G. Charles Roland, MD
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THE SAN DIEGO KNEE CLINIC

KNEE LIGAMENT INJURIES
&
KNEE RECONSTRUCTION

We will be offering counseling on diet and exercise. If interested, please contact my office and schedule a medically supervised *Health and Orthopedic Fitness* assessment appointment which will include a spine and joint health assessment evaluation. This assessment will not be covered by health insurance.

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Knee Ligament Injuries

The modern era has seen a dramatic increase in both competitive and recreational sporting activities by the population as a whole. We have also seen a consequent increase in problems related to knee ligament injuries. Knee ligament injuries are not limited to the athletic population, however, and are commonly seen as a result of industrial or job related accidents. The disability associated with these injuries can be quite severe. The principle disability associated with knee ligament injuries derives from pain and instability of the knee. The term "instability" means a looseness of the knee or a knee which "gives way." In most cases, the more significant the damage to the ligaments, the more significant the accompanying instability.

Most of the stability of the knee is provided by soft tissue structures such as the muscles, tendons, and ligaments, rather than the structure of the bones that make up the joint. The ligaments guide the knee in its normal range of motion and the force for movement is provided by the muscles. It is clear in the orthopaedic literature that abnormal motion in the knee joint can occur when a ligament is injured. Abnormal motion which results from ligament injury (Bollen, 2000), especially when a meniscus is also injured, can lead to premature arthritis. Thus, as orthopaedic surgeons, it is our goal to restore as much normal function and motion to the knee as possible following ligament injury.

Basic Anatomy of the Knee

The knee is the largest and most mechanically complex joint of the body. The knee is particularly susceptible injury. It is situated between the two longest bones in the body (the femur and the tibia), and must support the majority of the body's weight.

The knee is formed by four bones: 1) the femur or thigh bone, 2) the tibia or shin bone, 3) the fibula, which is the small bone on the outside of the tibia, and 4) the patella or kneecap.

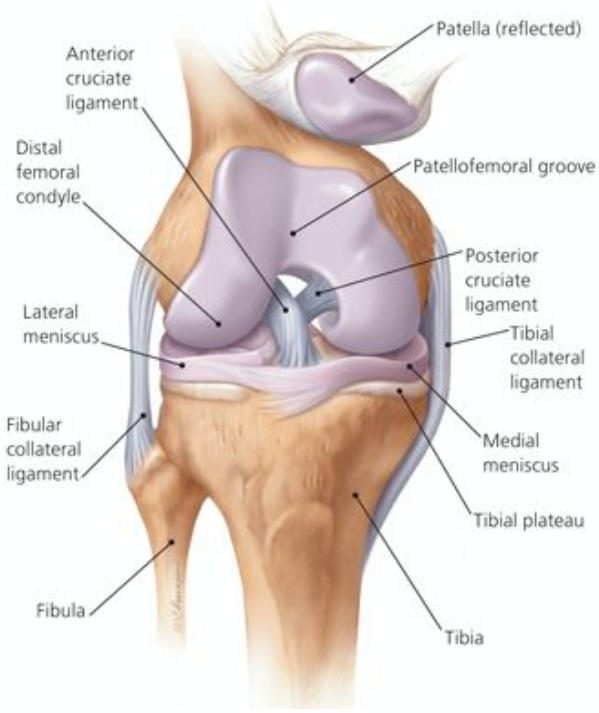


Figure 1. Knee Anatomy

Surrounding the entire joint is a thick fibrous sleeve known as the joint capsule, which provides a considerable degree of stability.

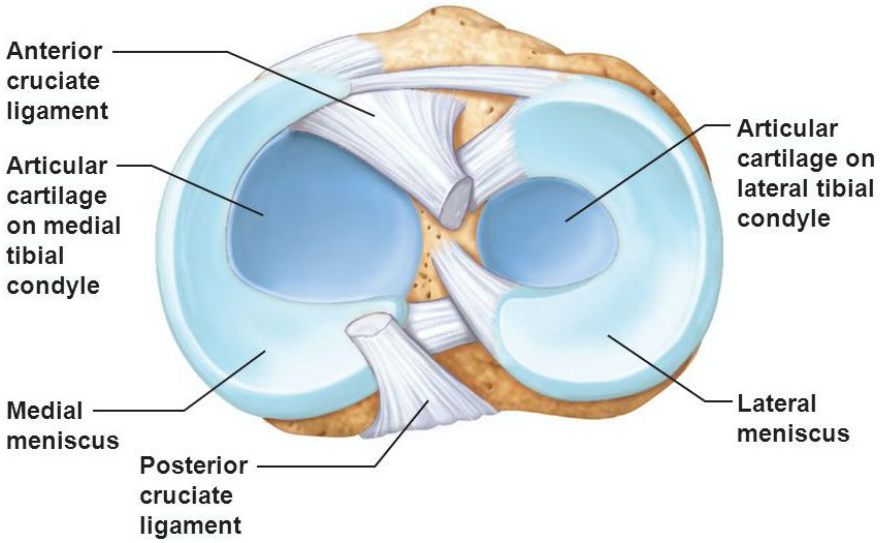


Figure 2. Superior view of the knee joint, menisci, and cruciate ligaments.

As mentioned, the knee relies primarily on muscles, tendons, and ligaments for stability. If the muscles are weak, then the chance of injury is increased. Significant injury to the ligaments can result from direct trauma to the knee, or may be the result of a twisting or cutting type of stress.

This type of injury is common in sports such as football, basketball, soccer, wrestling, and even baseball. These types of injuries also occur in the workplace.

Ligaments connect the bones together and form the joint (Fig 2). The medial collateral ligament connects the inside of the femur to the inside of the tibia. On the lateral or outside aspect of the knee, the lateral collateral ligament connects the femur to the fibula. On the lateral or outside aspect of the knee, the lateral collateral ligament connects the femur to the head of the fibula. These two ligaments are principally responsible for providing medial and lateral or side-to-side stability of the knee.

Three other ligaments located at the back of the knee (Fig 3) also assist the joint capsule in stabilizing the knee: 1) the posterior oblique, which is located on the inside back corner of the knee, 2) the oblique popliteal, which is on the back of the knee and 3) the arcuate complex which is located at the outside back corner of the knee.

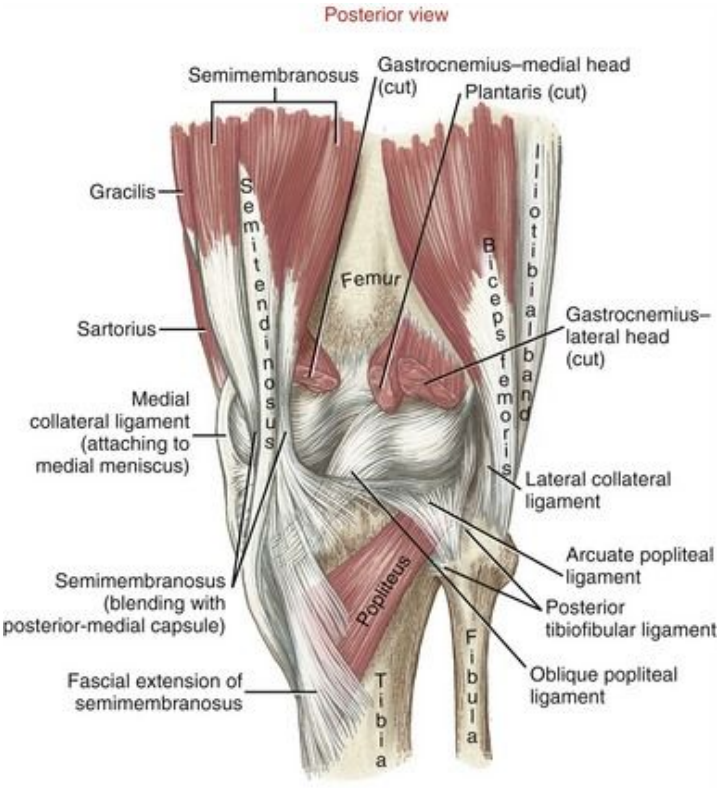


Figure 3. Knee Anatomy Posterior View

The medial and lateral collateral ligaments are more commonly injured. Deep inside the knee are the anterior and posterior cruciates or “crossed” ligaments. They also connect the femur to the tibia and are the principal static dynamic stabilizers of the knee.

They provide anterior and posterior, or front-to-back, stability in the knee, and are principally responsible for guiding normal motion of the knee. The anterior cruciate is the main restraint against the tibia moving too far backward on the femur.

While we consider the knee to be a simple hinge joint, motion at the knee is in fact a complex combination of rolling and gliding and the cruciate ligaments control this motion. When one or more of the knee ligaments is injured or completely torn, the normal motion is compromised and the knee may feel unstable (Figs 4 & 5).

Between the femur and the tibia are the semilunar cartilages, or menisci (Figs 1 & 2). These cartilages act as shock absorbers in the knee, but they also provide congruence between the ends of the femur and the tibia, whose shapes do not match. Injuries of the meniscus are the most common serious knee injuries and can also accompany severe ligament injuries in the knee. As you can see, because of their location, the menisci also provide stability in the joint. Severe damage to the menisci is generally felt to accelerate the aging process in the knee (please see the article on “Arthroscopy and Meniscus Surgery”).

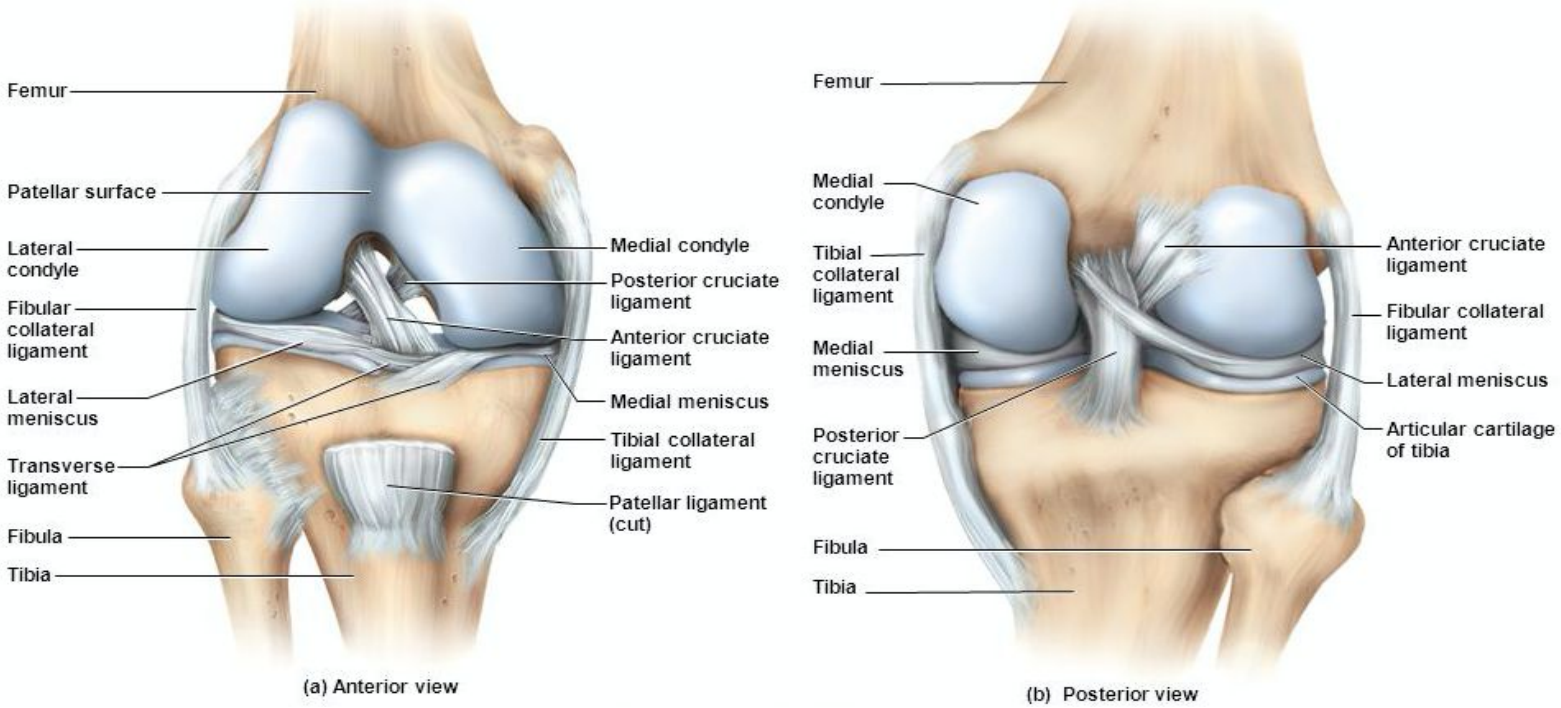


Figure 4. The four major knee ligament relative positions and functional relationships.

The ends of the bones which meet to form the joint are covered by a layer of articular or hyaline cartilage, which is very smooth membrane and provides lubrication for smooth joint motion. Damage to the ligaments or menisci, which leads to abnormal motion in the knee, will cause excessive wear at the articular cartilage, which encourages early arthritis of the knee. One of the reasons it is necessary to prevent abnormal motion of the knee is that articular cartilage has a very poor blood supply and receives most of its nutrition from the pumping action of the knee. Consequently, once severely damaged, the articular cartilage does not normally heal and arthritis with associated swelling, pain, and continued wear of the articular cartilage can develop.

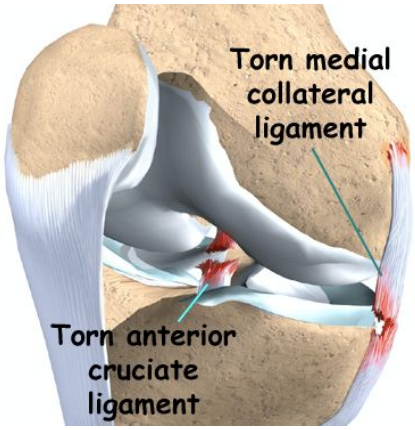


Fig 5. Mechanism of injury to the medial collateral ligament. If the force is sufficient, the anterior cruciate will tear. Meniscus tears and fractures of the tibial plateau are also common with this injury.

Symptoms and Examination of Knee Ligament Injuries

In the patient with an injury to the knee ligament, there is almost immediate swelling and pain. Range of motion is usually limited due to pain. The swelling results from bleeding, which accompanies a tear or rupture of a ligament. If the medial or lateral collateral ligaments have been torn, there may be localized areas of tenderness or either side of the knee. When the patient is first seen in the office, x-rays are always taken. Even though x-rays do not visualize soft tissue well, they still serve a valuable function (Karole, 2011). X-rays help us rule out the possibility of fractures involving the bony structures of the joint. If the patient is able, at least one of the films is taken with the patient standing so we can visualize how the joint performs under normal weight bearing.

One of the most important tools in making an accurate diagnosis is a complete and accurate history. Questions typically asked to obtain the history are as follows: Have you had a previous injury to this knee, and if so what was wrong and how was it treated? How did you hurt the knee this time? Did your knee pop or give way? Were you able to walk immediately after the injury? In many cases, an accurate history is the key to an accurate diagnosis.

After the x-rays and history are obtained, I proceed with a thorough and careful examination of the knee beginning with an inspection of the knee to ascertain the degree of swelling and tissue damage. I always compare the injured knee with the non-injured knee. I also check the pulse at the foot to ensure that no major vascular damage has occurred at the knee. The major vessels and nerves which supply the lower leg pass just behind the knee. In very serious knee injuries the popliteal artery, just behind the knee joint, can be injured. Fortunately, popliteal injuries are rare. I also palpate or feel all the accessible structures of the knee to see if they are tender or if they are in the proper position. Next, the range of motion in the injured knee is checked. With a severe ligament injury, range of motion is usually limited by pain or swelling, but the source or location of the pain tells us which structures are potentially involved. Special “hands on” testing is employed to determine exactly which ligaments are involved. If injury to either collateral ligament is suspected, then I may recommend special stress x-rays using STRESS TECHNIQUES.

It is somewhat more difficult to determine the status of the cruciate ligaments, particularly when dealing with acute or fresh injuries. Swelling, pain and the natural “guarding” of the leg muscles can make effective examination difficult, if not impossible. There are a number of “hands on” diagnostic tests for cruciate ligament

instability. I also use another special test instrument called the KT1000 OR THE ROLAND KNEE LIGAMENT ANALYZING SYSTEM. These devices are more specific for testing the cruciates and secondary ligaments in the front-to-back plane and side to side.

MRI is a very useful tool in evaluating acute and chronic knee injuries and complaints. It is not as accurate as arthroscopy, which looks directly at the knee joint for diagnostic and therapeutic purposes. Arthroscopy is the gold standard.

Reconstructive knee surgery is generally performed using arthroscopic techniques. Arthroscopy is a valuable diagnostic technique when dealing with knee ligament injuries, although in some cases, open surgery may be required for reconstructive purposes. Arthroscopy is a technique where a small, sterile microscope is inserted into the joint space to visualize the various structures of the joint. (For more detailed discussion of arthroscopy, please refer to the article “Arthroscopy and Meniscus Surgery”).

In severe knee ligament injuries where significant damage may have occurred to the joint capsule, arthroscopy is performed and irrigation fluid must be infused into the joint to provide adequate viewing. With a significant ligament or capsular injury, this fluid can leak into the tissues surrounding the knee. This leakage, if excessive, can cause muscle and/or nerve damage that could be permanent. Thus, special attention as to the degree of injury about the knee is given at the time of examination under anesthesia and during arthroscopy so that excess accumulation of fluid does not occur.

Surgical Management of Knee Ligament Injuries

Tears involving the ligaments are classified as sprains. Sprains are divided into three categories. To illustrate the different degree of sprains hold a piece of tissue paper in your hand and slowly begin to pull it apart. As you begin to pull you will first notice a weakening of the middle fibers with some minimal separation; this is a grade one sprain. As you pull more the tissue partially separates; this is a grade two sprain. The treatment approach taken will depend upon the severity of the sprain. Grade three sprain is a complete rupture of the ligament.

One of the most common injuries is a blow to the outside of the knee which forces the knee inward and tears the medial collateral ligament (Figs 5 & 6).

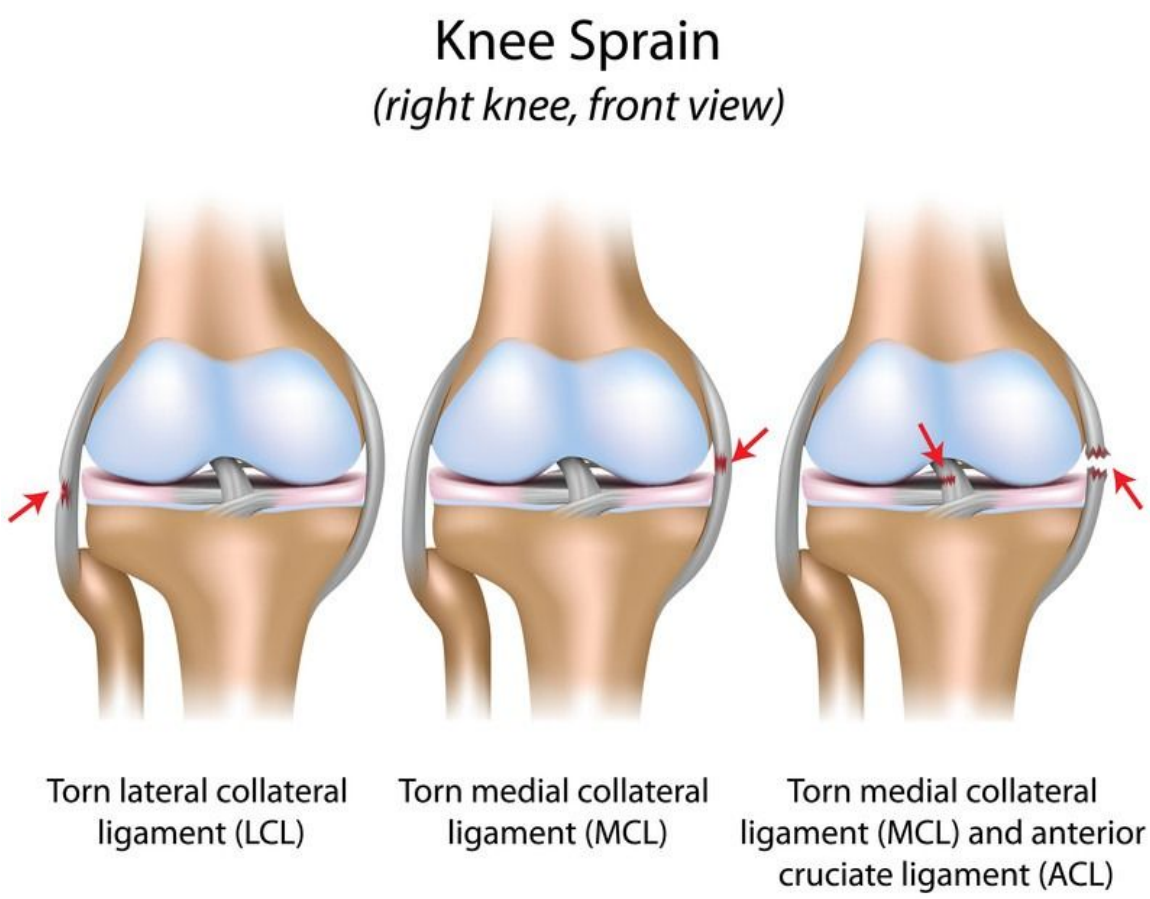


Figure 6.Lateral Collateral Ligament, Medial Ligament, Anterior Cruciate Ligament

With an isolated grade one and two medial collateral ligament sprain, and only the medial collateral ligament is involved, the injured knee is initially immobilized and iced to reduce swelling. Once the swelling is reduced, a progressive exercise program is started within the patient's tolerance. The level of activity is gradually increased and in 6 to 8 weeks, the patient is returned to normal activity. If pain or swelling develop upon return to increased normal activity, then the activity is moderated until tolerated without symptoms. If there is an isolated grade three tear of the medial collateral ligament without a meniscus tear, the limb is immobilized rigidly for 4 to 6 weeks to allow the ligament to begin healing. A gradual rehabilitation program is then begun to restore strength and range of motion. A return to full activity is permitted only when there is no pain or swelling, and full strength has returned.

In some cases of isolated medial collateral ligament tears with significant instability and especially with bone involvement, the torn ligament must be repaired or reattached to bone. In many cases, the medial meniscus also tears when the ligament is torn. In these cases, an attempt will be made arthroscopically to repair and reattach the

meniscus to its normal position. With severe ligament involvement, both the meniscus and ligament are repaired through a large incision if other structures are also injured which is consistent with a knee dislocation. If irreparable, the torn portion of the meniscus is removed.

Injuries of the lateral collateral ligament are less common, but the treatment parallels that for the medial collateral. Any repair of a grade three tear in the collateral ligament will always be performed through an open incision called arthrotomy. Techniques for performing extensive lateral collateral ligament repairs through the arthroscope have yet to be developed satisfactorily.

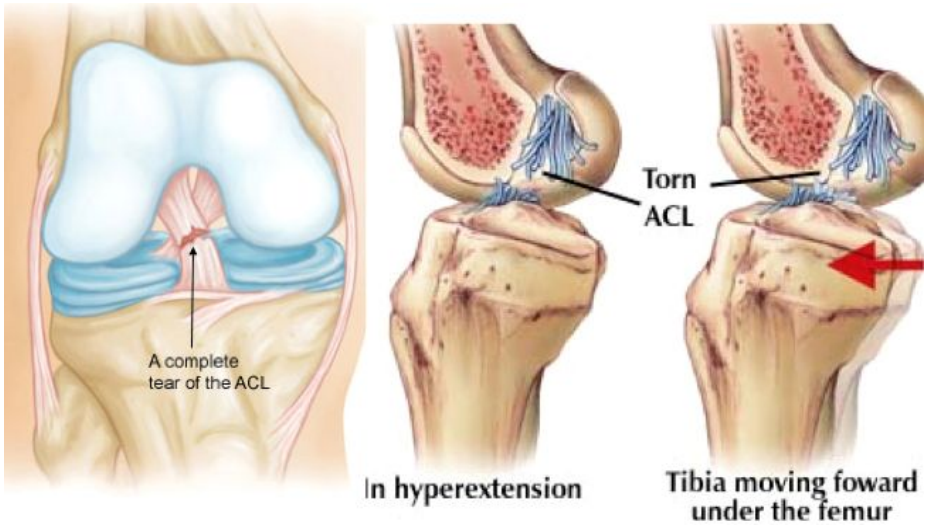


Figure 7. Anterior cruciate ligament tear.

Many knee ligament injuries involve at least a partial tear of the anterior cruciate ligament (Fig 7). The anterior cruciate ligament may be torn when you cut, pivot, twist, or decelerate suddenly on a fixed foot. The anterior cruciate may also be torn as a result of a large amount of stress to the medial knee. In about half of all anterior cruciate ligament tears, a meniscus is also torn. Many times the meniscus tear will heal without surgical repair. An attempt is made to arthroscopically repair the meniscus tear at the time of surgery if possible. If irreparable, the torn portion of the meniscus is excised. The management of the cruciate ligament injury will depend upon the nature and extent of the damage and the desires of the patient.

In the current literature, there is a significant dispute regarding the optimum treatment of anterior cruciate ligament tears. In the case of an isolated complete anterior cruciate ligament tear, some physicians prefer to treat the injury with immobilization while

others routinely recommend immediate surgery. Still others recommend immediate repair using some form of natural or artificial graft material. Most agree, however, that if the attachment is torn away with bone attached, then the area of bone attachment is surgically drilled and the ligament is reattached to the bone using sutures. With an acute or fresh injury, with bone avulsion, I personally recommend a direct repair of the torn ligament-bone complex to preserve as much normal function as possible.

Most common is the anterior cruciate ligament (ACL) tear in its midsubstance. In this instance, when the injury is fresh or acute, the ligament can be sutured back together tightly using a suture material which will be absorbed after a period of a few weeks.
I have performed several arthroscopic reconstructions of both acute and chronic anterior cruciate ligament complete tears. The arthroscopic approach offers the advantage of avoiding larger incisions at the medial (inside) aspect of the knee, potentially disrupting the normal function of the patella.

Figure 8. ACL Surgery

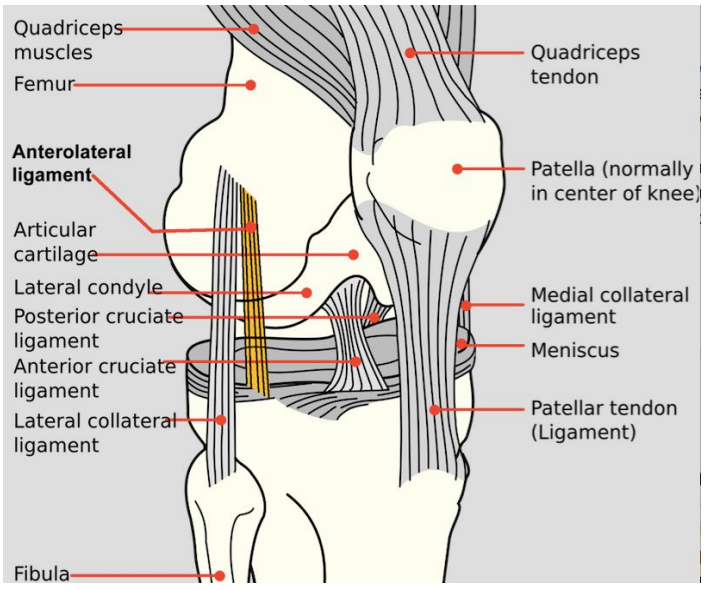


Figure 9. Anterolateral Ligament (marked in yellow)

The reconstructive technique is demanding and requires a graft taken from local tissues such as the patellar tendon or the hamstring. A lateral anterolateral ligament (ALL) reconstruction and/or the Andrews procedure is also optionally done to reinforce the structural integrity of the anterior lateral knee, assuming the ALL has been torn along with the ACL. The ALL provides extra support in controlling the anterior and rotatory movements of the knee.

It is connected to the femur and the lateral collateral ligament (LCL). The ALL has two distal connections, one linking to the lateral meniscus and the second links to the Gerdy tubercle on the tibia and the fibular head. It is present in the anterolateral region of the knee. Thus when moving distally, the ALL will bifurcate at close to half of its length.

The repair and reconstruction of a complete anterior cruciate ligament rupture is a frequent technique performed in orthopaedic surgery. Nevertheless, a recent study published in *Orthopaedic Journal of Sports Medicine* showed that a great number of patients still have residual anterolateral rotatory laxity after reconstruction, despite the advances in fields of surgical techniques and implants (Helito, 2013).

At the time of surgery, the torn irreparable anterior cruciate ligament is removed. The remainder of the technique is unchanged from the open technique. Occasionally the arthroscopic technique is technically unable to be performed and the open technique is performed with a local graft. If only the anterior cruciate ligament is repaired without grafting at the time of surgery, then the patient will likely have residual instability over time. Thus, in addition to a direct repair of the torn cruciate ligament, I usually have performed an Andrews-like procedure which is an extracapsular substitution. Extracapsular substitution means to relocate one or more tendon structures outside the lateral joint (most commonly the iliotibial band), and transfer it to a position where it can biomechanically assume part of the function of the anterior cruciate ligament and the anterolateral ligament. I have used more than one technique, but the procedure I most commonly perform is called the Andrews Procedure, in which one-third of the iliotibial band is fastened to the femur after externally rotating the tibia; in essence, providing an external ACL/anterolateral ligament. A screw is often used for fixation but depends on the techniques used, which are variable. This procedure helps keep the anterior lateral tibia from sliding forward and also decreases the strain on the repaired or reconstructed anterior cruciate ligament.

New studies done by Van der List, MD at Cornell University describe the technique of anterior cruciate ligament primary repair without using allograft or autograft. Van der List reports a high degree of success in primary repairs of the ACL, especially proximal complete ACL tears and distal ACL repairs with bone avulsion (List, 2016).

Injuries to the posterior cruciate ligament are fortunately far less common than anterior cruciate ligament injuries. In injuries of the posterior cruciate, it is possible to avoid a surgical repair if the patient is willing to assume a semi-sedentary lifestyle. However, if the patient wants to return to an active athletic lifestyle then, in my opinion, a direct aggressive surgical approach is indicated in an acute or fresh injury, especially when a

piece of bone is attached to the torn posterior ligament. The surgical approach is from the back of the knee and an extracapsular reinforcement is provided by the gastrocnemius muscle. The ligament is reattached to the bone, and any other damaged structures are also repaired at the time of surgery. An arthroscopy is also performed initially.
Artificial synthetic cruciate ligament grafts are being experimentally used and the long term success rate is quite low.

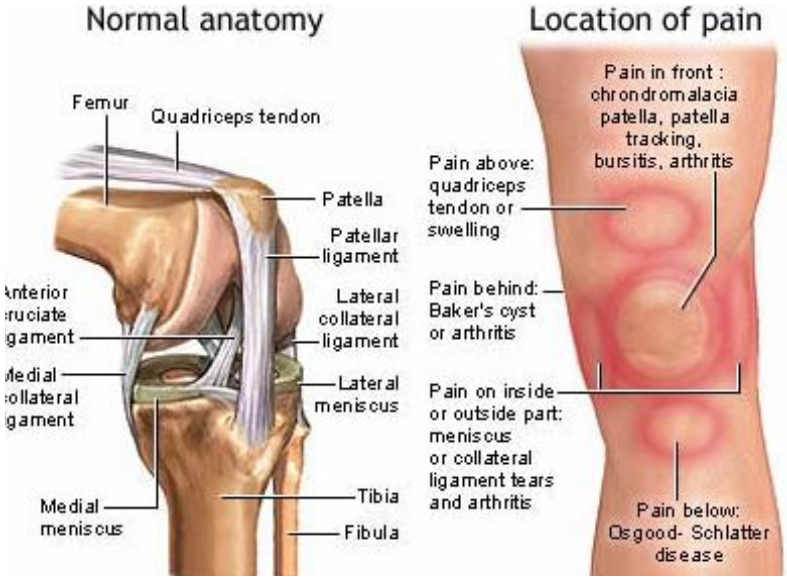
The meniscus is also very important to knee stability. In all knee ligament injuries the status of the menisci is always evaluated. The worst case encountered is when both a meniscus and a cruciate ligament are torn and not treated (Sandmann, 2013). This combination leads to increased instability of the knee and abnormal wear of the articular cartilage leading to premature arthritis. It is more common to see severe post traumatic arthritis in these cases. The onset of premature arthritis is probably faster in the athlete who returns to vigorous activity, particularly contact sports, when the knee remains unstable. In the long term this patient is likely to have significant instability with a high probability of premature posttraumatic arthritis.

Conservative management is an option for less active patients with an isolated anterior or posterior cruciate ligament tear. In these cases, an arthroscopy is performed to evaluate the cruciate ligament tear and meniscus, but no reconstruction of an isolated cruciate tear is done.

If the meniscus tear is identified at this time, it is repaired or excised (Cavanaugh, 2012). The knee, when the meniscus is repaired, is immobilized for a period of 4–6 weeks, then progressive rehabilitation to restore strength and range of motion follows. This option particularly applies to people whose occupation or athletic endeavors do not place an undue amount of stress on the knee. At the end of rehabilitation, the knee is evaluated for functional stability. which affects activity. A later reconstruction of the torn ligament can be performed. Studies are being carried out across the country which will help decide the efficacy of this conservative approach in the sedentary individual.

In chronic or old injuries of the anterior cruciate, it is not possible to directly repair the ligament. Thus, the treatment will depend upon the type and degree of the problem and the ligament(s) involved. Presently in chronic cases, tendons are usually transferred arthroscopically into the interior of the knee joint to replace the cruciate ligament. Extracapsular substitutions are also performed to add additional stability to the knee. The same operative procedures are also followed as previously described.

Tears of the lateral meniscus with ligament injuries are also less common than tears of the medial meniscus, but are seen in conjunction with severe knee ligament injuries. Tears of the lateral meniscus are difficult to treat surgically because it is difficult to isolate the meniscus from vital structures near the back of the knee, particularly the nerves and arteries that feed the lower leg. New technologies and approaches are evolving with repair of the lateral meniscus, however the surgical approach can be quite extensive and the patient much understand the potential risk to the nerves and arteries in this region. Usually, these tears are left alone if based near the capsule blood supply; most will heal without direct surgery. If they do not heal, an arthroscopy is performed later with either attempted repair or partial meniscus removal.



In severe knee ligament injuries, lateral or outward dislocation of the patella can also occur. In fact, patellar dislocations are sometimes mistaken for ligament injuries, so careful diagnosis is vital. There is disagreement in the current literature regarding the optimum treatment for a dislocated patella.

Figure 10. Quadriceps and Patellar Tendon Injuries

With patellar dislocations, the more traditional approach is a nonoperative approach in which the leg is casted for a period of 4 to 6 weeks. Following casting and physical therapy, bracing with a special patellar stabilizing brace is undertaken. If this method fails, and a continued or chronic patellar subluxation-dislocation occurs, then we may proceed with patellar stabilizing surgery.

There is another school of thought which disputes this conservative approach and recommends an immediate surgical approach in the attempt to avoid later problems. In the patient with a severe lateral dislocation of the patella with obvious tearing of the medial retinacular tissues, which stabilize the patella. It is my opinion that in this type of injury, in about 20% of the cases, loose pieces of bone are chipped from the underside of the patella and require removal. The correction surgery for this injury usually involves

an incision on the medial or inside of the knee, and suturing of the torn tissues to reposition the patella and/or stabilize the patella by restoring the ALL ligament with an autograft or allograft. In some cases, simple arthroscopy is required to remove only the bony fragments and a trial of conservative treatment is instituted.

The diagnosis of quadriceps and patellar tendon ruptures demands detailed record-taking and medical evaluation for the accurate evaluation of the tendon injuries. Tears of patellar tendon may be caused by either a very strong force, such as falling, bending, and jumping, or from inflammation, disease, steroid use, or previous surgery in the tendon area, which may put the patient in higher risk for tear. The initial findings of patellar tendon tears are a popping sensation, pain, swelling, difficulty walking, and one's inability to strengthen the knee. Partial tears are also common and are called "Jumper's knee" and are quite difficult to treat.

The complete tear diagnosis is usually based on physical exam, x-rays, and MRI. The patient usually demonstrates an inability to straighten the knee. For complete ruptures, immediate surgery is indicated and reattachment of the tendons is performed followed by immobilization. In some cases, tendon grafts are required in massive tears and/or when the injury occurred several weeks or months prior.

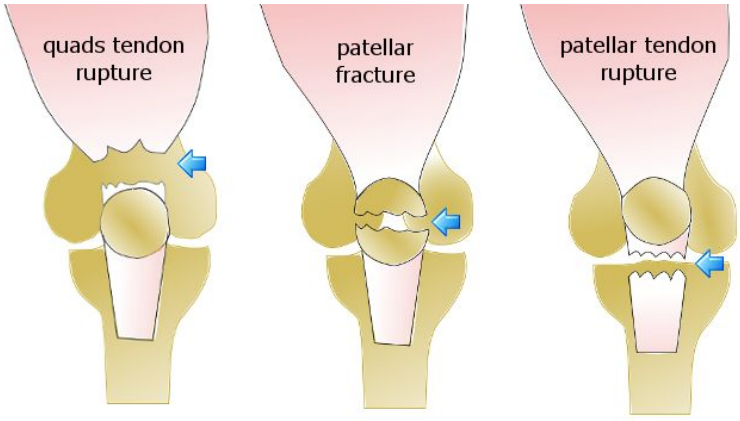


Figure 11. Quadriceps and patellar tendon rupture

Postoperative Care of Knee Ligament Injuries

After a knee ligament repair or reconstruction, the patient's limb is immobilized rigidly in an immobilizer followed by an adjustable brace for a period of 4–8 weeks, depending upon the injury and surgical treatment. This initial immobilization allows healing of the ligament to occur without the stresses induced by active motion. Following this early period, a brace that allows a controlled degree of motion will be fitted and a comprehensive rehabilitation program will be started under the supervision of a licensed physical therapist. Rehabilitation is exceedingly important. The strength that

was lost following the injury must be restored. Restoration of strength is vital since the large muscles that cross the knee are principal stabilizers of the knee and provide as much as 50% of knee stability when the muscles are contracted. A supervised physical therapy program also stimulates nerves that may not be functioning normally after surgery. The patient is not allowed to return to full activity until full strength is restored. I often recommend a repeat MRI to assess the degree of healing. Otherwise, he or she is liable to reinjure the knee if complete healing has not occurred..

A knee brace is recommended for the first 6 months following the start of physical therapy. Theoretically, maximum ligament healing in terms of strength is accomplished at one year following surgery, and the brace is no longer needed after this time (Mangine, 2008). As mentioned earlier, the surgical repair is an attempt to restore stability at the joint. In the first 6–12 month period following surgery the brace serves to provide a gradual, controlled return to full range of motion. The brace also serves to guide the motion of the knee and to protect it from stresses which might reinjure the ligament. Many patients will continue to use a knee brace even after the initial one year period, as some patients will have residual instability of the knee.

It is important that each patient realize the limitations of the bracing and their own limitations following a severe knee ligament injury. While an important adjunct to treatment, the knee brace is the least important component of the rehabilitation process. The brace will provide some functional stability and will act as a constant reminder to the patient to protect the knee. The brace protects you from ordinary stresses which might overstress the operated ligament, but the brace will not protect you from extraordinary stresses. Because of the shape of the leg combined with muscular contractions, most patients will experience brace migration or the tendency of the brace to slide down the leg. And though all manufacturers strive to reduce bulk, most knee braces do tend to be bulky and may affect speed, agility, or gait.

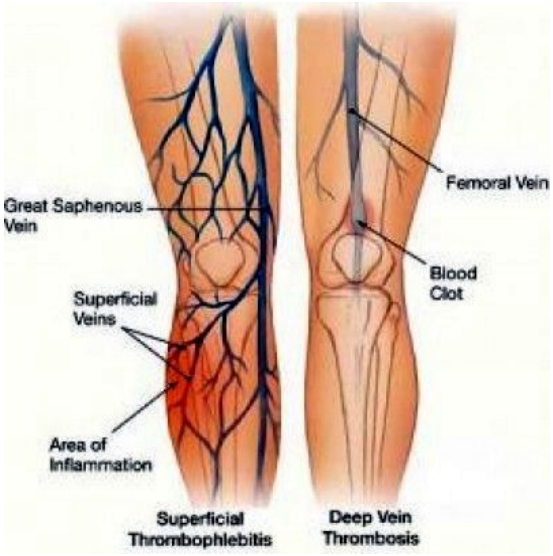


Figure 12. Inflamed Knee

Thus, it is important to observe the following keys to return to improved function following a major knee ligament injury:

1. Participation in a comprehensive rehabilitation program designed to return strength, flexibility, and neuromuscular control to the limb. Even after the supervised rehabilitation has ended, the patient must keep the muscles of the upper and lower leg strong, as they are prime stabilizers of the knee.

2. A lifestyle modification is indicated, particularly for those people involved in contact sports. Those patients who have suffered injury to multiple ligaments are not encouraged to return to contact sports, even if a protective brace is permitted.
This does not mean that you should become an invalid following a severe ligament injury. There are many sports in which you may compete at a high level without undue risk to the repaired knee.

3. The use of a knee brace during activities in which the knee may be particularly vulnerable is also indicated to protect the knee.

As with any surgery, there are risks connected with reconstructive surgery of the knee. Fortunately, there are few. The principal risks are infection, phlebitis and/or clot formation in the veins, and nerve injury. Strict sterile technique is always used in surgery, accompanied by the liberal use of intravenous antibiotics, and antibiotic solutions to irrigate the joint at the time of surgery. In spite of all precautions, infections do sometimes occur, though they are rare. Most of these infections are handled quite well by oral antibiotics. If a deep infection, which does not respond to an oral antibiotic, does occur, the patient is readmitted to the hospital and intravenous treatment with antibiotics is begun. In rare cases, repeat surgery may be required.

Phlebitis or inflammation of the vein with clot formation may also occur. These clots can break loose and travel to the heart or lungs. This is known as an embolus and can be fatal. This problem is more prevalent in patients over the age of 40, or those who have varicose veins. In these patients I recommend that they take one non enteric coated aspirin in the morning on the day prior to surgery and continue this through the period of immobilization. Aspirin is an effective anticoagulant or blood thinner. In those patients with severe varicose veins, a more powerful anticoagulant may be recommended and started prior to surgery and continued for a few weeks after.

In the leg, nerve problems are usually the result of swelling after surgery. Nerves in the skin are cut during major ligament surgery, which can leave some numbness about the

knee and calf. At the time of surgery, bleeding is controlled with the use of a tourniquet and coagulation techniques. Small drains are occasionally used but rarely for about 24 hours postoperatively to help reduce swelling.

In very serious acute or chronic knee ligament injuries, experimental artificial grafting materials have been used in place of, or as a buttress for, repaired ligaments. However, there is no substance presently available, artificial or otherwise, which has been shown to be significantly better than the reconstructive techniques currently employed. Work is also being done on artificial substitutes for the meniscus, but as yet we have produced no workable reliable artificial replacement.

Cadaver grafts or so called allografts are currently being used for stabilization as well. The risk of failure is slightly higher when using these grafts for ACL surgery. There also is a slight chance of the graft being infected prior to surgery, which would lead to a surgical infection post operatively. The occurrence is quite low, though. My philosophy is that the graft should be obtained from the patient's own body, which has been shown to provide the best results in terms of failure rate and infection.

Each individual knee injury is unique, as are the needs and desires of each individual patient. Since each patient will progress as a different rate, return office appointments are imperative to evaluate your individual recovery. These return visits are also essential in order that we may be able to perform long term evaluation for the various types of techniques used. This long term follow up is essential if we are to continue to improve patient care.

Severe knee ligament injuries can have serious long-term effects. The approach we employ is designed to attempt to return normal function to the knee. Return to 100% of normal function cannot presently be expected, but occasionally occurs, including a return to vigorous sports. The current literature states one can expect 80% of the patients to return to a Good/Excellent level using the previously described techniques. The remainder of patients require continued treatment with a brace or even future surgeries. In cases where severe degeneration of the joint has occurred, an artificial or prosthetic knee joint may be required.

Platelet Rich Plasma

Platelet Rich Plasma (PRP) is a new technique we are using to promote faster and better healing after knee surgery especially in meniscus surgery. As there is evidence that PRP may accelerate the healing of residual meniscus tears in the knee. **Platelets** consist of proteins, cytokines, and other bioactive factors located in the peripheral

blood. They contribute to the regulation of homeostasis and promote wound repair. **Plasma** contains clotting factors, proteins and ions. Recent literature suggests that for optimal therapeutic purposes physicians should use a platelet concentration of
1 million platelets per microliter and a 3- to 5-fold increase in growth factor concentration and cytokines" (Mehta, 2008). In the plasma, numerous proteins are contained, such as insulin-like growth factor (IGF), platelet-derived growth factor (PDGF), platelet factor interleukin (IL), platelet-derived angiogenesis factor (PDAF), epidermal growth factor (EGF), transforming growth factor (TGF), vascular endothelial growth factor (VEGF), and fibronectin (Lubkowska, 2012). In the dense granules of platelets such bioactive factors are also found, specifically calcium, dopamine, serotonin, histamine, and adenosine. Such non-growth bioactive factors control inflammation, proliferation, and remodeling in the process of wound healing (Boswell, 2012). PRP is also used in an attempt to slow down the arthritic degeneration process, preserve chondrocytes which are cartilage cells that line the joint. PRP also stimulates ligament, tendon tissue repair, and meniscal healing.

German and Swiss scientists confirmed that PRP percutaneous injections release therapeutic properties for pain relief and promote the decrease in grade 2 meniscal lesions progression in patients over the 6 months time period (Blanke, 2015).

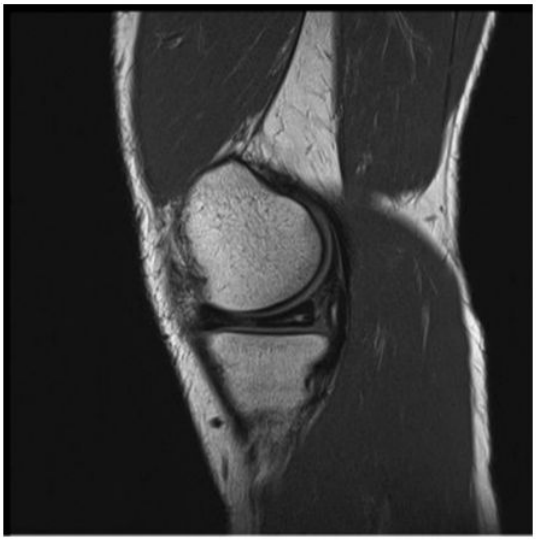


Figure 1. Meniscal lesion before injections (patient 7).

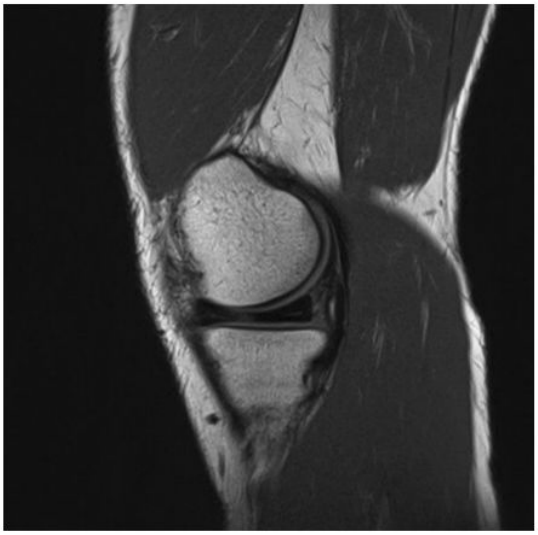


Figure 2. Meniscal lesion 6 months after injections (patient 7).

Image Source: Blanke, F., *Percutaneous injections of Platelet Rich Plasma for treatment of intrasubstance meniscal lesions.* Muscles, Ligaments and Tendons Journal 2015;5 (3):162-166

Another study on animals treated with PRP injections for meniscal tissue defects revealed the curative properties of PRP of the inner, avascular meniscus. Subjects treated with PRP showed significantly greater scores for the number of fibro-chondrocytes and production of extracellular matrix compared to the control group (Ishida, 2007). Moreover, several studies suggest the additive effect of PRP-containing growth factors for increased meniscal cells activity and augmentation of meniscal repair and healing during horizontal cleavage meniscal tears repaired via an open surgery. A team of surgeons from France in one such study invited 17 patients for open meniscal repair surgery of horizontal tears extending into the avascular zone-Group 1, and additional 17 patients underwent same surgery with introduction of PRP injections at the end of the open meniscal repair-Group 2 (De Chou, 2015).

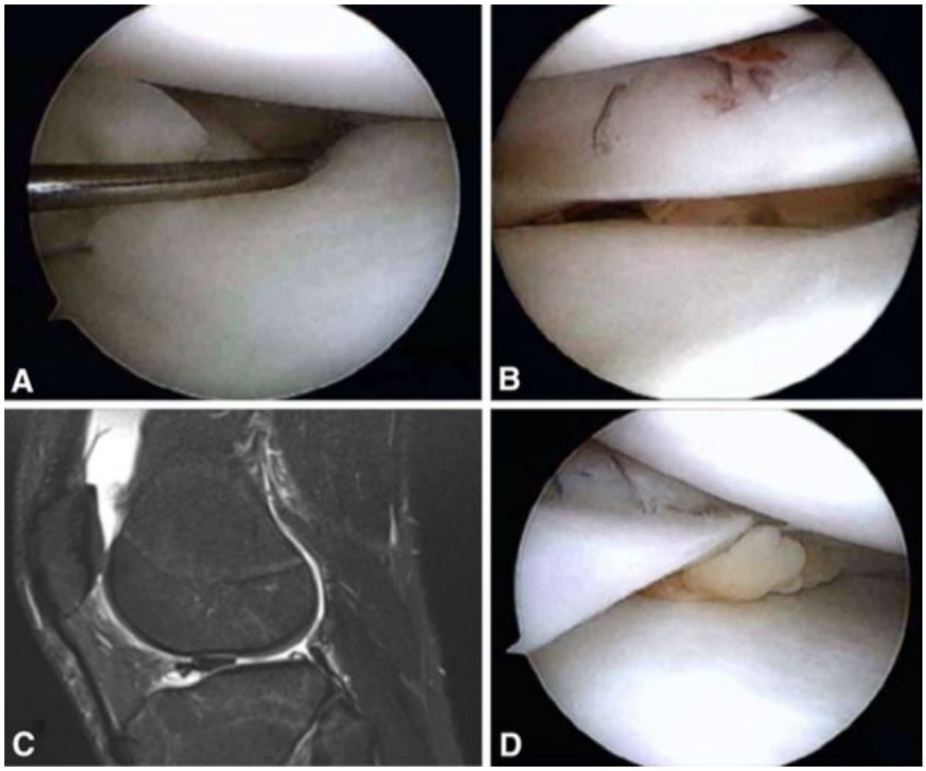


Fig. 1A–D (**A**) An intraoperative image of a displaced meniscus tear is shown. (**B**) An inside-out repair is performed with PRP augmentation. (**C**) MRI demonstrates a bucket-handle lateral meniscus tear and (**D**) PRP augmentation of this meniscus repair.

Source: Griffin, J.W., et al. *Platelet-rich Plasma in Meniscal Repair: Does Augmentation Improve Surgical Outcomes?* Clinical Orthopedics and Related Research. 2015. 472: 1665-1672.

The MRI results of this study demonstrated that 5 patients from Group 2 had full disappearance of hypersignal within the repaired meniscus at 24 months postoperative time-frame (De Chou, 2015). Such evidence suggest the additive effect of PRP to improve outcome results after open meniscal repair surgery. Due to patient's individual meniscal injury variations, PRP can be injected in the knee at the time of surgery or fairly soon after surgery. Meta-analysis of PRP technology confirms that PRP treatment promotes more robust healing in an attempt to preserve the meniscus tissue and to provide faster and better healing of the residual meniscus and knee joint tissues, including the ACL and PCL ligaments.

Currently health insurance coverage does not pay for PRP treatment. We will discuss various payment options to receive this treatment if it is felt to be advantageous to your condition(s).

Hyaluronic Acid

Hyaluronic Acid (HA) is also used in either post-surgery cases or in non-surgical cases applied within the joint to ameliorate arthritis-associated pain.

Hyaluronate or hyaluronan is contained in cartilage and the synovial fluid. HA is a large viscoelastic glycosaminoglycan molecule that is contained in synovial fluid and cartilage matrix. Chondrocytes (cartilage cells), fibroblasts (collagen producing cell) and the synovial cells all secrete HA into the joint. HA Is approved by the The Food and Drug Administration (FDA) and is either generated from bacterial fermentation in vitro or from harvested rooster combs. Such HA contain Hylan G-F 20, sodium hyaluronate, and high-molecular weight hyaluronan (McArthur, 2012). In healthy patients, synovial fluid contains a normal HA amount or concentration and serves as a viscous lubricant for healthy knee movements, much like a lubricant in a car.

There is a decreased amount of HA in the synovial fluid of OA patients (Trigkilidas, 2013). In OA patients the synovial inflammation contained in proteases, free radicals, and cytokines leads to the disruption of organic HA synthesis and contributes toward the progression of OA (Brockmeier, 2006). A healthy level of HA is crucial in providing anti-inflammatory properties to regulate cartilage homeostasis, and to slow the chondrocyte apoptosis (cell death) which occurs with OA.

Stem Cell Technology

Mesenchymal stem cells (MSCs) exhibit properties both in multipotent differentiation (cells that may develop into more than one cell type) and immunomodulation (immune response alteration to a desired level) (Wyles, 2015). Based on these unique properties, stem cells have the therapeutic potential to treat osteoarthritis (OA). Since 1990 there have been promising clinical trial results from the U.S., India, Germany, Singapore, and Iran that the intra-joint injection of MSCs can be an effective therapy for treating OA (Sarabi, 2016). Furthermore, clinical trials in Spain have illustrated MSCs injected with more advanced stem cells technology for localized treatment of OA, using bioabsorbable material (hydrogel) as a vehicle carrier (Lamo-Espinosa, 2016). Many of these clinical trials were performed with bone marrow derived MSCs, but other MSCs derived from adipose and the umbilical cord can also have great potential to treat OA, as they share similar characteristics to bone marrow MSCs (Uth, 2014). In general, adipose and umbilical cord MSCs have a higher culture life expansion potential (have a higher duration to secrete regenerative factors) and may be more readily available, but not necessarily exhibit strong therapeutic regenerative (ability to heal damaged tissue) potential as BM-MSCs.

Interestingly, both allogeneic (donor cells) and autologous (host cells) MSCs have therapeutic potential to treat OA, and it may be that allogeneic MSCs may be a more convenient “off-the-shelf” therapy to utilize due to the immune-evasive nature of MSCs lacking HLA antigens (does not stimulate the host immune response as a foreign substance) and other co-stimulatory molecules to elicit an immune rejection response (Gupta, 2012). Lastly, dosages from 10–100 million MSCs per intra-articular injection are recommended for a therapeutic response to treat OA corresponding to the severity of disease or injury, and the patient’s Body Mass Index (BMI) (Lamo-Espinosa, 2016), but potentially a smaller dosage of MSCs could be used in a scaffold (hydrogel) to have a stronger localized treatment effect.

I consider the stem cell technology as a new technique in orthopedic surgery, aimed to rejuvenate joint and body parts. We are currently researching the use of stem cell techniques in joints, muscles, and tendons. It appears based on the current literature that the technique is promising. We are moving forward, starting to apply the stem cell technology in practice. And I am currently using advanced arthroscopic techniques to stimulate the body’s own stem cells, while performing various complex surgical arthroscopic procedures.

REFERENCES:

1. Baugher WH. White GM. *Primary evaluation and management of knee injuries.* Orthop Clin North Am 1985; 16(2):315.
2. Bin, S., et al. *Surgical Outcome of 2-Stage Management of Multiple Knee Ligament Injuries After Knee Dislocation.* Arthroscopy: The Journal of Arthroscopic and Related Surgery, 2007(23): 10. 1066-1072. Web. http://docplayer.net/25465658-Traumatic-dislocation-of-the-knee-confirmed-by-surgical-outcome-of-2-stage-management-of-multiple-knee-ligament-injuries-after-knee-dislocation.html
3. Kalore,NV.,Gioe TJ.,Singh,JA., *Diagnosis and Management of Infected Total Knee Arthroplasty.* The Open Orthopaedics Journal. 2011; 5: 86–91. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3092427/
4. Brindle, T., Nyland, J., Johnson, DL., The Meniscus: Review of Basic Principles With Application to Surgery and Rehabilitation. The Journal of Athletic Training. 2001 Apr-Jun; 36(2): 160–169. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC155528/
5. Butler DL, Noyes FR, Grood ES. Ligamentous restraints to anterior posterior drawer in the human knee. J Bone Joint Surg Am 1980;62-A:259.
6. Cavanaugh, JT., Kilian, SE., *Rehabilitation following meniscal repair.* Current Reviews in Musculoskeletal Medicine. 2012 Mar; 5(1): 46–58. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3535118/
7. Cox, CL., Spindler, KP. *Multiligamentous Knee Injuries – Surgical Treatment Algorithm.* North America Journal of Sports Physical Therapy. 2008 Nov; 3(4): 198–203. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2953345
8. David, G., et al. Rheumatoid Arthritis and Joint Replacement: Impact of Biologics. The American Journal of Pharmacy Benefits. 2014. 256-264
9. DeGrace,DM. *Analysis of Medial Collateral Ligament Injuries of the Knee.* The Orthopaedic Journal. Harvard Medical School. 2013. 15. Web. http://www.orthojournalhms.org/volume15/research/deGrace_MCL.html.
10. Devgan, A., et al. *A prospective study to evaluate the clinico-radiological outcomes of arthroscopic single bundle versus double bundle anterior cruciate ligament reconstruction.* Journal of Clinical Orthopaedics and trauma. 2016. 236-242
11. Girgis FG, Marshall JL, Al Monajem ARS. The cruciate ligaments of the knee joint. Anatomical, functional and experimental analysis. Clin Orthop 1975;106:216.
12. Hughston JC, Andrews JR, Cross MJ, Moschi A. Classification of knee ligament instabilities: part I. The medial compartment and cruciate ligaments. J Bone Joint Surg Am 1976;58-A.159.

13. Hughston JC, Andrews JR, Cross MJ, Moschi A. Classification of knee instabilities: part II. The lateral compartment. J Bone Joint Surg Am 1976;58-A:17.
14. Hughston JC, Eilers AF. The role of the posterior oblique ligament in repairs of acute medial (collateral) ligament tears of the knee. J Bone Joint Surg Am 1973;55-A:923.
15. Kaplan EB. Some aspects of functional anatomy of the human knee joint. Clin Orthop 1962;23:18.
16. Kristjansson, B., et al. *Current Perspective in Mesenchymal Stem Cell Therapies for Osteoarthritis.* Stem Cell International. 2014, 13
17. Van der List, JP., et al. *Preservation of the Anterior Cruciate Ligament: A Treatment Algorithm Based on the Tear Location and Tissue Quality.* The Orthopedic Technologies and Techniques. 2016. e393-e405
18. Mangine, RE., Minning, SJ., Eifert-Mangine, M., Colosimo, AJ., Donlin, M., *Management of the Patient with an ACL/MCL Injured Knee.* North American Journal of Sports Physical Therapy. 2008 Nov; 3(4): 204–211. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2953343/
19. Matsushita, T., et al. *Factors Associated with the Status of Meniscal Tears Following Meniscal Repair Concomitant with Cruciate Ligament Reconstruction.* Connective Tissue Research. 2017
20. Musumeci, G., Castrogiovanni, P., Leonardi, R., Trovato, FM., Szychlinska, MA., Giunta, AD., Loreto, C., Castorina, S. *New Perspective for articular cartilage repair treatment through tissue engineering: A contemporary review.* World Journal of Orthopedics. 2014 Apr 18; 5(2): 80–88. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4017310/
21. Orth, P., et al. *Current perspective in stem cell research for knee cartilage repair.* Stem Cells and Cloning: Advances and Applications 2014:7 1-17
22. Palmer I. On the injuries to the ligaments of the knee joint: a clinical study. Acta Chris Scand 1938;53(suppl):11.
23. Phisitkul, P., et al. *MCL Injuries of the Knee: Current Concepts Review.* The Iowa Orthopaedic Journal. 2006; 26: 77–90. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1888587/
24. Sandmann, GH., Adamchyk, C., Garcia, ED., Doebele, S., Buettner, A., Milz, S., Imhoff, AB., Vogt, S., Burgkart, R., Tischer, T. *Biomechanical comparison of menisci from different species and artificial constructs.* BMC Musculoskeletal Disorders 2013. 14:324. Web. https://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/1471-2474-14-324
25. Seijas, R., et al. *Advances in anterior cruciate ligament reconstruction techniques.* Annals of Translational Medicine. 2016 (4):24, 507

26. Simon, D., Mascarenhas, R., et al. *The Relationship between Anterior Cruciate Ligament Injury and Osteoarthritis of the Knee.* Advances in Orthopedics. 2015 (11) 928301. Web. https://www.hindawi.com/journals/aorth/2015/928301/
27. Sonnery-Cottet, B., et al., *Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction.* Arthroscopy Techniques. 2016 (5): 5, e1253-1259
28. Wang, Y., Wei, L., Zeng, L., He, D., Wei, X. *Nutrition and degeneration of the articular cartilage*. Knee Surgery, Sports Traumatology, Arthroscopy journal. 2013 Aug; 21(8): 1751–1762. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3717153/.
29. Wang, M., et al. *Advances and Prospects in Stem Cells for Cartilage Regeneration.* Stem Cells International. 2017. 16.
30. Warner, BT., Moulton, SG. *Anatomic Reconstruction of the Proximal Tibiofibular Joint.* Arthroscopy Techniques, 2016(5):1, e207-e210. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4886107/pdf/main.pdf
31. Zhang, H., *Anatomic Anterolateral Ligament Reconstruction Improves Postoperative Clinical Outcomes Combined with Anatomic Anterior Cruciate Ligament Reconstruction.* Journal of Sports Science and Medicine. 2016 (15), 688-696
32. Lewis, DA., et al. *Comparison of four alternative national universal anterior cruciate ligament injury prevention programme implementation strategies to reduce secondary future medical costs.* British Journal of Sports Medicine. 2016; 0:1-7. Print.
33. Helito, CP., et al. *Anatomy and Histology of the Knee Anterolateral Ligament.* Orthopaedic Journal of Sports Medicine. 2013. Web.
34. Lamo-Espinosa, J. M., Mora, G., Blanco, J. F., Granero-Moltó, F., Nuñez-Córdoba, J. M. Sánchez-Echenique, C., Bondía8, J. M., Aquerreta, J.D., Andreu, E. J., Ornilla9, E., Villarón, E. M. Valentí-Azcárate, A., Sánchez-Guijo, F., Consuelo del Cañizo, M., Valentí-Nin, J. R., and Prósper, F. *Intra-articular injection of two different doses of autologous bone marrow mesenchymal stem cells versus hyaluronic acid in the treatment of knee osteoarthritis: multicenter randomized controlled clinical trial (phase I/II).* Journal of Translational Medicine. (2016) 14:246. Web.https://translational-medicine.biomedcentral.com/articles/10.1186/s12967-016-0998-2
35. Gupta, P.K., Das, A.K., Chullikana, A., Majumdar, A.S. *Mesenchymal stem cells for cartilage repair in osteoarthritis.* Stem Cell Research and Therapy. 2012. 3:25. Web. https://www.ncbi.nlm.nih.gov/pubmed/22776206
36. Boswell SG, Cole BJ, Sundman EA, KAras V., *Fortier LA Platelet-rich plasma. A milieu of bioactive factors*. Arthroscopy 2012;28:429-439.
37. De Chou, E.S., Boisrenoult, P., Beaufils, P., *Platelet-rich plasma for open meniscal repair in young patients: Any benefit?* Knee Surgery, Sports Traumatology, Arthroscopy. (2015) 23: 51. doi:10.1007/s00167-014-3417-3

38. Ishida K., Kuroda R., Miwa M. *The regenerative effects of platelet-rich plasma on meniscal cells in vitro and its in vivo application with biodegradable gelatin hydrogel*. Tissue Eng. 2007;13:1103-1112. Web.
39. Lubkowska, A., Dolegowska, B., Banfi, G. *Growth factor content in PRP and their applicability in medicine.* J Biol Regul Homeost Agents. 2012 Apr-Jun;26(2 Suppl 1):3S-22S. Web. https://www.ncbi.nlm.nih.gov/pubmed/23648195
40. Mehta, S., Watson, JT. *Platelet-rich concentrate: Basic science and clinical applications.* J Orthop Trauma 2008; 22:432-438.
41. Griffin, J.W., et al. *Platelet-rich Plasma in Meniscal Repair: Does Augmentation Improve Surgical Outcomes?* Clinical Orthopedics and Related Research. 2015. 472: 1665-1672.
42. Blanke, F., *Percutaneous injections of Platelet Rich Plasma for treatment of intrasubstance meniscal lesions.* Muscles, Ligaments and Tendons Journal 2015;5 (3):162-166
43. McArthur, BA., et al. *Long term safety, efficacy, and patient acceptability of hyaluronic acid injection in patients with painful osteoarthritis of the knee.* Patient Prefer Adherence 2012; 6: 905-910. Web.
44. Sarabi, Z.S., Afshari, J.T., Ghassemi, A., Yaghobi, M., *Mesenchymal stem cell and osteoarthritis: a literature review.* Reviews in Clinical Medicine. 2016; Vol 3 (No 2). 84-86. Web. http://rcm.mums.ac.ir/article_6830_900.html
45. Trigkillidas, D., Anand, A.*The effectiveness of hyaluronic acid intra-articular injections in managing osteoarthritic knee pain.* 2013. Annals of The Royal College of Surgeons of England. 95: 545-551. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4311527/pdf/rcse9508-545.pdf
46. Uth, K., Trifonov, D. *Stem cell application for osteoarthritis in the knee joint: A minireview.* World Journal of Stem Cells. 2016. 6(5): 629-636. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4178263/
47. Wyles, C.C., Houdek, M.T., Behfar, A., Sierra, R.J. *Mesenchymal stem cell therapy for osteoarthritis: current perspectives.* Stem Cells and Cloning: Advances and Applications 2015:8 117–124. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4559256/