Introduction

There is a relative lack of research and literature investigating injuries to the posterior cruciate ligament despite the fact that it is an important stabilizer[139].

The posterior cruciate ligament is an anatomically and bio-mechanically complex structure. PCL is the strongest ligament about the knee and is approximately twice as strong as ACL, and so, PCL ruptures are uncommon[65].

The stability of the knee depends on ligaments, tendons, and muscles. The posterior stability of the knee depends mainly on the posterior cruciate ligament and the posterolateral structures of the knee. The posterior cruciate ligament is considered the primary stabilizer of the knee joint because it provides the central axis of rotation and major restraint to posterior tibial translation[140].

The most common mechanism of injury is motor vehicle accidents or direct force to proximal anterior tibia. Also sports related injuries result from hyperextension of the knee with the foot typically planter flexed. The common mechanism of postrolateral instability are postrolaterally direct blow to the medial part of the tibia that cause knee hyperextension[141].

Diagnosis of the PCL injury depends on examination and invistigation, posterior drawer test is a specific one for PCL injury and different imaging modalities such as X-ray, CT, MRI is the best invistigation and arthroscopy. The injury may be isolated or associated with other ligaments, complete or partial, even avulsion from bony attachment injuries depends on the mechanism and severity of truma[75].

The tretment of the PCL injuries in non athletic patient is usually conservative when it is isolated PCL and instability not more than 10mm but the treatment is usually surgical if the instability is more than 10mm and the patient is athletic, bony avulsion of the PCL and in combined ligamentous injury of the knee[142].

The general consensus has been that isolated PCL tears do well when treated non surgically and the multiple ligaments injuries about the knee should be surgically stabilized. Trickey called the PCL the central pivot point of the knee and recommended early surgical treatment of all PCL tears[143]. Inspite of the importance of the PCL there was no much research on it as ACL so its mechanism, types, of injury, new lines of diagnosis and treatment especially arthroscopic one became the main concern of knee orthopedists in the last decades[113].

Arthroscpic reconstruction of the PCL is advancing, single and double tunnel reconstruction was described. interest is increasing in techniques that allow direct fixation of a tibial bone plug, inlay technique allows that[75].

The benefits of arthroscopy over open surgery are being much less trumatic to the muscles, ligaments, and tissues, smaller incisions faster healing, recovery and less scarring. Arthroscopic surgical procedures are often performed as an outpatient basis and the patient is able to return home on the same day, so arthroscopy appears to be attractive alternative approach rather than open surgery[113].

Aim of the work

The aim of the study is to review the up-to-date literatures in arthroscopic reconstruction of the posterior cruciate ligament injuries and to have better understanding of this injury and its management.

Anatomy of the Posterior Cruciate ligament

Introduction:

The posterior cruciate ligament (PCL) has become an increasingly popular subject of orthopaedic research and debate. Despite recent advances in our understanding of the anatomy and biomechanics of the PCL and the effects of PCL injury on knee function, injury of this ligament remains a challenging problem. For many years, PCL injury had been considered a rare and relatively clinically benign event. The incidence of injury has been reported to be higher than previously believed[(1)], and studies have shown that chronic PCL-deficiency is associated with poor clinical outcomes[(2)].

Clinical and basic science research has led to the development of new techniques for PCL reconstruction. No single technique, however, has proven to be efficacious in restoring knee stability and altering the natural history of PCL-deficiency. Furthermore, an increased awareness of combined posterior cruciate and posterolateral corner (PLC) injuries has raised new concerns in the orthopaedic community[(2)].

Developmental anatomy:

Studies have shown that the knee joint develops as a cleft between the mesenchymal rudiments of the femur and tibia in about the eighth week of development[(3)]. As the mesenchyme in the region of the future knee joint condenses to form the precartilage of the joint and joint capsule, some vascular mesenchyme becomes isolated within the joint. This tissue is the precursor to the intra-articular structures of the knee (cruciate ligaments and menisci)[4].

The cruciates ligaments of the human knee joint, first appear as condensations of vascular synovial mesenchyme at about 7-8 weeks of development. At 10 weeks the anterior and posterior cruciates ligaments are separate from each other and are easily distinguished from one another by the direction of their parallel fibers**.** Over the next 4 weeks the cruciates ligaments become better differentiated from the adjacent tissue and the attachment sites appear to be more specialized blood vessels are also seen in the loose tissue surrounding the cruciates ligaments at this time[3]**.** By 18 weeks the cruciate ligaments stand almost alone, and a few vascular elements are to be found within their substance. During the following weeks the chief changes in addition to growth, are the increase in vascularity and the appearance of define fat cells in the mass of connective tissue anterior to the cruciate ligaments and inferior to patella, thus the infrapatellar fat bad comes into being at this time. By 20 weeks the cruciate ligaments resemble those of the adult and their remaining development consists of marked growth with little change in form[3]**.**

The posterior stability of the knee depends mainly on:

***A**- The posterior cruciate ligament (PCL).*

***B**- The posterolateral structures (PLC).*

A- Anatomy of the PCL:

The PCL arises from the posterior tibia 10 mm below the joint line and extends anteromedially to the lateral surface of the medial femoral condyle. Anatomically, it is considered an intraarticular but extrasynovial ligament. Synovium that is reflected from the posterior capsule surrounds the medial, lateral, and anterior border of the ligament[5]. **(Fig1)**

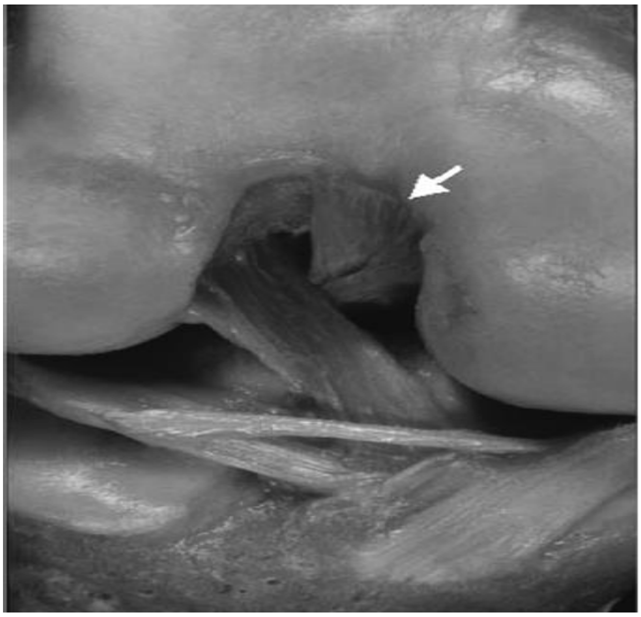

Fig. (1): Anatomical view of a right knee. Note the wide insertion of the PCL (as indicated) on the medial femoral condyle[6].

The average length of the PCL is between 32 and 38 mm with a cross-sectional area of 31.2 mm at its midsubstance level, which is 1.5 times that of the anterior cruciate ligament (ACL) cross-sectional area[6]**.** The femoral and tibial insertion sites of the PCL are approximately three times larger than the cross-sectional area of the midsubstance of the ligament[7]**.**

The femoral attachment the ligament runs medially, anteriorly and obliquely superiorly to be attached into the depth of the intercondylar notch and also on the edge of the lateral surface of the medial condyle**. (Fig 2)**

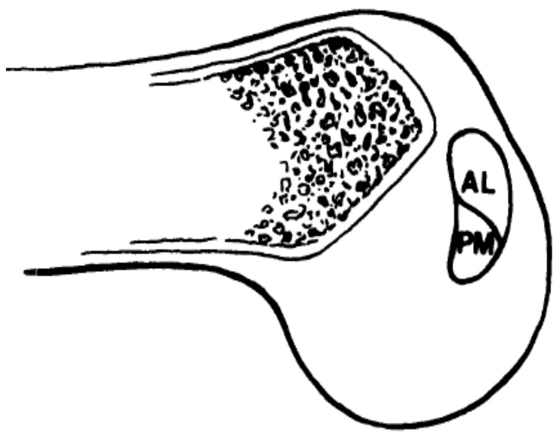

Fig (2): Femoral insertion of the PCL, and anterolateral (AL) and posteromedial (PM) bundles[8].

The tibial attachment to a depression between the posterior aspect of the two tibial condyles, approximately 1cm below the articular surface[9]**(Fig3).**

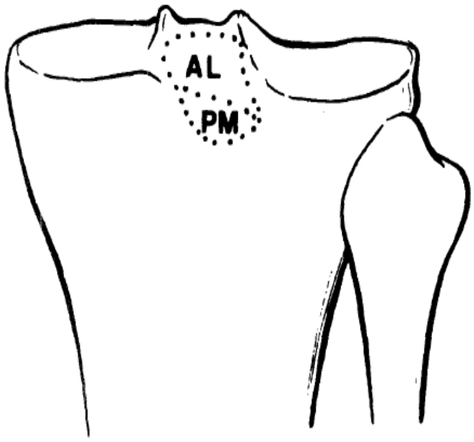

Fig (3): Tibial insertion of the PCL and anterolateral (AL) and posteromedial (PM) bundles[8].

Hefzy et al[10]**,** observed that**,** at very few fibers of the PCL behave isometrically, with most of the fibers lengthening upon knee flexion**.** The large ligamentous insertion sites and the lack of isometry within the fibers of the PCL complicates the task of designing a PCL reconstruction technique that adequately recreates the anatomical and biomechanical properties of the intact PCL. The fibers of the PCL are usually reported as two separate bundles, the anterolateral (AL) and the posteromedial (PM) bundles[6]**.**

The distinct insertion sites of these two bundles on the tibia and femur are approximately equal in size[7]**.** The AL bundle is two times larger in cross-sectional area than the PM bundle[6]**.** Functionally, the two components have different tensioning patterns that are dependent on the degree of knee flexion. During passive flexion and extension of the knee the AL bundle is more taught in flexion and lax in extension, conversely, the PM bundle is more taught in extension and lax in flexion[5].

The PCL architecture has been described as four fiber regions based on their orientation and function at different degrees of knee flexion[11]. Further study is needed to evaluate the biomechanical and clinical implications of this more recent anatomic description. In addition to the PCL, the meniscofemoral ligaments (MFLs) of Humphrey (anterior) and of Wrisberg (posterior) comprise the PCL complex. They originate from the posterior horn of the lateral meniscus, run adjacent to the PCL, and insert anterior and posterior to the PCL on the medial femoral condyle[12].

The importance of the MFLs has not been fully characterized. Described as the 'third cruciate ligament' at the beginning of the 19th century, it has recently been suggested that the MFLs contribute to the anterior–posterior and rotatory stability of the knee[6]. The middle geniculate artery provides the majority of the blood supply to the PCL, giving of branches to the synovial tissue that surrounds the ligament[13].

- Functional anatomy:

The major control of the knee stability has been ascribed to the PCL this strong ligament which according to tensile testing is approximately two times stronger than any other ligament around the knee[14].

The PCL serves two major functions:

a- It is a primary restraint against posterior tibial displacement.

b- It works in conjunction with the ACL to regulate the screw home mechanism of the knee. It also resist varus-valgus rotation of the tibia especially in the absence of the collateral ligments. in addition this ligament resists internal rotation of the tibia[15].

- Micro anatomy:

The PCL is made up of multiple fascicles, the basic unit of which is collagen[16]. Non parallel interlacing networks of this collagen fibrils (150-200nm in diameter) are grouped into fiber (1 to 20 um in diameter) that in turn make up a subfascicular units (100 to 250 um in diameter). This subfascicular units are surrounded by a loose band of connective tissue known as endotendon. Three to Twenty subfasciculi, bound together, form a fasciculus which may be from 250 um to several millimeters in diameter this are surrounded by epitenon. This interfascicular connective tissue also supports the neurovascular elements of the ligaments[17].

These individual fascicles either are oriented in a spiral fashion around the long axis of the ligament or pass directly from the femur to the tibial attachment. The entire continuum of fascicles, forming the ligament is surrounded by the paratenon a connective tissue covering similar to but much thicker than the epitenon[16].

- Blood supply of the PCL:

The major vascular supply to the PCL is the middle geniculr artery(MGA), a branch of the popliteal artery. The MGA also supplies the synovial sheath, which is a major contributor to the blood supply of the PCL. The MGA originates behind the popliteal surface of the distal femur and passes anteriorly to enter the posterior capsule of the knee joint at the level of the intercondylar notch. The base of the PCL is supplied by some of the capsular vessels arising from the popliteal and inferior genicular arteries. The various vessels enter the PCL at various levels and run within the ligament in superior inferior direction[(18)]. Lymphatics accompany most of small blood vessels, showing similar regional distribution. Compared to the surrounding synovial layer, the amount of vessels in the substance of the ligament is lower. Both the fibro cartilaginous entheses of posterior cruciate ligament are devoid of blood vessels, and a third avascular zone is located in the central part of the middle third[(19)].

- Neve supply of the PCL:

The PCL is supplied by nerve fibers From the popliteal plexus. Which receives contributions from the posterior articular nerve (aprominent branch of the posterior tibial nerve) arises at a variable level above the knee or within the popliteal fossa. From this origin, it courses laterally, wrapping around the popliteal vein and artery and descends into the fatty substance of the popliteal plexus. Fibres from this dense plexus penetrate posterior capsule and course through the synovial lining of the cruciate ligaments[20]**.** *Schultz et al*[21]**,** noted fusiform mechanoreceptor structures resembles golgi tendon organs, thought to play a role in proprioceptive reflex arcs, were located on the surface of the ligament in fibrous fatty and vascular tissue well beneath the synovial sheath**.** In a histological study of mechanoreceptors in PCL healthy knees, identified ruffini corpuscles (pressure receptors) vaterpacini corpuscles(velocity receptors) and free nerve endings (pain receptors) these studies indicate that disruption of the PCL alters not only the kinematics of the knee but also the afferent signals of the centeral nervous system[22]**.**

Biomechanics of the PCL

Tensile Properties:

Compared with the anterior cruciate ligament (ACL) and medial collateral ligament (MCL), the PCL has a relatively low incidence of injury. This phenomenon has been attributed in part to its considerable strength. *Kennedy et al*[23]**,** were the first to study the tensile properties of the PCL and reported its tensile strength to be 2 times greater than that of the ACL using excised specimens. The stiffness and ultimate load of the femur- PCL-tibia complex were 204 ± 49 N/mm and 1627 ± 491 N, respectively[24]**.** The tensile testing of the AL and PM components of the PCL showed that the linear stiffness of the AL component (120 ± 37N/mm) was significantly larger than that of the PM component (2.6 times) and the MFL (2.7 times)**,(Fig4)**[6]**.**

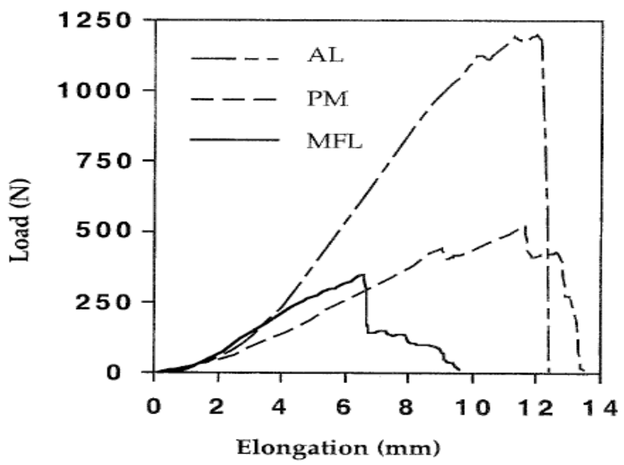

Fig (4): Typical load-elongation curves for the AL, PM, andMFL[6]**.**

MFL components of the PCL complex from the same knee[(6)]. The ultimate load of the AL component (1120 ± 362 N) was more than 3 times as large as that of the PM component and 5 times larger than for the MFL. Midsubstance rupture was the primary mechanism of failure in younger specimens (less than 49 years), whereas two thirds of the older specimens failed at the ligament insertion. The elastic modulus of each bundle was also determined, with the AL and PM components having moduli of 294 ± 115 MPa and 150 ± 69 MPa, respectively. The modulus of the MFL was not significantly different from that of the AL component[(6)].

Because the AL component is larger, stronger, and stiffer than the PM component, it is proposed that the AL component should be the primary focus of single bundle reconstructive procedures. However, these data also indicate that the PM component and MFL are structurally important and should be considered when reconstructing the PCL[(25)].

- Contribution to Knee Function:

Known external loads are applied to the tibia while the resulting kinematics of the intact knee are recorded. A ligament is then sectioned, and the external load is applied again while the kinematics of the ligament-deficient knee are recorded. In this way, the kinematic contribution of the ligament can be determined. The kinematics determined for the intact knee can also serve as a basis for the evaluation of ligament reconstructions. Under a posterior tibial load on the order of