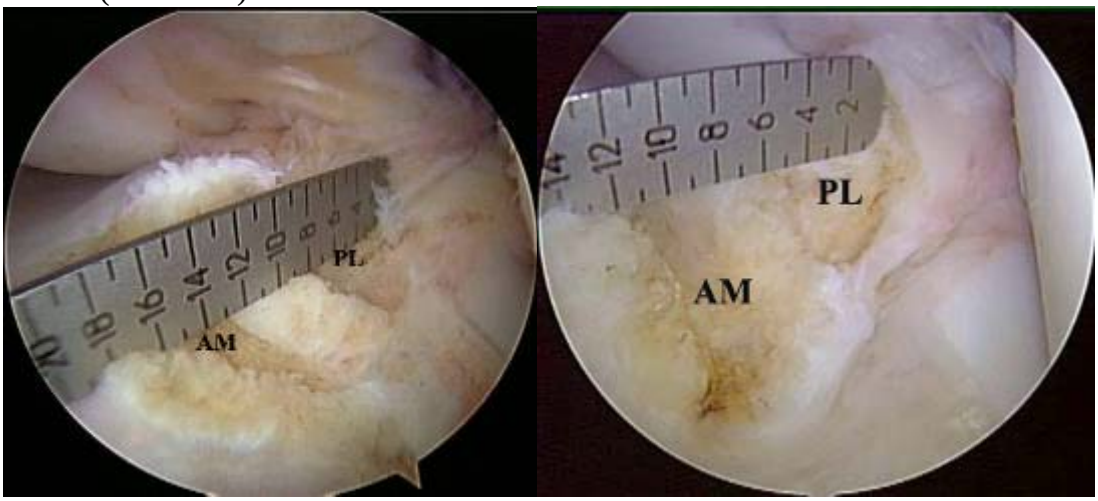
To better understand how "Double-Bundle" ACL reconstruction has evolved from "Single-Bundle" surgery, one should consider a door hinge. A door with one hinge is like a Single-Bundle reconstruction—it will open and close, but the hinge is required to do too much work. Over time it will loosen and the door will wobble. In comparison, a Double-Bundle reconstruction is like a door with two or three hinges. The work is shared between the hinges, and the door can open and close smoothly for long periods of time without falling apart. One hinge doors can be seen in log cabins, while in Medieval times two hinges were used. Today's doors have three hinges, representing an evolution in design.

The principles of anatomic double bundle ACL reconstruction surgery

- Reproducing the anatomy of ACL by reconstructing both the AM and PL bundles.
- Reproducing the insertion sites of ACL by identifying them carefully and measuring their sizes, followed by drilling the bone tunnels precisely where they belong
- Reproducing the tension pattern of each bundles of the ACL by fixing them at their respective angles
- A La Carte surgery (ie. individualizing each surgery for each patient)

In regards to A La Carte surgery, how much variation is there?

- Here is an example of two patients - similar age and height
- This is a measurement of the tibial insertion points which dictate the tunnel and subsequent graft size (see below)

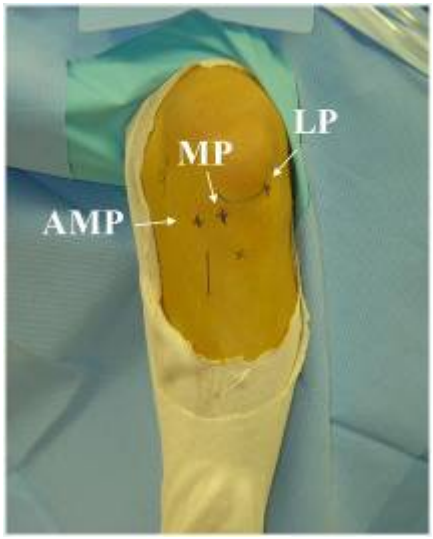


- As we can see, the tibial insertion sites here are markedly different - 17mm on the left picture and only 12mm on the right.

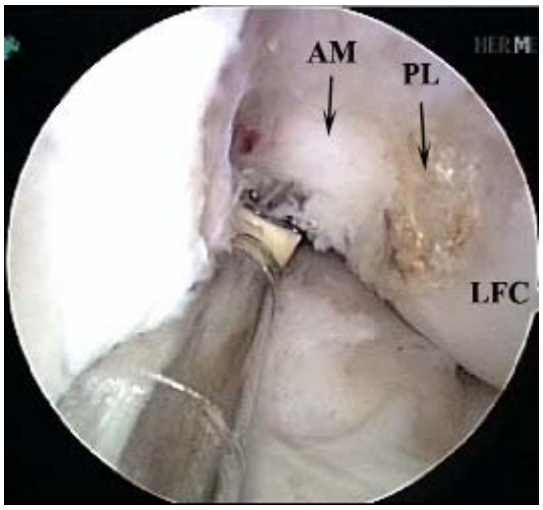
What are the details of the surgery?

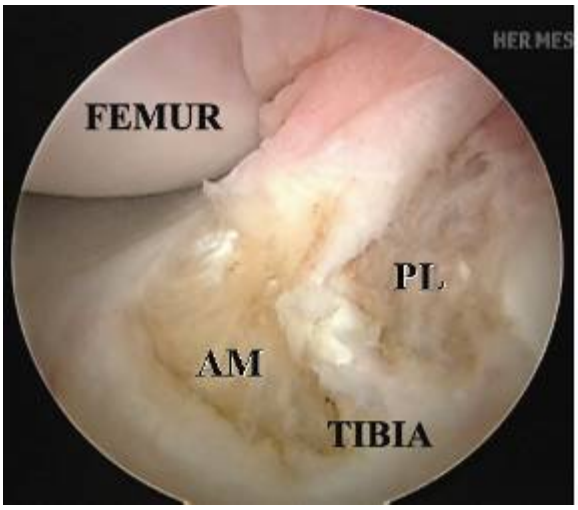
- For ACL reconstruction, we typically use four small incisions:
    - Three arthroscopic incisions: AL—Anterolateral Portal, AM—Anteromedial Portal, AC—Accessory Portal

- One tibial incision for the bone tunnels
- Occasionally, an additional incision is made on the lateral (outer) aspect of the knee joint over the femur to help secure the grafts.

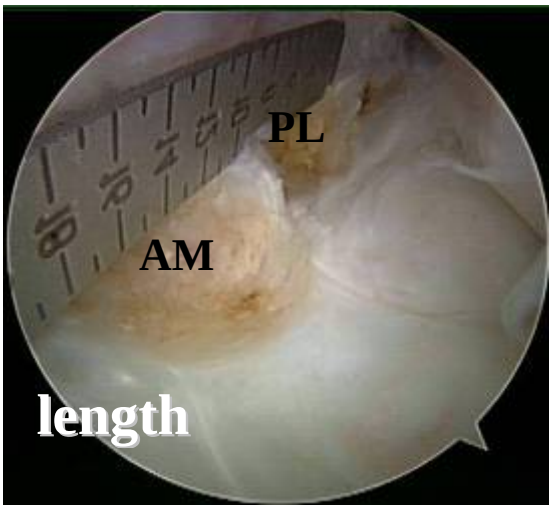


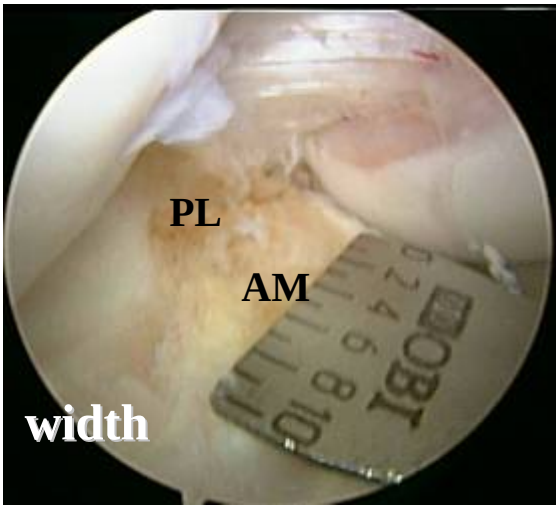
- ACL reconstruction usually takes 60 to 90 minutes.
- First, the insertion sites of both bundles (AM and PL) of the old ACL are first marked on the femur and tibia.
- The injured ACL is then removed with arthroscopic equipment.



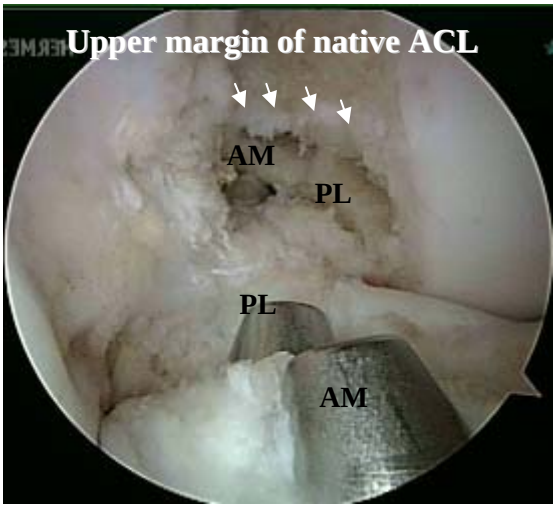


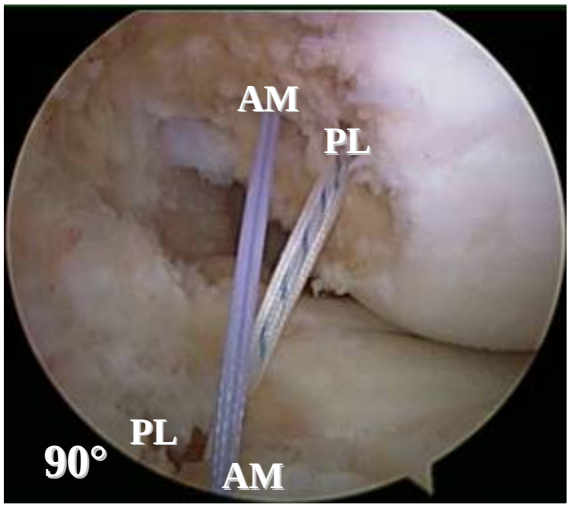
- The insertion areas of the AM and PL bundle are measured to decide what graft size to use for each patient.



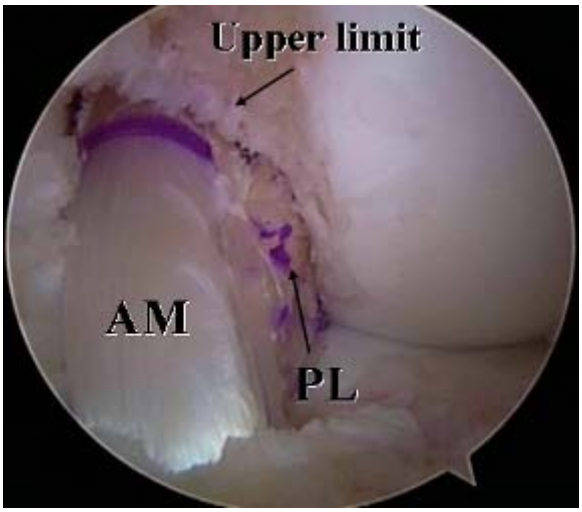


- Care is taken to place the new tissue grafts in the exact position of the original bundles of the ACL, creating an "Anatomic" reconstruction.
- For each bundle of graft tissue (AM and PL) one tunnel is created in the femur and one in the tibia (total = 4).
- Each tunnel measures anywhere from 5 to 9mm in diameter and dictates final graft size
- Guide wires are placed first, to ensure correct tunnel placement, and then the bone is drilled to create the tunnels.

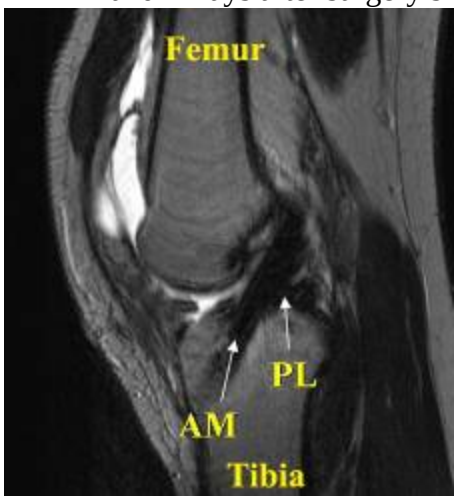




- The grafts are then passed through the tunnels and fixed to the femur and tibia with a combination of special fasteners, screws and sometimes staples:



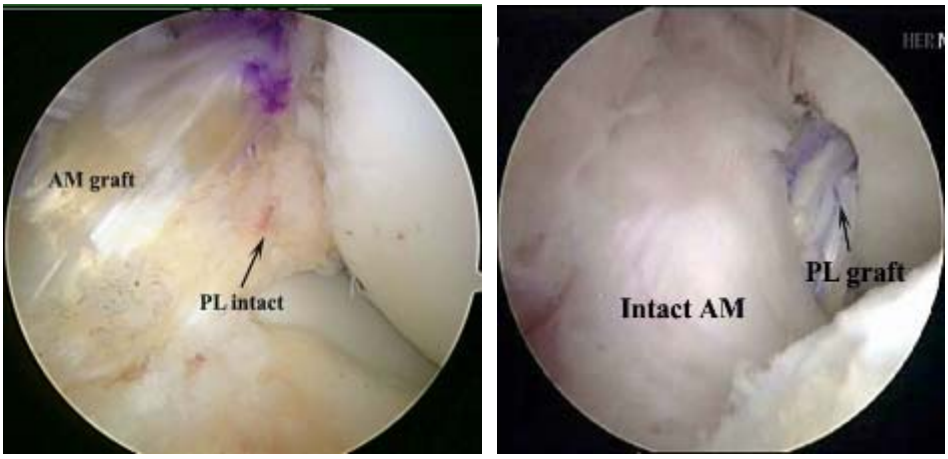
- MRI and X-rays after surgery show the Double-Bundle ACL reconstruction:



- After Double-Bundle reconstruction, we have found most patients to have excellent range-of-motion, typically equal to the other knee. These results are better than with the Single-Bundle ACL reconstruction, and can be seen as early as 1 to 3 months after surgery:

Is it possible to tear just one bundle?

- Yes – this is rare but does happen
- Clinically an isolated tear of the:
    - AM bundle leads to anterior-posterior instability
    - PL bundle leads to rotatory instability
- In this case we can save the intact bundle and "augment" the ACL with a single bundle reconstruction – either the AM or PL… whichever one is torn



- On the left is a picture of a PL intact, AM (only) reconstruction
- On the right is a picture of a AM intact PL (only) reconstruction

Do we perform single bundle ACL reconstruction?

- Yes – we perform single bundle ACL reconstruction in approximately 20 % of the patients.
- Except for the one bundle tear described above, there are a few more scenarios that we prefer to perform single bundle surgery, including
    - Patient has a small native ACL insertion site, which will be identified during the surgery
    - Patient is still growing and their growth plate is not closed
    - Patient has severe arthritic changes
    - Patient who is suffering from multiple ligament injury
- However, unlike the traditional ACL surgery, our single bundle surgery is performed in an anatomic fashion. We will carefully investigate the rupture pattern of the ACL and identify the native ACL insertion site, just like we do in double bundle ACL surgery. Then, the tibia and femur bone tunnels are placed at the center of the native insertion site.

Where do the grafts for ACL reconstruction come from?

- The graft tissue can come from your own body (autograft) or from a cadaver (allograft). At UPMC we most commonly use Hamstring Tendon when autograft is chosen.
- Disadvantages to autograft primarily relate to harvest-site morbidity as well as potential loss of function from the tissue taken.
- Multiple types of allograft tissue are commonly used including Hamstring tendon, Tibialis tendon, and Achilles tendon.
- Allograft tissue is comprehensively screened by tissue banks for diseases such as Hepatitis and HIV, and overall is a safe option for graft tissue. Disease transmission is very uncommon. [19]
- For Double-Bundle ACL reconstruction, allograft tissue is commonly used.

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