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# Etiology and diagnosis of athletic injuries to the ligaments of the knee joint

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## Introduction:

In recent years the diagnosis and care of ligamentous injuries about the knee has received added emphasis because of the general publicity given to athletic injuries. The demonstration by numerous surgeons that early comprehensive diagnoses and repair of the injured structures often can lead to complete rehabilitation has focused increasing emphasis on providing early definitive care. [3] Injuries of the knee are often sustained by the younger and more active individuals who have a strong motivation to return to full activity and are unencumbered by disability-compensation considerations. Strong ligaments and supple active muscles as seen in athletes are decided assets in rehabilitative efforts.

The knee is probably the most vulnerable joint in the body from the standpoint of athletic injury, accounting for more than a quarter of all sports injuries. [8] Football accounts for the vast majority of the ligamentous injuries about the knee. However, the runner who catches his spikes, or a basketball player making a sudden pivot can do as much damage to the knee as that which may occur to a football player who is blocked from the side or "clipped." This high incidence is understandable in view of the knee's vulnerable location. The functional limitations of the hinge joint add further to the vulnerability.

Function of the ligaments:

The ligaments of the knee have two functions: 1) they guide the joint through its normal range of motion and 2) help to prevent the occurence of abnormal and non physiological mobility. In both of these activities the ligaments act as important members of the "joint team" which includes the ligaments themselves, the articular surfaces, the menisci, the joint capsule, and most important of all, the groups of muscle which control motion of the knee. The muscular import is based upon the fact that they are extremely strong and positioned and attached in such a manner as to utilize the fullest possible efficiency in guiding and strengthening the joint. These ligaments also have a very rich sensory inervation such that abnormally strong impulses such as are initiated when the ligament is forcably overstretched, brings about contraction of the allied muscle group nearby preventing further injury and subluxation of the knee. This mechanism is readily apparent in the muscle spasm seen after injuries to the knee joint. [(1)]

Throughout the normal range of motion, certain fibers of one or more of the ligaments of the knee are tense affording stability to the joint. The other ligaments, or at least some of their fibers, are relaxed allowing a motion to occur. They are so arranged that when they are all tense, i.e. in hyperextension, no motion of the knee is possible except flexion without ligamentous injury.

In order to understand the functions of the ligaments, the types of motion in the knee joint must first be considered. The two functional types of motion in the knee joint are: 1) flexion and 2) extension and medial and lateral rotation. (6) It is this rotational component that makes the knee vulnerable to injury. The two femoral condyles roll, spin and skid independently of each other on the tibial plateau accounting for the rotation of the femur on the tibia. This permissible rotation at any time varies considerably depending on the degree of flexion of the knee.

Small amounts of accesory non-functional motions occur or may be manually elicited in the intact knee: 1) Abduction-adduction rocking of the femur on the tibia; a gap actually occuring between the tibia and femur on either side of the joint. 2) Anterior-posterior or sagittal displacement of the femur on the tibia; this may be elicited by pulling or pushing the tibia directly forward or backward on the femur when the knee is flexed. 3) Medial-lateral displacement in the frontal plane. This can occur only when the knee is flexed beyond 90 degrees and in a normal joint this motion is minimal. In ligamentous injuries to the knee, the range of these non-functional movements may be increased. Clinically, the demonstration of this increased mobility is of great diagnostic importance.

Anatomy and function of the individual ligaments:

The tibial or medial collateral ligament is triangular in shape with its base being anterior and its apex extending posterior attaching to the medial-tibial condyle posteriorly. The ligament is divided into four segments for descriptive purposes, namely: the long anterior superficial fibers, the anterior deep fibers, the posterior-superior oblique fibers and the posterior-inferior oblique fibers. (6)

In full flexion, the long anterior superficial fibers are tight. Hence, no abduction rocking may occur and the rotary motions are checked to a certain extent. As the femur moves toward extension, this portion of the ligament begins to relax while the posterior oblique fibers tighten and the whole ligament shifts slightly forward in relation to the tibia. In mid-flexion, all of the fibers of the tibial-collateral ligament are somewhat relaxed allowing a few (approximately 5 degrees) of abduction rocking. As extension proceeds, the long superficial fibers again tighten slightly and all of the deep oblique and direct fibers become quite tense so that abduction rocking is prevented and further medial rotation is prohibited. The deep fibers anchor to the medial meniscus so that it is not sucked into the joint with motion. (1)(10)

The fibular-collateral or lateral-collateral ligament is round and cord-like and is attached superiorly to the lateral-epicondyle of the femur and inferiorly to the head of the fibula. It divides the tendon of the biceps femoris muscle and is superior to the popliteus tendon. This ligament is relaxed in all positions of flexion. It begins to tighten at about 150 degrees of extension and continues to do so until hyperextension is reached. In the extended position it effectively prevents adduction rocking. This ligament, although relaxed in flexion is also an important factor in preventing both medial and lateral rotation. (1)

The cruciate ligaments lie obliquely between the condyles of the femur and it is important to remember that they exist in part in the anterior-posterior and in part in the medial-lateral planes. The anterior cruciate ligament is attached below to the anterior intercondyloid fossa of the tibia a little in front of it's intercondylic eminence. The fibers pass obliquely upward, backward and lateral and are attached on the medial surface of the lateral-femoral condyle. The posterior cruciate ligament, the larger of the two ligaments is fixed below to the posterior margin of the tibia and extends upward and anteromedially attaching to the lateral aspect of the medial condyle. The anterior cruciate ligament is tense in extension and hyperextension. It relaxes immediately after flexion has begun, thus allowing greater freedom of motion of the lateral-femoral condyle which then rolls backward on the tibial plateau. It remains relaxed until almost complete flexion is reached when some of the long antero-medial fibers tighten. The tightening of the anterior cruciate ligament in extension along with the fibular collateral ligament firmly anchors the lateral half of the joint anteriorly so that a continuation of the movement into hyperextension can occur only if there is a simultaneous medial rotation of the femur. This is the so-called "final compulsory rotation." [7][6]

The long posterior fibers of the posterior cruciate ligament are tight in extension and some of the fibers of this ligament are tight throughout all degrees of flexion; the zone of tension shifting progressively from front to back as the joint moves from flexion to extension. This tension results in a better fixation of the medial-femoral condyle throughout flexion.

In addition to the above mentioned ligaments, the posterior capsule of the joint is also reinforced by two expansions; the arcuate ligament on the lateral side and the oblique popliteal ligament. These ligaments strengthen the capsule posteriorly and are extremely tight in hyper-extension.

<u>Interaction of the ligaments:</u>

Selective injuries have been produced to ligaments of the knee in freshly amputated specimens with the following results. Complete division of the tibial collateral ligament produces abduction rocking at 5 to 15 degrees of flexion, but there is no lateral instability in full extension. There is no increased anterior-posterior sagittal displacement or a positive drawer sign. [2][1]

With complete division of the anterior cruciate ligament, if all the other ligaments are left intact, there is no lateral instability found. The anterior drawer sign is increased by 5 to 10 mm. and the knee may be moved to as much as 25 degrees of extension beyond a straight line. [1]

<u>Mechanism of ligamentous injuries:</u>

When the knee joint is subjected to a severe or abnormal force, it tends to subluxate. The capsule or one or more of the ligaments may be overstretched or completely ruptured. Four types of subluxating forces are described: 1) hyperextension; a blow on the anterior aspect of the extended leg forces the knee into hyperextension. If the force is sufficiently severe, the posterior capsule is stretched and weakened. A few of the posterior fibers of the posterior cruciate ligament may be frayed and then the major injury, the rupture of the anterior cruciate ligament may follow, usually with evulsion of a fragment of bone from it's tibial insertion, 2) abduction, flexion, and internal rotation; this type of subluxating force is met with most frequently in football and skiing injuries. The weight of the body is thrown inward and the femur is rotated medially, while the foot is fixed by the weight of the body or by some obstruction. A stretching or partial tearing of the long superficial and direct deep fibers of the tibial collateral ligament first occur followed by a rupture of the anterior cruciate ligament or the fraying of some of it's fibers near the superior insertion as it becomes stretched over the medially shifted medial border of the lateral-femoral condyle. Some authorities feel that the posterior cruciate ligament is also frequently injured as a result of this type of injury. Such injuries are also frequently associated with tears of the medial meniscus, [(4)(12)] 3) adduction, external rotation, and flexion; these are rare but are occasionally seen in football, motorcycle accidents and skiing accidents. The injury force is applied to the medial side of the leg near the knee joint while the foot is fixed. In this type of injury, the fibular collateral ligament is the first to rupture followed shortly by the anterior cruciate ligament and often by the tendon of the popliteus muscle, 4) sagittal displacement; a force producing posterior tibial displacement with the knee flexed produces a saggital subluxation injury. In order for this to occur, the posterior cruciate ligament must be torn and it is usually avulsed from it's tibial insertion with a small fragment of bone.

Consideration of injuries to specific ligaments:

Injuries to the tibial collateral ligament. The commonest position in which the knee joint is injured is one of abduction flexion and medial rotation. The first structure to offer passive resistance to forcable exaggeration of this position is the tibial collateral ligament. Therefore, injuries to this ligament occur more frequently than to any other supporting structure of this joint. There are many different types of rupture and tear to this ligament. Injuries can involve combinations of one or all of the four parts of this ligament described above.

Isolated injury to the medial-collateral ligament is a typical lesion with a well defined clinical picture. The patient's first complaint of pain on the inner aspect of the joint and soon after the injury the pain is not so severe and the patient will often remain active. The pain, however will gradually increase until the disability becomes pronounced. They also complain of inability to fully extend the knee. At first this position of flexion is purely voluntary to relieve discomfort, but later it is produced by involuntary spasm of the hamstring muscles. Walking may still be possible, but with only the toes touching the ground. (11)

Clinical findings include tenderness over the inner surface of the knee and active and passive resistance to complete extension of the joint. Forced abduction at the knee causes pain which is referred to as inner surface. Another important finding which is important in a number of cases is the so-called abduction rocking and this sign is difficult to elicit unless complete muscle relaxation can be secured as with a general anesthetic. With the patient under general anesthetic, an x-ray can be taken with the knees in flexion comparing both sides and an increase separation of the joint surface is mainly found on the injured side in cases of complete rupture of this tibial-collateral ligament. [11][4] Swelling with bleeding into the joint may or may not be present. When present to any considerable degree, it is often painful and therefore may prevent adequate examination. Furthermore, it may interfere with healing of damaged tissues and encourage the formation of adhesions. For these reasons, immediate, and when necessary repeated aspirations are advocated in all cases in which the joint is distended. Aspiration is also of value in diagnosis and treatment. [1]

As was mentioned above, injury to the cruciate ligaments is also frequently associated with this injury. The absence of a positive drawer sign, however would suggest that no concommitant lesions of the cruciate ligaments are present. On the other hand, a positive drawer sign with an extensive abduction rocking is evident of injury to the cruciate ligaments, especially the anterior cruciate. [12] Limitation of extension may be due to reflex spasm caused either by injury to the tibial collateral ligament, locking by a displaced meniscus or distention of the joint with blood. Injection of the tender area of the injured ligament with novacain is therefore of value in diagnosis. If the reflex arch is blocked by the anesthetic and there is no hemarthrosis or injury of the meniscus the joint will assume a position of extension. Under anesthesia with complete aspiration, a displaced meniscus will resist extension.

Injuries to the fibular collateral ligament. These injuries are quite rare and occur when the knee is forced into the position of adduction flexion and rotation and may be associated with tearing of the lateral portion of the joint capsule. [1] A common site of injury is the inferior insertion of the ligament, the ligament taking with it a fragment of bone from the head of the fibula. Clinical findings are a history of violence to the knee forcing it into adduction with pain referred to the outer aspect of the joint and local tenderness and swelling over its lateral aspect. Lateral adduction rocking can be elicited with the knee held in extension and may be confirmed by x-rays of both knees held in exactly the same position. In associated trauma to the external popliteal nerve, sensory and motor changes will be apparent on examination of the foot and leg. [2]

Injuries to the cruciate ligaments. Isolated injuries to the cruciate are less common than isolated injuries to the collateral ligaments. [1] Damage to the anterior cruciate ligament is usually caused by forcable hyperextension of the joint and injury to the posterior cruciate ligament by a blow on the front of the upper end of the tibia with the femur and foot fixed. These injuries are often accompanied by hemorrhage with pronounced distention of the joint. In the case of a rupture of the posterior cruciate ligament, a hematoma in the popliteal space may dissect its way to the surface. [4]

Clinically, the patient complains that the leg "crumples and gives away," and that there is a feeling of complete insecurity when the knee moves into a position of flexion. The instability of the joint in the sagittal plane gives rise to so-called drawer sign. If the anterior cruciate ligament has been torn the tibia can be displaced forward on the femur abnormally as compared with the other side. If the posterior cruciate has been torn, the tibia can be displaced forward on the femur abnormally as compared with the other side. If the posterior cruciate has been torn, the tibia can be displaced backward on the femur to an abnormal degree. Reflex tonus of the hamstrings will eliminate the anterior drawer sign if the patient has not been seen immediately after the accident occured. Suspected damage to either cruciate calls for a careful history eliciting the mechanism of injury and a thorough and complete examination. This examination frequently will require a general anesthetic. Isolated injuries of the cruciate ligament are often sprain fractures and therefore x-rays immediately after injury are helpful in diagnosis. In such cases, an operation to replace the fragment is often indicated. [4]

Combined injuries. Severe trauma may cause injury to more than one ligament and various combinations may occur depending upon the direction and violence of the force causing the injury. Both cruciate ligaments may be ruptured by extreme hyperextension or a blow from the inner side of the knee may rupture the fibular-collateral and one or both of the cruciate ligaments. In addition to the ligamentous tears, there may be avulsion or compression fractures of the joint surfaces. Frequently a meniscus is torn or displaced.[4][12]

The most common combined injury is that which results from forced abduction, flexion and medial rotation from the femur on the tibia. This type of trauma usually causes not only a complete rupture of the tibial collateral ligament, but also with further abduction it results in stretching or tearing of the anterior cruciate over the medially displaced inner border of the lateral-femoral condyle. Associated damage to the medial meniscus is frequently present also. This triad results in mared abduction rocking and a positive drawer sign.[12] Operation with repair of torn ligaments is always indicated.

Summary:

Experience by many authors, particularly those who are associated with a close supervision of athletic contestants has shown that adequate diagnosis and surgical repair, when indicated, may return the patient with a severely injured knee to the stresses of competitive athletics. The knee is a particularly vulnerable joint, being subjected not only to considerable body weight but also to strong propulsive and rotatory stresses that are the prerequisites of athletic agility. For the infrequent examiner, determination of which knee is injured sufficiently to require reconstructive procedures or immobilization is difficult.

The presence of hemarthrosis or a history suggestive of violent injury to the knee indicates that not only should complete roentgenograms, including anteroposterior, lateral, notch, and tangenital patellar views, be taken but also that the knee be examined exhaustively. This includes examination with anesthesia if uncertainty remains in the mind of the examiner. Since much more information will be gained by examination of the knee immediately after the accident, this opportunity, if present, should not be lost. Later, arrival at a correct diagnosis may be much more difficult.

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