COMPARATIVE STUDY BETWEEN TOTAL KNEE ARTHROPLASTY USING PATIENT SPECIFIC INSTRUMENTATION AND TOTAL KNEE ARTHROPLASTY USING CONVENTIONAL INSTRUMENTATION

Submitted for partial fulfillment of M.D. degree in orthopedic surgery

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Usama Hassan Saleh

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كلية الطب

جامعة القاهرة

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بسم الله الرحمن الرحيم

إِنَّ الَّذِينَ آمَنُوا وَعَمِلُوا الصَّالِحَاتِ إِنَّا لَا

نُضِيعُ أَجْرَ مَنْ أَحْسَنَ عَمَلًا

سورة الكهف الآية (٣٠)

Chapter 1

Review of literature

Functional Anatomy of the Knee

The knee joint is the largest and most complicated articulation in the human body. In this joint, three functional spaces exist: the medial femoro-tibial space, the lateral femoro-tibial space, and the patellofemoral space. (8)

The knee joint is a synovial joint, modified hinge and in addition to flexion and extension; its motion has a rotary component. It is a compound joint that includes two condylar joints between the femur and the tibia and a saddle joint between the patella and the femur. (9)

The stability and mobility of the knee are dependent on complex interactions between:

I- Osseous factors (shape of the articulating surfaces).
II- Soft tissue factors:
A- Passive stabilizers (capsule, menisci and ligaments).
B- Active stabilizers (muscles). (8)

(I) Osseous anatomy:

Patello-femoral articulation:

The articulation between the patella and the femoral trochlea forms the anterior or patellofemoral compartment (Figure 1-1). The medial facet is smaller and slightly convex. The facets are covered by the thickest hyaline cartilage in the body. The femoral trochlea is separated from the medial and lateral femoral condyles by indistinct ridges; the lateral ridge is more prominent. The main function of the patella is to increase the moment arm of the quadriceps mechanism. (10)

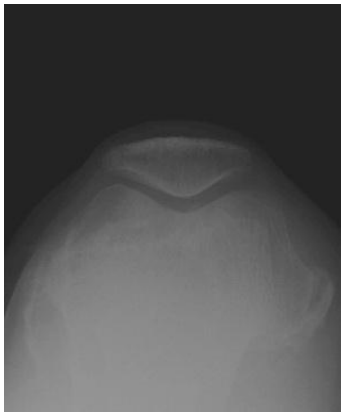


Figure 1-1: Patellofemoral articulation (Thesis cases)

Tibio femoral joint

Articular surfaces of the femur and tibia are not congruent (Figure 1-2A). The femoral condyles are asymmetric in shape and dimensions; the larger medial condyle has a more symmetric curvature. The lateral femoral condyle is slightly shorter, wider and sharply increasing radius of curvature posteriorly the lateral epicondyle is a small but distinct prominence to which attaches the lateral collateral ligament. On the medial condyle the prominent adductor tubercle is the insertion of the adductor magnus. The medial epicondyle lies anteriorly and distally to the adductor tubercle and is a C-shaped ridge with a central depression or sulcus. The medial collateral ligament originates from the sulcus rather than the ridge. [8, 10&12]

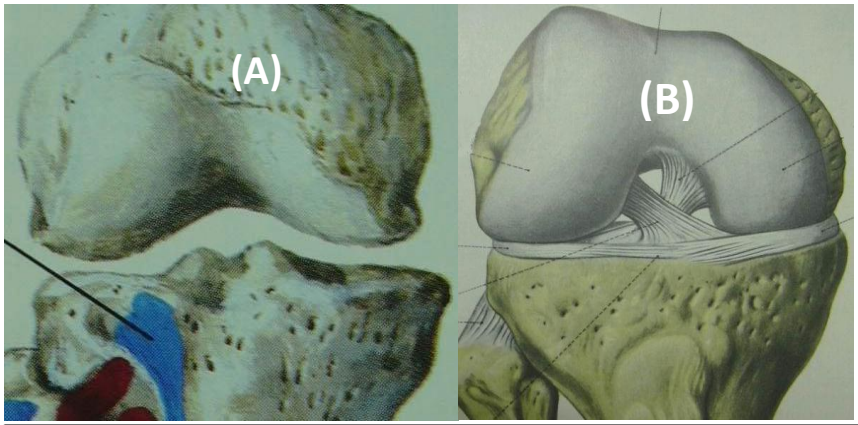


Figure 1-2: (A) Incongruent tibio-femoral articulation with asymmetrical femoral condyles.
(B) The congruency is improved by the menisci. [11]

(II) Soft tissue anatomy

A) The Menisci:

The menisci are asymmetric, wedge-shaped crescentic plates of fibrocartilage located on the articular surface of the tibia. Both menisci possess two fibrous horns; posterior and anterior. The superior surface is concave, thereby deepening the tibial surface on which the femoral condyles roll, slide and spin. The inferior surface of the meniscus is flat. In addition to deepening the articular surface of the tibia, the menisci serve as shock absorbers, transmitting approximately half the axial loads across the joint. Furthermore, the menisci are essential for joint stability, lubrication and proprioception. (13)

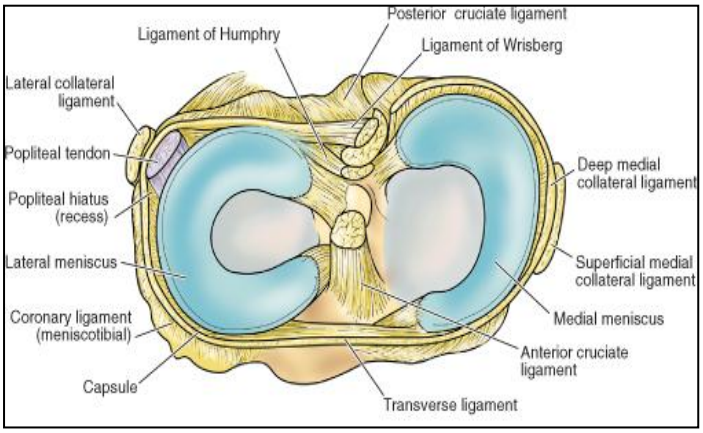


Fig.1-3: Superior aspect of the tibial plateau. (14)

B) The capsule and muscles:

The fibrous capsule of the knee joint is not a complete structure. Rather, the knee is surrounded by tendinous expansions, which reinforce the capsule. Between the capsule or tendinous expansions and synovial lining are various intra-articular structures, including ligaments and fat pads. (10)

Anteriorly (Figure 1-4), the fibrous capsule is absent above and over the patellar surface. The ligamentous sheath in this area is composed mainly of a tendinous expansion from the rectus femoris and the vasti

musculature, which descends to attach around the superior half of the bone. The four components of the quadriceps mechanism form a three-layered quadriceps tendon that inserts into the patella. The fibers of the medial retinaculum formed from the aponeurosis of the vastus medialis insert directly into the side of the patella to help prevent lateral displacement of the patella during flexion. (13)

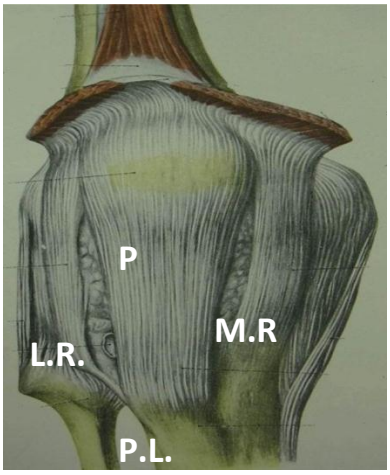


Figure 1-4: anterior view of the knee soft tissue structures. P.: Patella, M.R.: Medial retinaculum, L.R.: Lateral retinaculum, P.L.: Patellar ligament. (11)

Posteriorly (Figure 1-5), capsular fibers extend from the femoral surface above the condyles and the intercondylar line to be inserted in the posterior border of the tibia. This portion of the capsule is strengthened by the oblique popliteal ligament, which is derived from the semimembranosus tendon. Additional posterior reinforcement relates to the arcuate popliteal ligament. (11)

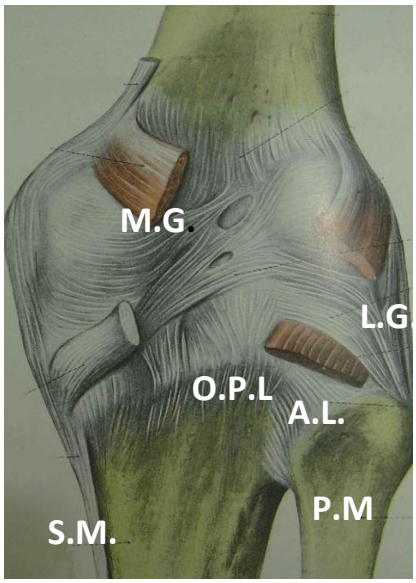


Figure 1-5: posterior view of the posterior soft tissue structures.
S.M.: semimembranosus tendon, O.P.L.: oblique popliteal ligament, A.L.: arcuate ligament,
P.M.: popliteus muscle,
M.G.: medial head gastrocnemius. L.G.: lateral head gastrocnemius. (11)

Laterally (Figure 1-6), capsular fibers run from the femoral to the tibial condyles. In this area, the fibular collateral ligament is found, which is attached above to the lateral epicondyle of the femur and below to the fibular head. It is intimate with the tendon of the biceps femoris muscle. The biceps femoris muscle is formed of two heads; the long head arises from the ischeal tuberosity, whereas the short head arises from the linea aspera. The two heads unite above the knee joint in a common tendon those folds around the lateral collateral ligament insertion on the fibular styloid. (10)

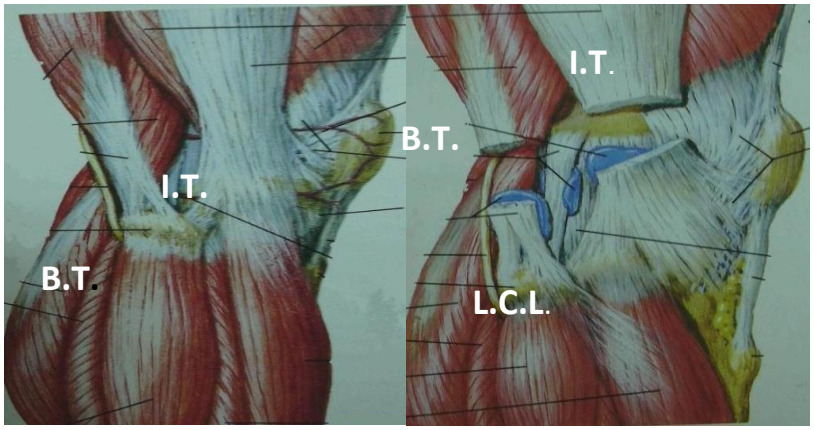


Figure 1-6: lateral view of the knee soft tissue structures: I.T.: ilio-tibial band, B.T.: biceps tendon, L.C.L.: lateral collateral ligament. (B) After transecting the ilio-tibial band and biceps tendon to view the lateral collateral ligament. **(11)**

Medially (Figure 1-7), the capsule is strengthened by tendinous expansions from sartorius and semimembranosus muscles. These fibers pass upward to the tibial collateral ligament, which is attached above to the medial epicondyle of the femur and below to the medial tibial condyle and shaft. On its deep surface, the fibrous capsule connects the menisci and adjacent tibia, a connection termed the coronary ligament. (8)

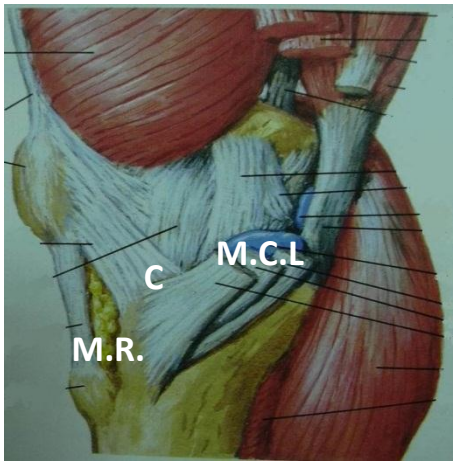


Figure 1-7: Medial view of the knee soft tissue structures.
M.C.L.: medial collateral ligament, M.R.: medial retinaculum,
C.: capsule,
P.A.: Pes anserinus [11]

The tibial and fibular collateral ligaments reinforce the medial and lateral sides of the joint. They are taut in joint extension, and in this position, they prevent rotation of the knee. [8,10]

Action of the muscles:

The movements of the knee are flexion, extension, and rotation. Flexion is performed by the hamstrings and biceps femoris and, to a lesser extent, by the gastrocnemius and popliteus. Extension is performed by the quadriceps. The rotatory movement of the knee is purely passive, and is due to the articular geometry and passive stabilizers. The exception is the lateral rotation of the femur that precedes flexion by unlocking the joint. The popliteus muscle performs this movement. [10]

C) Ligaments of the knee:

Nicholas and Minkoff (1978) referred to the medial and lateral "quadruple complexes" as being principal stabilizers of the knee. The medial quadruple complex is made up of the tibial collateral ligament, the semimembranosus, the tendons of the pes anserinus, and the oblique popliteal ligament portion of the posterior capsule. The lateral quadruple complex is made up of the iliotibial band, the lateral collateral ligament, the popliteus tendon, and the biceps femoris. Posteriorly the capsule is reinforced by the oblique popliteal ligament, at the posteromedial corner

by the ramifications of the semimembranosus, and posterolaterally by the structures contributing to the arcuate complex. [12]

1- The medial ligament (tibial collateral ligament):

The medial collateral ligament can be divided into three layers:

Layer 1: the most superficial, it is the deep fascia and its plane is defined by the fascia that invests the sartorius muscle.

Layer 2: is the plane of the superficial ligament, which consists of parallel and oblique portions. The anterior parallel fibers arise from the medial femoral epicondyle and consist of heavy and vertically oriented fibers running distally to an insertion on the medial surface of the tibia on an average 4.6 cm inferior to the tibial articular surface, immediately posterior to the insertion of the pes anserinus. The posterior oblique fibers run from the femoral epicondyle and blend with the underlying layer 3 (capsule)

Layer 3: The capsule of the knee joint. Beneath the superficial medial ligament, forms a thick vertically oriented band of short fibers known as the deep medial ligament. The deep ligament extends from the femur to the mid-portion of the meniscus and tibia. [15]

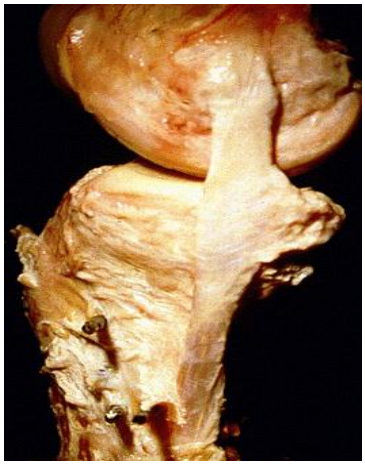
Functional anatomy of the medial collateral ligament:

The medial collateral ligament (Figure 1-8) can be divided functionally into two bands:

1- Anterior band (remains tight during knee flexion)
2- Posterior band (tight in knee extension)

The long fibers of the medial collateral ligament are the primary stabilizers of the medial side of the knee against valgus and external rotary stress. [15]

Fig.1-8: Medial collateral ligament [11]



2-The lateral stabilizers:

The supporting structures on the lateral side of the knee may also be described as consisting of three layers:

Layer 1: the most superficial which includes:

A- The lateral knee retinaculum: anteriorly.

B- The ilio-tibial band and fascia lata: posteriorly.

Layer 2: the middle layer, which includes:

A- The lateral collateral ligament.

B- The fabellofibular ligaments.

C- The arcuate ligament.

Layer 3: the deep layer is the lateral capsule. [15]

A- The lateral knee retinaculum:

Is composed of two major components:

1-The superficial oblique retinaculum: runs superficially from the ilio-tibial band to the patella.

2- The deep transverse retinaculum: dense composed of three layers:

I. The epicondylo-patellar band (the lateral patello-femoral ligament): provides supero-lateral patellar support.

II. The deep transverse dense retinaculum: coursing directly from the iliotibial band to the mid-patella is the dense, deep, transverse retinaculum. It is the primary support for the lateral patella.

III. The patello-tibial band: inserted inferiorly.

Overall, the lateral retinaculum provides a stronger support to the patella than its medial side. (15)

B- Ilio-Tibial Tract:

The ilio-tibial tract (Figure 1-9) is a vertical band of thickening in the lateral part of the fascia lata. Its superior attachment is to the outer lip of the iliac crest behind the iliac tubercle. Its inferior attachment is to a tubercle on the anterior aspect of the lateral tibial condyle (Gerdy's tubercle). The posterior third of the ilio-tibial band, inserts proximally into the lateral epicondyle of the femur and distally into Gerdy's tubercle.

It thus forms an additional ligament that is contiguous anteriorly with the vastus lateralis and posteriorly with the biceps.

The iliotibial band and biceps tendon remain parallel to each other as in extension, all serving to enhance lateral stability. (15,16)

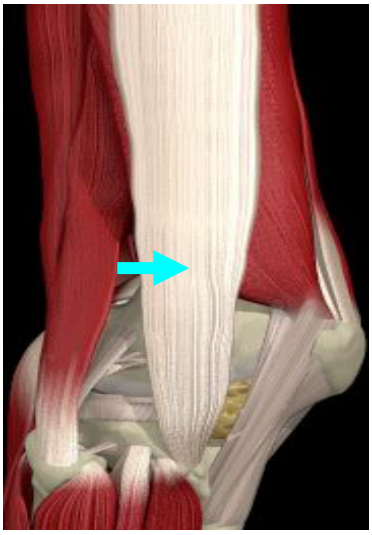


Fig.1-9: Ilio-tibial tract (16)

C- Lateral Collateral Ligament:

The lateral collateral ligament (Figure 1-10) is a cord-like structure. It is attached superiorly to the lateral femoral epicondyle on the lateral surface of the lateral femoral condyle. Its inferior attachment is to the fibular head where it blends, in part, with the tendon of insertion of biceps femoris. Unlike the tibial (medial) collateral ligament, which blends with the capsule of the knee joint and is partly attached to the medial edge of the medial meniscus. It is of prime importance in stabilizing the knee against varus stress with the knee in extension. (16)

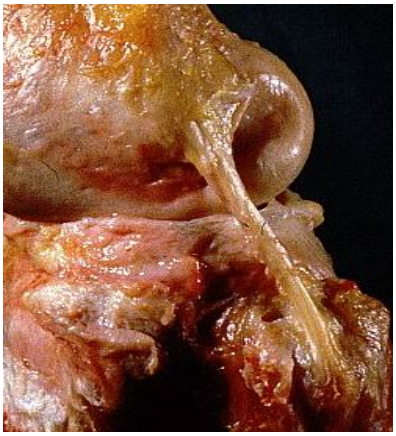


Fig. 1-10: Lateral collateral ligament (16)

D- The popliteus muscle:

The popliteus muscle has three origins (Figure 1-11), the strongest of which is from the lateral femoral condyle. Other important origins are from the fibula (popliteo-fibular ligament) and from the posterior horn of the lateral meniscus. The femoral and fibular origins form the arms of an oblique Y-shaped ligament. The arms are joined together by the capsule and meniscal origin. The arcuate ligament is not a separate ligament but is a condensation of the fibers of the origin of the popliteus. The popliteus muscle is a prime medial rotator of the tibia during the initial stages of flexion (unlock the extended knee) and also acts to withdraw the meniscus during flexion. In addition it supplies rotary stability to the femur on the tibia and aids the posterior cruciate ligament in preventing forward dislocation of the femur on the tibia. (12)

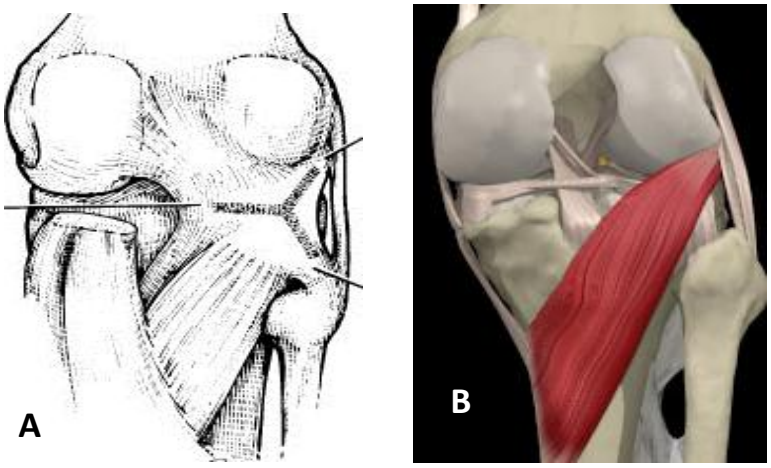


Figure 1-11: (A) The three origins of popliteus muscle
(B) Popliteus muscle. [16]

E- The arcuate ligament:

The most constant and strongest fibers of the arcuate ligament form a triangular sheet that diverges upward from the fibular styloid. The lateral limb of this mass is dense and strong and is attached to the femur and the popliteus tendon, while the weaker medial limb curves over the popliteus muscle. [10]

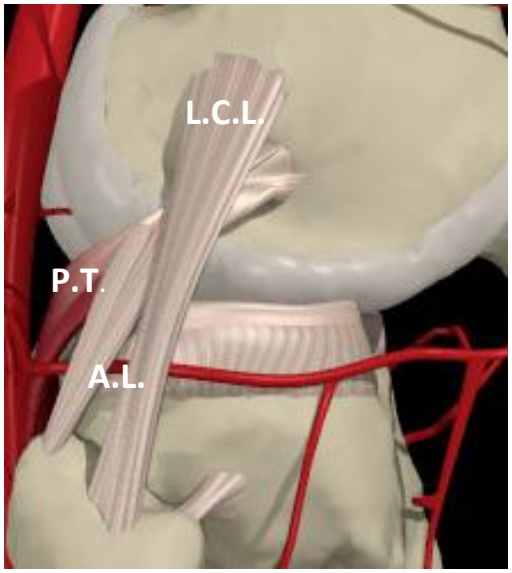


Fig.1-12: A.L.:Arcuate ligament,
L.C.L.: lateral collateral ligament,
P.T.:Popliteus tendon [16]