CHAPTER I

1.1 INTRODUCTION:

Anatomy is the scientific study of the structure of organism. A Human anatomy forms firm foundation of the whole art of medicine and introduces to the greater part of medical terminology. "Anatomy is to Physiology as Geography is to History" i.e., it describes the theatre in which the action takes place (R Shanne Tubbs 2015). Anatomy can be studied well by the dissection; but it is now studied by all possible techniques which can enlarge the boundaries of the anatomical knowledge. Furthermore, the anatomical variations such as supernumerary muscles, thickened fascia, bands or variant muscular origin, variant course of arteries, veins and nerves which helps to explore the medical science.

The anatomy and geometry of the knee are both unique and variable. The locomotion-related bones and joints are in good shape, but they are subjected to constant friction as a result of weight bearing, and so the locomotion joints wear down. Arthritis has crippled the joints that were once unfettered. Knee osteoarthritis is one of the most common causes of impairment in those over the age of 65. Total knee arthroplasty is the best treatment for end-stage arthritis of the knee. Over the previous four decades, total knee arthroplasty has advanced significantly, providing patients with a better quality of life and restoring knee joint function. According to Kurtz et al., an estimated 1.5 million primary total knee arthroplasty and 384,000 primary total hip arthroplasties were performed in the United States by 2020, with these numbers expected to rise to 3.48 million and over half a million by 2030 for primary total knee and total hip arthroplasty, respectively. In scholarly publications dealing with arthroplasty concerns, the similar upward trend was found, with a five-fold rise in the number of articles in 2018 compared to 1988 (WHO).

The scope of improvement, advancement of instrumentation, modifications in implant designs, and changes in preoperative and postoperative protocols have all improved surgical results dramatically over the years. With large increases in treatments expected to be conducted annually in the future, modern arthroplasty has evolved into a procedure that can provide long-term benefits and functional improvement. Because knee joint surgeries are technically challenging and rapidly evolving procedures, an extensive anatomical study of this relevant surgical field would aid in the planning of required interventions in a variety of pathological and degenerative conditions of the knee to restore normal functioning and gait.

The knee joint has long stimulated the interest of medical professionals and researchers since it is one of the most commonly involved joints in a variety of pathological and degenerative illnesses that affect the global population. Furthermore, the existence of a complex combination of intra capsular ligaments, extra capsular ligaments, and dynamic muscle stabilizer has heightened interest in learning about the anatomy of the knee joint.

In the search for food and locomotion, walking on two limbs places the centre of mass over the foot. The necessity to adopt an upright posture and maintain our upright torso has resulted in relative modifications in limb musculature. It has served as a fulcrum for the joint's powerful extensor and flexor muscles during propulsion. Weight bearing and movement are the primary functions of the lower limb. This functional demand, combined with the development of a habitual erect bipedal posture, has resulted in a dramatic shift in the functional and mechanical requirements of all skeletal systems. As a result, when compared to the upper limb, the lower limb requires more strength and stability. Weight bearing in men is primarily associated with extended knee postures. The knee has been optimally adapted to the stresses and loads acting at and through the knee joint throughout mankind's evolution. Many stabilizing forces offset the biomechanical demands placed on the joint, including the major demands placed on the knee joint (Laura, 2015).

The current scenario of medical, surgical, and rehabilitative therapy of the knee joint has generated interest in research. A cadaveric examination of the knee joint will greatly add to the current knowledge base and will absolutely benefit orthopaedic surgeons, general surgeons, plastic surgeons, anatomists, physical therapists, and research aspirants. The purpose of this study is to determine the numerous measures, characteristics, and attachment landmarks of each anatomical structure of the joint, as well as the morphometric data of ligaments, which will aid in the selection of grafts for surgical repair of injured ligaments during reconstruction.

1.2 ANATOMY OF KNEE JOINT

The knee joint is the largest and most complex synovial joint in the body. It is consisting of three distinct joints lying within a single joint capsule which includes: the patellofemoral joint, medial tibiofemoral joint and lateral tibiofemoral joint. The tibiofemoral mechanism is aided by the patella bone. The superior tibiofibular joint is not part of the knee joint complex because it does not lie within the knee joint capsule and is functionally related to the ankle joint.

The menisci divide the knee joint into compartments, resulting in a functionally modified hinge joint and a structurally compound, complicated, and Condylar kind of synovial joint. To house, adapt, and maintain the big, convex femoral condyles in place for knee articulation, the tibial condyles are very tiny and shallow. Meanwhile, the patellofemoral articulation has small articular surfaces, and the joint is insecure due to outward angulations between the long axis of the thigh and the leg (Susan Standring).

Even with the benefits provided by the menisci, the stability of the joint is significantly maintained and dependent on various factors, given the incongruence inside the knee joint, which include:

(1) The factors strengthen the capsule of the knee joint.

(2) The medial and lateral collateral ligaments stabilize the tibiofemoral articulation of the knee joint from either side.

(3) The cruciate ligaments maintain anteroposterior stability tibiofemoral articulation of knee of joint.

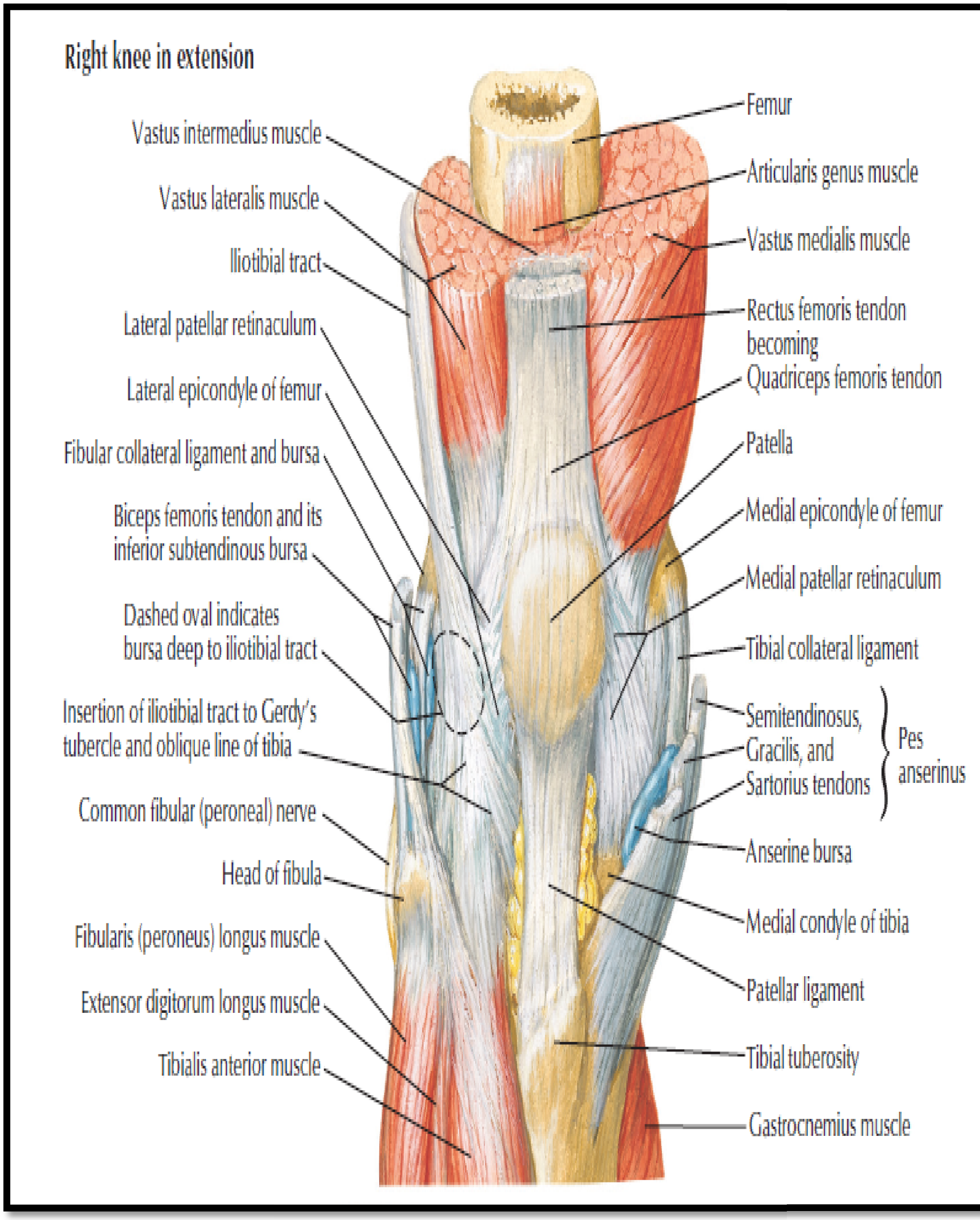

Figure 1.1: Anterior aspect of knee joint; Source: Frank H. Netter; (Netter's atlas of Human Anatomy)

1.3 FUNCTIONS OF KNEE JOINT

The only constant in the anatomy of the knee joint is its intricate function. The anatomical play between the bone components such as the femur, tibia, patella, and fibula, as well as the joints, muscles, ligaments, tendons, and other structures found surrounding the knee, has developed from the functional complexity of joints. Only a few anatomical structures are solely responsible for one particular function. Every function of the knee, in general, is the product of a complicated teamwork of various anatomical parts (Carolyn krisner).

The knee joint is made for mobility and stability; it extends and contracts the lower extremity to lift and lower the body or move the foot in space. It supports the body while standing, along with the hip and ankle. In actions such as walking, running, climbing, and sitting, the knee joint is a key functional unit. The knee has been optimally adapted to the stresses and loads acting at and through the knee joint throughout mankind's evolution.

In the human body summarizing knee joint functions as:

- The knee carries a large portion of our body weight, in our daily activities.
- The knee allows a wide range of motion for flexion-extension and internal rotation – external rotation.
- • The normal function of the muscles that span the knee joint effectively controls stability during the gait cycle. The knee moves across a 60° range during the usual gait cycle, from 0° extension at initial contact or heel strike to 60° at the end of an initial swing. As the knee extends at first contact and shortly before heel-off, there is some medial rotation of the femur (Carolyn krisner).

1.4 JOINTS OF KNEE COMPLEX

A lax joint capsule of the knee encloses the two articulations: The tibiofemoral and the patellofemoral joints.

■On the distal end of the femur, the convex bony partner articular surface is comprised of two asymmetrical condyles. The medial femoral condyle has a larger surface area than the lateral femoral condyle, which aids in the knee joint's locking mechanism.

■Two tibial plateaus (condyles) on the proximal end of the tibia with their matching fibrocartilaginous menisci make up the concave bony partner articular surface. In comparison to the lateral tibial plateau, the medial tibial plateau is larger.

■The menisci of the knee contribute to improve the articular surfaces of the knee joint's congruency. The coronary ligaments connect them to the tibial condyles and joint capsule, the transverse (inter meniscal) ligaments connect them to each other, and the patella meniscal ligaments attach them to the patella. There may also be anterior and posterior meniscofemoral ligaments linking the lateral meniscus to the femur (Carolyn krisner).

1.4.1. TIBIOFEMORAL JOINT

The largest synovial joint in the body is the tibiofemoral joint. It is a complicated synovial joint that is a component of the knee joint. It is structurally a double condyloid, functionally a modified hinge variety, and functionally a modified hinge variety.

Massive medial and lateral condyles of the distal end of the femur make up the proximal articular surface of the knee joint. The femoral condyles do not lie directly below the femoral head, but are slightly medial to it, due to the obliquity alignment of the shaft of the femur to accommodate for articulation with hip bone and forming bony pelvis. As a result, the lateral femoral condyle aligns with the femur shaft more directly than the medial femoral condyle. As a result, the medial femoral condyle must extend more distally, keeping the femur's distal end virtually horizontal. The condyles have a convex form in the sagittal plane, with a decreased radius of curvature posteriorly.

Additionally, the medial and lateral femoral condyles have a minor convexity and very less curvature in the frontal plane. In comparison to the medial femoral condyle, the lateral femoral condyle is displaced anteriorly. Furthermore, the articular surface of lateral femoral condyle is shorter than the articular surface of medial femoral condyle.

Asymmetrical medial and lateral tibial condyles or plateaus constitute the distal articular surface of the knee joint. Although the medial tibial plateau has a larger anteroposterior diameter than the lateral tibial plateau, the lateral tibial articular cartilage is thicker than the medial tibial articular cartilage. Because the proximal tibia is longer than the shaft, it overhangs the shaft in the back. The tibial plateau dips posteriorly around 7° to 10° to accompany this posterior overhang, making it easier to flex the tibiofemoral joint.

The tilt, which is greatest at birth, gradually diminishes with adulthood and is much more pronounced in regular squatters. A roughened area known as the intercondylar area and two bony spines known as the intercondylar tubercles separate the medial and lateral tibial condyles. These tubercles become caught in the femur's intercondylar notch during knee extension. The tibial plateaus are mostly flat, with a sliver of convexity at the anterior and posterior borders, indicating that the bony design of the tibial plateaus does not correspond to the convexity of the femur condyles. Because of this lack of bony support, a menisci-like accessory joint structure is required to increase joint congruency.

1.4.2. PATELLOFEMORAL JOINT

The patellofemoral joint is a saddle variety of synovial joint and is forming a part of the knee joint.

The patella's posterior articular surface is suited to the femur's patellar articular surface. In the shape of an inverted U, it extends across the front surfaces of both femoral condyles. It is an asymmetrical sellar surface since the entire area is concave transversely and convex in the sagittal plane (Carolyn krisner).

1.5 STRUCTURE OF KNEE JOINT

The design of the knee joint has not changed fundamentally over millennia. However, the knee joint is a weight-bearing joint and most subjected to wear and tear. Further, the joint is vulnerable to both acute injury and the development of osteoarthritis. The structures around the knee have been classified into three groups by Larson namely the:

1. Osseous structures
2. Extra-Articular structures
3. Intra-Articular structures

1.5.1. OSSEOUS STRUCTURES OF KNEE JOINT

The osseous structures of the knee consist of three components: Femoral condyles, the tibial plateau, and the patella.

1. FEMORAL CONDYLES

The femoral condyles are two rounded Prominences that are eccentrically curved, more anteriorly than posteriorly. Anteriorly condyles are flattened and provide a greater surface area for contact and weight transmission.

The medial femoral condyle is broader and more convex medially than the lateral condyle, with a greater radius of curvature and a longer projection. The medial epicondyle is a protrusion on it. Laterally, the lateral femoral condyle is flat and aligned with the shaft. It is sturdier and stronger, and it plays a major role in transmitting body weight to the tibia. It has a lateral epicondyle prominence and a popliteal groove right under the epicondyle that houses the popliteus tendon. The lateral femoral condyle appears to be longer in the inferior view. The lateral tibial surface, however, finishes before the medial condyle when the patellofemoral surface is eliminated (Susan Standring, A.K. Datta).

Figure 1.2: Osseous articular structures of knee joint- Patella, Distal end of femur and proximal end of tibia; Source: Gosling; (Color Atlas and Textbook of Human Anatomy).

2. TIBIAL PLEATU

The proximal tibial surface often referred to as the tibial plateau, is formed by the expanded proximal end of the tibia and has asymmetrical medial and lateral tibial condyles. The large convex femoral condyles articulate with the flat tibial condyles to form the knee joint. The medial tibial condyle is concave, longer in the anteroposterior direction, and more oval. The Lateral Tibial Condyle is flat, shorter from anterior to posterior, and more circular (BD Chaurasia).

The medial tibial condyle is oval and longer antero-posteriorly than the lateral tibial condyle. The peripheral surface is covered by the meniscus; the concave surface comes in direct contact with the medial femoral condyle. Its lateral margin is raised towards the intercondylar region (BD Chaurasia, Susan Standring).

The lateral tibial condyle posterolaterally overhangs over the shaft. It is more circular and has a small circular facet inferiorly for the articulation with the fibula. The articular surface is fairly flat centrally; anteriorly and posteriorly the surface slopes inferiorly, in the sagittal plane. The peripheral surface is covered by the meniscus; the concave surface is presented to the lateral femoral condyle (BD Chaurasia, Susan Standring).

The intercondylar area is a rough-surfaced area between both condylar articular surfaces. It is the narrowest in an intercondylar eminence. As the articular surfaces diverge, the intercondylar area widens behind and in front of the eminence. The medial and lateral tibial condyles are separated by a roughened area and two bony spines called the intercondylar tubercles. These tubercles become lodged in the intercondylar notch of the femur during the extension of the knee. The tibial plateaus are predominantly flat, with a slight convexity at the anterior and posterior margins, which suggests that the combined bony architecture of the moderate convex tibial plateaus and convex femoral condyles does not fit well for joint stability. The lack of bony stability necessitates the presence of accessory joint structures (menisci) to improve joint congruency (Susan Standring, A.K. Datta).

3. PATELLA

The patella, sometimes known as the "knee cap," is the biggest sesamoid bone implanted in the quadriceps femoris tendon. The patellar articulating surface of the femoral condyles is located anterior to the distal end of the femur. The ligamentum patellae connect the patella to the tibia and it is preset within an anterior joint capsule. It's a flattened triangular bone with a distally tapering end and a proximally curled end. Antero inferiorly, the thick superior border (or base) slopes. The lateral and medial boundaries, which are thinner, converge distally (BD Chaurasia, Susan Standring).

The anterior surface of the patella is rough, convex, and subcutaneous. It is separated from the skin by a pre-patellar bursa. The surface is longitudinally ridged and covered superficially by the continuation of fibers of the tendon of the rectus femoris muscle which converge as a patellar ligament as a single tendon (Susan Standring).

The superior (upper three-quarters) of the patella's posterior surface is smooth and articulating, whereas the inferior (lower one-fourth) is rough and non-articulating. The superior posterior surface features a smooth oval articular area that fits into the intercondylar groove on the femoral patellar surface, and it is divided into lateral and medial facets separated by a vertical ridge, with the lateral facet usually being larger and wider. Each facet is further divided into equal thirds by faint horizontal lines. A short strip of seventh odd facet is present along the medial edge of the patella, which meets the medial femoral condyle in excessive flexion. The roughened apex of the patella offers attachment to the patellar ligament on the inferior side (Susan Standring, BD Chaurasia).

The patella is primarily responsible for increasing the moment arm of the quadriceps femoris in its effort to extend the knee. Its cartilaginous surface reduces the friction between the patella and the femoral condyles and dissipates the forces between them. A patella, on the other hand, enhances the mechanical advantage of the quadriceps by fifty percent by improving the efficacy of their extensor mechanism. They also protect the femoral condyles from injury by nourishing the articular cartilage (Susan Standring, A.K. Datta).

1.5.2. EXTRA-ARTICULAR STRUCTURES OF KNEE JOINT

Collateral ligaments and musculotendinous units are extra-articular structures that support and influence the function of the knee joint. The tibial collateral ligament and the fibular collateral ligament protect the knee joint from valgus and varus stress and offer side-to-side stability. The quadriceps mechanism, gastrocnemius, pes anserinus, hamstrings, iliotibial tract, and popliteus muscle are the musculotendinous units which thus support and stabilize the knee joint (Carolyn krisner, Lynn Allen Colby, David J. Magee).

1.5.3. INTRA-ARTICULAR STRUCTURES OF KNEE JOINT

The principal intra-articular structures are the medial and lateral menisci, anterior cruciate ligament and posterior cruciate ligament.

The menisci are two wedge-shaped semilunar fibrocartilaginous discs that interconnect the femoral condyles to the tibial plateaus and are linked to the intercondylar areas anteriorly and posteriorly. The Menisci serves as spacers, deepening the joint, reducing articular cartilage tension, and preventing mechanical injury to the chondrocyte. They are weight-bearing structures that help to support the joint, enhance articular cartilage nourishment, facilitate the rotation of opposing articular surfaces of the joint during lock-home movements, and help to transmit body weight from the femur to the tibia.

The Anterior Cruciate Ligament and Posterior Cruciate Ligament provide antero-posterior stability to knee joint. The cruciate ligaments are located within the knee joint capsule, but not within the synovial membrane. It is attached from the surfaces of the femoral condyles facing the intercondylar fossa and is placed on the tibial plateau, where it seems like limb of an "X" cross each other (Carolyn krisner, Lynn Allen Colby, David J. Magee, Susan Standring, Vishram Singh).

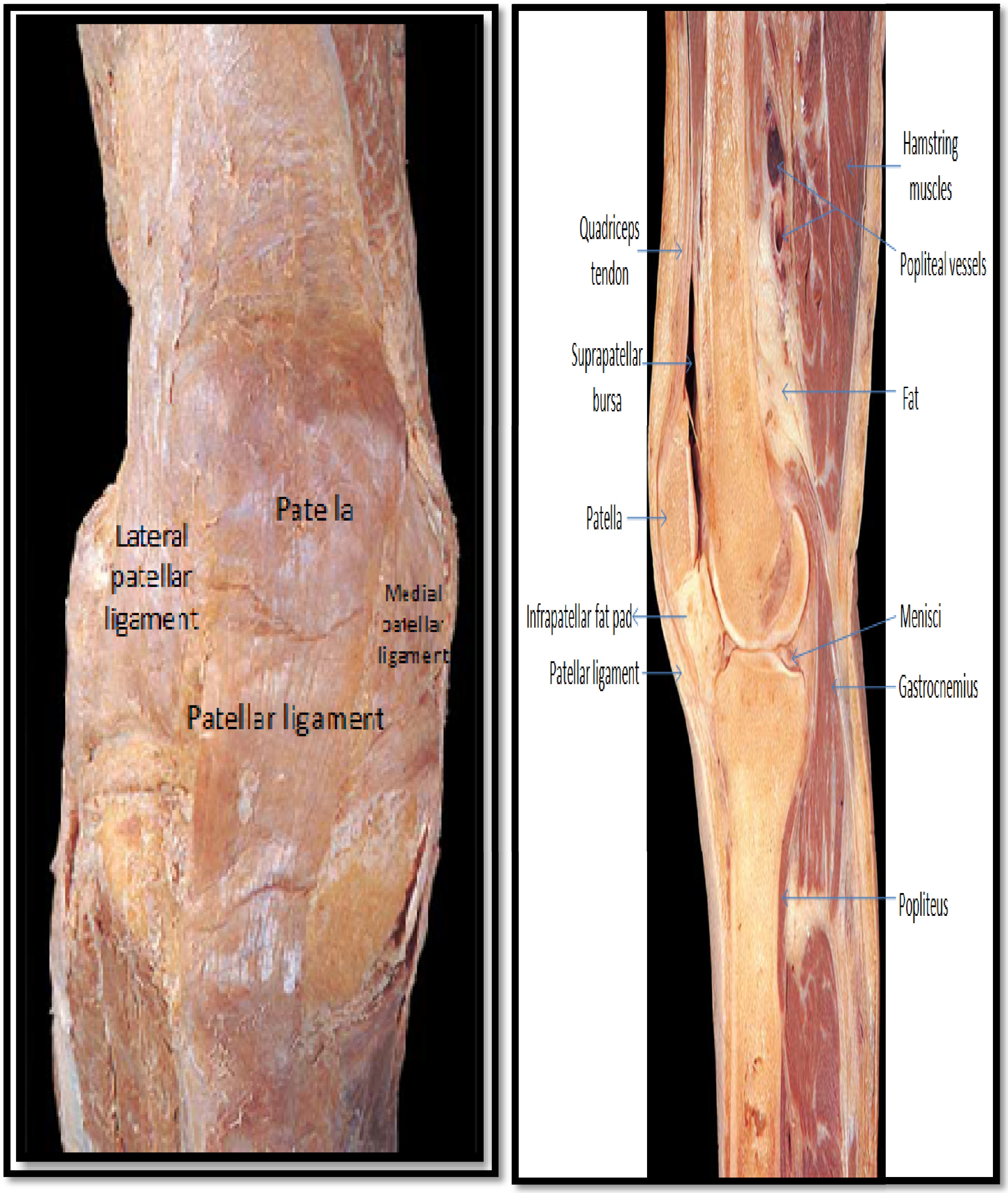

Figure 1.3: Extra articular structures of knee joint- anterior aspect of knee and cross-section of knee joint; Source: Gosling; (Color Atlas and Textbook of Human Anatomy)

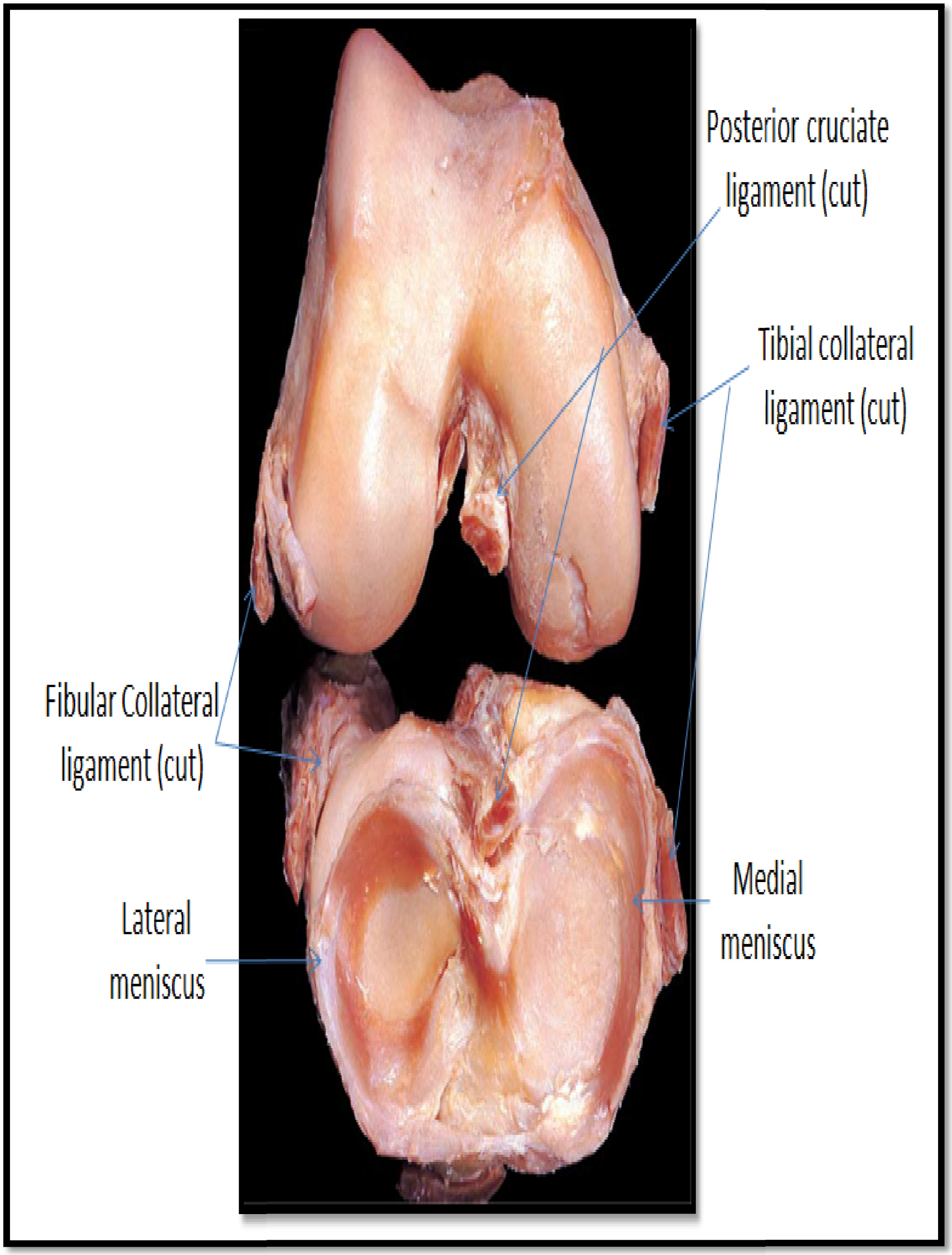

Figure 1.4: Intra articular structures of knee joint; Source: Gosling; (Color Atlas and Textbook of Human Anatomy)

1.6 LIGAMENTS RELATED TO KNEE JOINT

The ligaments of the knee along with the muscles and tendons surrounding the knee maintain static stability of the joint. They play a crucial role in the biomechanics of the knee joint. These ligaments are:

JOINT CAPSULE

There is a large and lax joint capsule that covers the tibiofemoral joint and the patellofemoral joint. It is composed of an outer fibrous layer and a complex thinner inner synovial membrane.

The joint capsule has an intrinsic role in preventing excessive joint motions and maintaining joint integrity as a basic passive structure. Nociceptors, Pacinian, and Ruffini corpuscles all heavily innervate it. By triggering reflex-mediated muscle responses, these receptors may aid in the muscular stabilization of the knee joint. It's also in charge of maintaining a tight seal to retain the lubricating synovial fluid within the joint area (Susan Standring, Vishram Singh).

FIBROUS LAYER OF JOINT CAPSULE

In the knee joint, the synovial lining is covered by a fibrous capsule, which provides passive support for the joint. Depending on the location, the fibrous joint capsule is composed of two or three layers. The fibrous layer is firmly attached to the inferior aspect of the femur and the superior portion of the tibia.

The fibrous capsule is attached about half to one centimeter beyond the joint borders on the proximal femur. It is deficient anteriorly, where it is replaced by a patella, quadriceps femoris, and lateral and medial patellar retinacula, while the suprapatellar bursa pierces it in the middle. The capsule is linked to the intercondylar line posteriorly on the femur, and it covers the origin of popliteus laterally on the femur. (David J. Magee, Susan Standring, Vishram Singh).

It is attached about half to one centimeter beyond the articular margins distally on the tibia. It is deficient anteriorly, where it descends along the condyle margins to the tibia tuberosity; posteriorly, it is attached to the intercondylar ridge, which limits the attachment of the posterior cruciate ligament; and posterolaterally, there is a gap behind the lateral condyle for the popliteus tendon to pass through. The popliteus tendon exits through a gap in the fibrous capsule that leads to the suprapatellar bursa. Gaps frequently communicate with bursae located deep within the gastrocnemius' head and the semimembranosus (Krisner, Susan Standring, Vishram Singh).

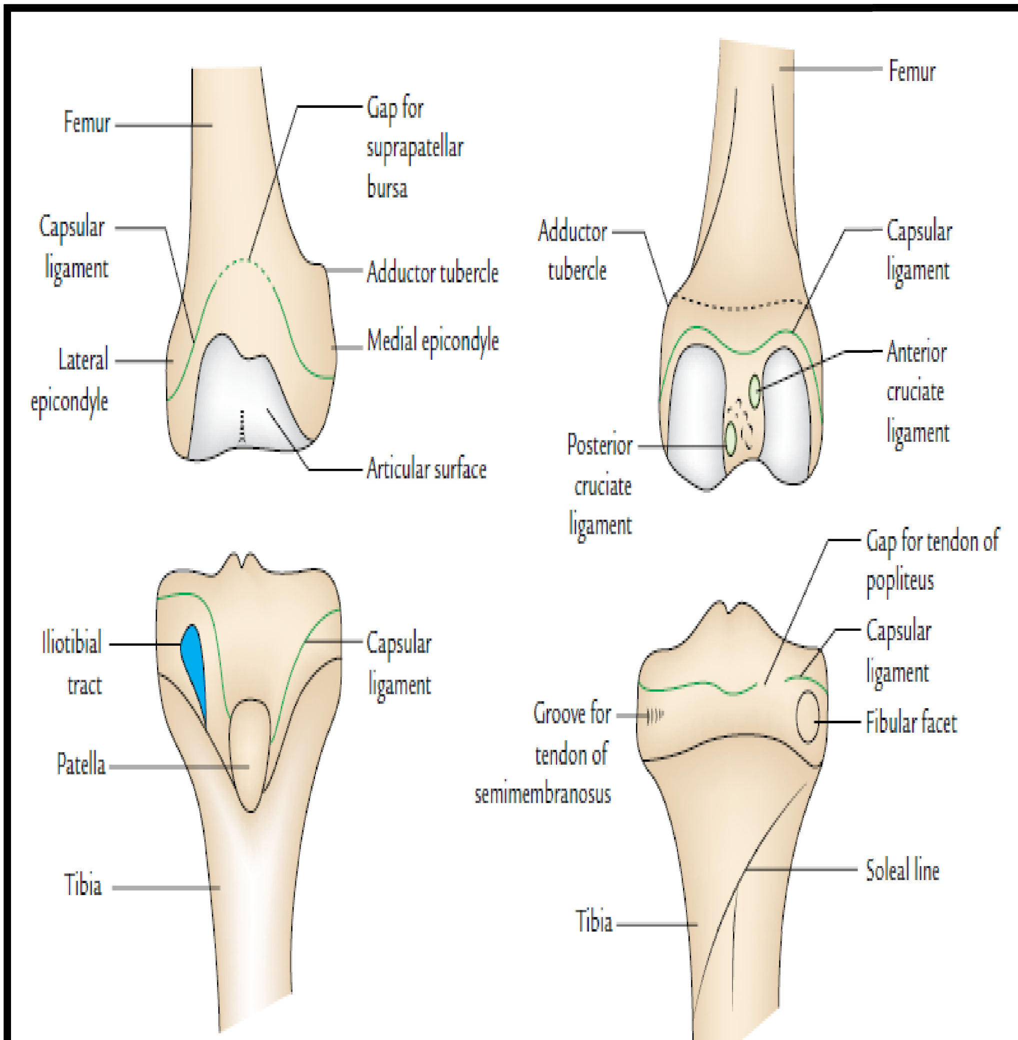

Figure 1.5: Capsular attachment of knee joint; Source: Vishram Singh; (Textbook of Anatomy Abdomen and Lower limb)

The anterior portion of the knee joint capsule is termed the extensor retinaculum. A facial layer covers the distal quadriceps femoris muscles and extends inferiorly. Deep into this layer, the lateral and medial retinacula are composed of a series of transverse and longitudinal fibrous bands connecting the patella to the surrounding structures. Medially, the thickest band within the medial patellar retinaculum is the medial patellofemoral ligament (MPFL). Its transversely oriented fibers run anteriorly from the adductor tubercle of the femur to blend with the distal fibers of the vastus medialis. They eventually insert onto the superomedial border of the patella (A.K.Datta).

The transversely oriented fibers within the lateral retinaculum are called the lateral patellofemoral ligament, which travels from the IT band to the lateral border of the patellar bone. The remainder of the retinacular bands includes the longitudinally oriented medial and lateral patellotibial ligaments and obliquely oriented medial patellomeniscal ligaments. The medial portion of the joint capsule is consisting of the superficial and deep portions of the MCL (Susan Standring, Vishram Singh).

MODIFICATIONS OF FIBROUS CAPSULE

- The fibrous capsule is attached to the menisci's periphery. The coronary ligament refers to the fibrous capsule that lies between the menisci and the tibia.
- There is a cord-like thickening of the capsule lying deep to the fibular collateral ligament is called the Short lateral ligament. It extends from the lateral epicondyle of the femur to the medial border of the apex of fibula, where it merges with the popliteus tendon (Susan Standring).
- The capsular ligament is weak, and it is strengthened anteriorly by the medial and lateral patellar retinaculum, which are extensions from the vastus medialis and lateralis, respectively; laterally by the iliotibial tract; medially by expansions from the sartorius and semimembranosus tendons; and posteriorly by the oblique popliteal ligament (Susan Standring, Vishram Singh).

SYNOVIAL LAYER OF JOINT CAPSULE

The synovial membrane lines the inside of the fibrous capsule of the knee, as well as the portions of the bones that are enclosed inside it, but it ceases at the periphery of the articular cartilages, the lateral and medial menisci. It is continued anteriorly above the patella as the suprapatellar bursa, and it covers the deep surface of the infrapatellar pad of fat that separates it from the patellar ligament of the knee below. The infrapatellar fold is a median triangular fold of the synovial membrane that extends upward and backward from the fat pad to the femur's intercondylar fossa. The infrapatellar synovial fold's lateral borders are free, forming the alar folds, which contain the fibro-fatty tissue. From the posterior aspect of the fibrous capsule, the synovial membrane projects forward in the intercondylar region as a cul-de-sac to envelope the sides of both cruciate ligaments and in front of the anterior cruciate ligament (Susan Standring, Vishram Singh).

The synovial tissue's function is to secrete and absorb synovial fluid into the joints so that avascular tissues like the menisci can be nourished and lubricated. The joint capsule's synovial lining is highly intricate. The synovium invaginates anteriorly between the femur condyles after breaking away from the inner wall of the fibrous joint capsule. The invaginated synovium attaches to the anterior surface and sides of anterior cruciate ligament. As a result, the ACL and PCL are both retained within the fibrous capsules (intracapsular), but outside of the synovial sheath (extra synovial).Posterolaterally, the synovial lining delves between the popliteus muscle and lateral femoral condyle, whereas posteromedially it may invaginated between the semimembranosus tendon, the medial head of the gastrocnemius muscle, and the medial condyle of the femur (Inderbir Singh, Susan Standring, Vishram Singh).

Several fat pads that reside within the fibrous capsule are excluded by the synovium complex folds, making them intracapsular but extra synovial. The anterior and posterior suprapatellar fat pads are located prior to the distal femoral epiphysis and posterior to the quadriceps tendon, respectively. The infrapatellar fat pad (Hoffa's) is located deep within the patellar tendon (David J. Magee).

2. LIGAMENTUM PATELLE

The patellar tendon (patellar ligament) extends from the patella to the tibial tuberosity and is the central band of the tendinous insertion quadriceps femoris. The ligament is enclosed by a well-defined sheath called the parapatellar sheath. It is flat and strong, with a length of 6-8 centimeters and a width of 2.5 centimeters. The ligament is linked to the smooth upper part of the tibial tuberosity below and the edges and rough posterior surface of the patella above. The infrapatellar pad of fat, subcutaneous infrapatellar bursae, and deep infrapatellar bursae are all associated to it (Susan Standring, Vishram Singh).

Figure 1.6: Patellar ligament of knee joint; Source: Present study (2021)

3. TIBIAL COLLATERAL LIGAMENT (TCL)

It is also known as medial collateral ligament. It is about 10cm long, thick, strong, and flat band of fibrous tissue. It represents the degenerated tendon of insertion of the ischial head of the adductor magnus. It is consisting of superficial and deep parts; both are separated by a bursa. Superiorly both parts are attached to the medial epicondyle of the femur just below the adductor tubercle (Susan Standring).

The superficial medial collateral ligament is a long and flat ligament that extends proximally from the medial femoral epicondyle and runs distally to the medial aspect of the proximal tibia. The inferior medial genicular nerve and vessels are enclosed inside it. Its lowest part is crossed superficially by the tendons of the sartorius, gracilis, and semitendinosus (Guy ropes). The deep medial collateral ligament is a short ligament that blends in with the fibrous capsule and medial meniscus's peripheral margin. It is linked to the proximal aspect of the medial tibial plateau and the inferior aspect of the medial femoral condyle (Susan Standring).

The principal constraint to severe valgus (abduction) and lateral tibial rotation strains at the knee joint is the medial collateral ligament, particularly the superficial part of the ligament. In the absence of the principal restrictions against anterior tibial translation, it also helps to resist anterior translation of the tibia on the femur (BD Chaurasia, Susan Standring, Vishram Singh).

4. FIBULAR COLLATERAL LIGAMENT (FCL)

It is also known as lateral collateral ligament (LCL). It is a 5 centimeter long, cord-like ligament attached to the lateral epicondyle of the femur and below the head of the fibula in front of the apex and embraced by the biceps femoris tendon. The degenerated tendon of the peroneus longus muscle is represented by the ligament. The popliteus tendon separates the deep section of the ligament from the capsule and lateral meniscus. The inferior lateral genicular nerve and arteries separate its lower half from the capsule (BD Chaurasia, Susan Standring, Vishram Singh).

5. MENISCI

Menisci (meniscus in singular) are two crescent-shaped intra-articular discs made up of fibrocartilage, lying within the tibiofemoral joint and located above the tibial condyles, covering one-half to two-thirds of the articular surface of the tibial plateau. It deepens the articular surfaces of the condyles of the tibia and furthermore, partially divides the joint cavity into the upper (menisco-femoral) and the lower (menisco-tibial) compartments. Flexion and extension movement of the knee takes place in the upper compartment, whereas the rotation of the knee occurs in the lower compartment. Both the menisci are open towards the intercondylar tubercles. They are thick peripherally and thin centrally (Susan Standring).

Each meniscus has two ends, one anterior and one posterior that are linked to the tibia. two thin surfaces—the upper surface is concave for the femur; the lower surface is flat for the peripheral two-thirds of tibial condyles—and two borders—the thick outer border is fixed to the fibrous capsule and the free thin inner border, and two thin surfaces—the upper surface is concave for the femur; the lower surface is flat for the peripheral two-thirds of tibial condyles (Carolyn krisner, Lynn Allen Colby).

MEDIAL MENISCUS

Medial meniscus is semilunar in shape. It has anterior and posterior horns or ends. The horns are attached to the intercondylar area of the tibia. It is wider from behind than in front. It is adherent to the deep portion of the tibial collateral ligament and firmly attached to the tibial plateau by the ligaments called coronary ligaments (Carolyn krisner, Lynn Allen Colby).

LATERAL MENISCUS

It is nearly four fifths circular in shape with more or less a uniform width. It has anterior and posterior horns or ends, attached to the intercondylar area of the tibia. The posterior horn of the lateral meniscus is attached to the medial condyle of femur by the anterior and posterior meniscofemoral ligaments. These meniscofemoral ligaments play an important role in regulating the movements of lateral meniscus during the extension of the knee joint. The lateral meniscus is attached to the medial part of the tendon of popliteus and thus the mobility of its posterior horn is controlled by the popliteus and two meniscofemoral ligaments (Susan Standring).

MENISCAL ATTACHMENTS

Anteriorly, both the menisci are connected to each other by the transverse ligament known as intermeniscal ligament. It extends transversely and connects the anterior ends of the medial and lateral menisci. It is present only in about 40% of the individuals (Susan Standring).

To the patella, both the menisci are also attached directly or indirectly via the patellomeniscal ligaments, which are anterior capsular thickenings (David J. Magee).

To the tibia, the peripheral margins of the medial and lateral menisci are connected to the tibia by coronary ligament. The fibres of which are composed of the fibers from the knee fibrous capsule.

The medial meniscus is firmly attached to the joint capsule through medial thickening that extends distally from the femur to the tibia. This capsular thickening, referred to as the deep portion of the medial collateral ligament, which contributes to the restricted motion of the medial meniscus. The anterior and posterior horns of the medial meniscus are attached to the anterior cruciate ligament and posterior cruciate ligament respectively. Through capsular connections, the semimembranosus muscle connects to the medial meniscus (BD Chaurasia).

The anterior horn of the lateral meniscus and the anterior cruciate ligament share a tibial insertion site. Posteriorly, the lateral meniscus attaches to the posterior cruciate ligament and the medial femoral condyle through the meniscofemoral ligaments. There are two meniscofemoral ligaments that have a variable presence in the human knee. When present, both originates from the posterior horn of the lateral meniscus and insert on the lateral aspect of the medial femoral condyle either anterior to the PCL on the tibia, anterior meniscofemoral ligament (ligament of Humphry) or posterior to the PCL on the tibia, posterior meniscofemoral ligament (ligament of Wrisberg). These are not considered true ligaments because they are attaching bone to meniscus, rather than bone to bone (Susan Standring).

The medial meniscus has greater ligamentous and capsular restraints, limiting translation to a greater extent than the lateral meniscus. The relative lack of mobility of the medial meniscus may contribute to its greater incidence of injury (Maheshwari, Mahaskar).

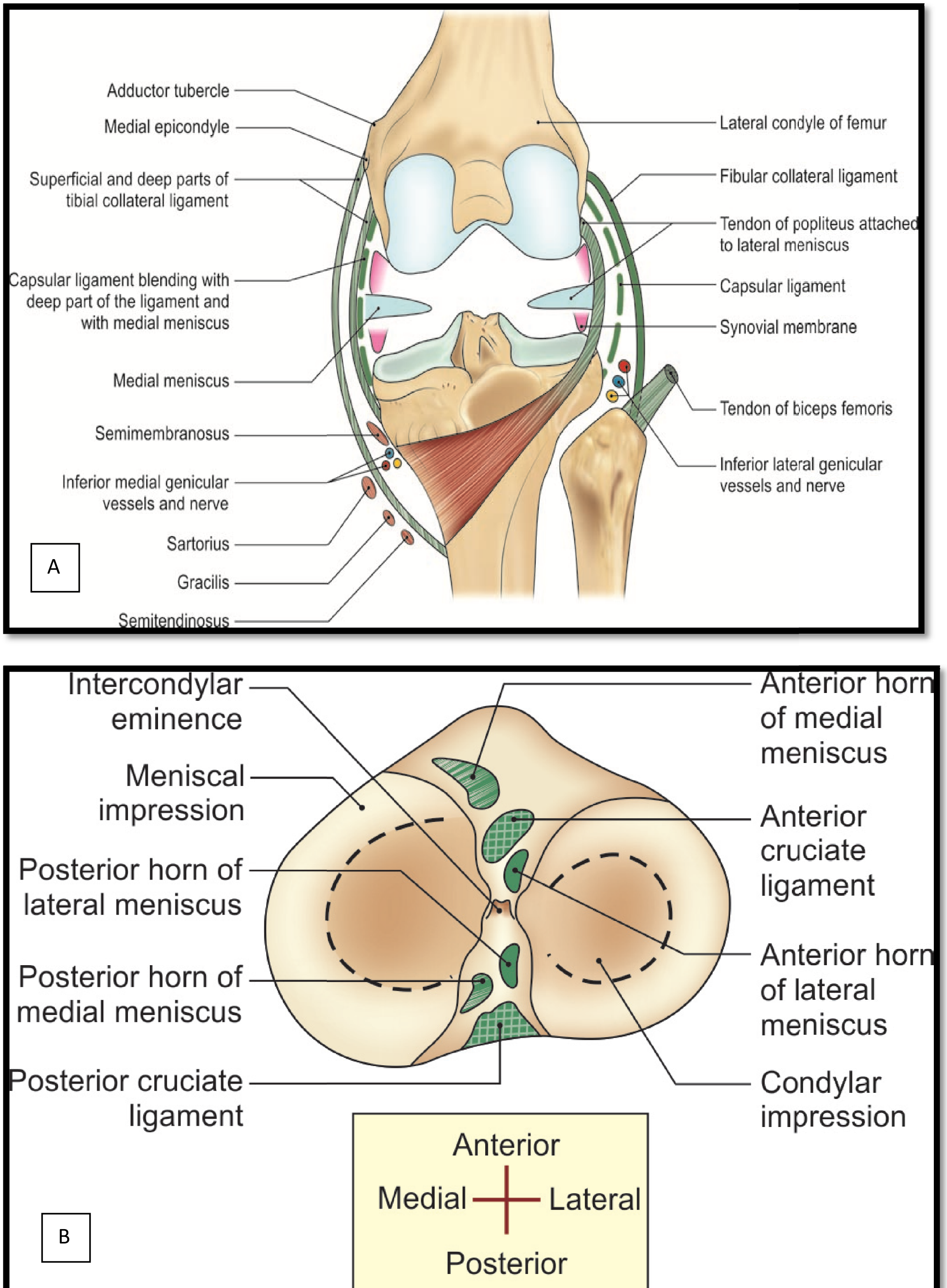

Figure 1.7 A. & B: Menisci of knee joint; Interrelationship of menisci in intercondylar area of tibia; Source: B.D. Chaurasia; (Textbook of Anatomy Abdomen and Lower limb

FUNCTIONS OF MENISCI

Menisci perform very important functions as in increasing the concavity of the tibial condyles for the better congruence with the femoral condyles. It acts as swabs to lubricate the joint cavity and plays pivotal role as a shock absorber to protect the articular cartilage during weight transmission and hence in reducing the friction between tibia and femur bone (Carolyn krisner; Lynn Allen Colby). The strong attachments of menisci prevent them from being squeezed out during compression of the tibiofemoral joint and therefore, allowing for greater contact area between the menisci and the femur. In additionally, with the presence of menisci, the contact area at the tibiofemoral joint is increased and joint stress is reduced (Susan Standring).

Two structurally different regions of the menisci have been identified. The inner two-thirds of each meniscus consist of radially organized collagen bundles, and the peripheral one-third consists of larger circumferentially arranged bundles (Ghadially et al 1983). Thinner collagen bundles parallel to the surface line the articular surfaces of the inner part, while the outer portion is covered by synovium. The different structural arrangement of two regions performs specific biomechanical functions. The inner portion of the meniscus is suitable to resisting compressive forces while the peripheral portion is suitable to capable of resisting tensional forces.

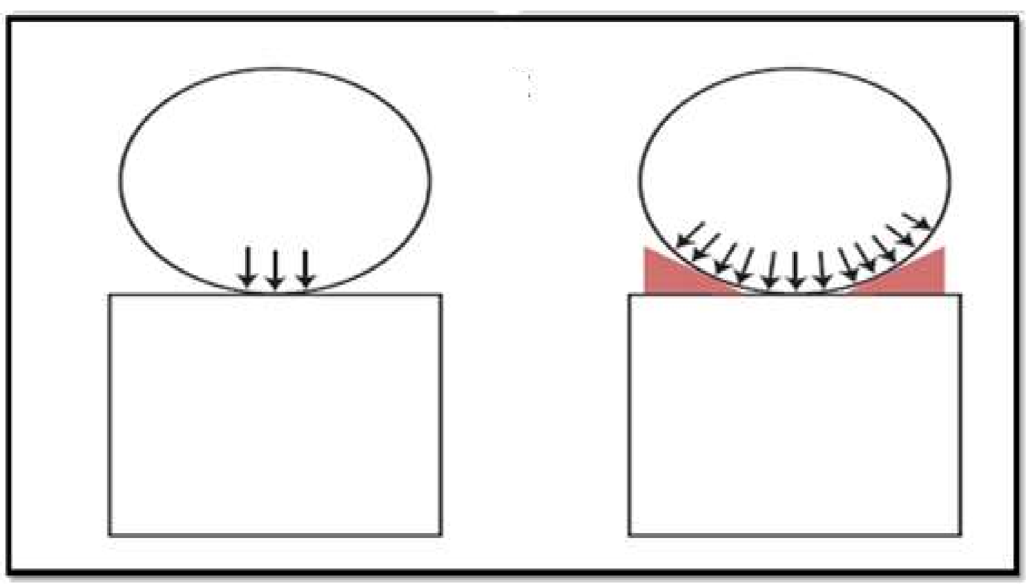

Figure 1.8: Image showing distribution of weight with the presence of menisci; Source: Carolyn krisner; Lynn Allen Colby (Therapeutic Exercise Foundations and Techniques).

MENISCI NUTRITION AND INNERVATION

Meniscus covers approximately two-thirds of its tibial articular surface. In infants and young children canal-like structures open on to the surface of the menisci, and may transport nutrients to deeper, less vascular areas. Cartilage canals are tubes containing vessels that are found in the hyaline cartilage prior to the formation of a secondary ossification centre. The significant development of cartilage canals clarifies their function in the process of bone formation.

The meniscus possesses blood vessels throughout the meniscal body during the first year of life. Once weight-bearing begins, vascularity decreases until just the exterior 25% to 33% of the joint and it is vascularized by capillaries from the joint capsule and synovial membrane. Only the margin of the meniscal body is vascularized after 50 years. In adults, the blood supply to the menisci of the knee reaches the outer 10% to 33% of the body of the menisci. This portion of the menisci is capable of inflammation, repair, and remodeling.

The peripheral portion receives nutrition through blood arteries, whereas the core portion receives nourishment by synovial fluid diffusion. Intermittent loading of the meniscus by weight-bearing or muscle contractions is required for fluid diffusion to sustain nourishment. As a result, the meniscus may not receive adequate nutrition during lengthy periods of immobilization or non–weight-bearing circumstances. (Carolyn krisner; Lynn Allen Colby, Susan Standring) Further, tears of the menisci are common. Peripheral tears in the vascularized zone have the potential to heal satisfactorily, especially with surgical intervention. But, tears in the less vascular or inner zones seldom heal spontaneously; if surgery is indicated, these menisci are often resected. (Gray's Anatomy)

The horns of the menisci and the peripheral vascularized portion of the meniscal bodies are well innervated with free nerve endings (nociceptors), ruffini corpuscles, pacinian corpuscles, and Golgi tendon organs (mechanoreceptors). The presence of nociceptors gives pain felt by patients after a meniscal tear, at least for tears located in the periphery. Proprioceptive deficits may potentially occur after meniscal injury as a result of injury to the mechanoreceptors within the meniscus (Carolyn krisner; Lynn Allen Colby). The central one-third is devoid of innervations.

6. CRUCIATE LIGAMENT

The anterior and posterior cruciate ligaments are two thick, strong fibrous bands that provide a direct bond of union between the femur and the tibia bone. The cruciate are often so named because they cross each other and are classified as anterior or posterior depending on where they attach to the tibia. It supports the knee joint's anteroposterior stability. The cruciate ligaments are extrasynovial but intracapsular. They are the primitive femorotibial joints' collateral ligaments (Carolyn krisner; Lynn Allen Colby, Susan Standring).

ANTERIOR CRUCIATE LIGAMENT (ACL)

ACL consists of antero-medial bundle and posterolateral bundle and provides antero-posterior stability of knee joint. The ACL on tibia is attached below to the anterior part of intercondylar area. Its fibre runs obliquely upward, backward and laterally and attached to the posterior part of medial surface of the lateral femoral condyle. Ligament is taut during the extension of knee and prevents the posterior dislocation of femur on tibia and anterior dislocation of tibia on femur (Carolyn krisner; Lynn Allen Colby, Susan Standring).

POSTERIOR CRUCIATE LIGAMENT (PCL)

PCL on tibia is attached below to the posterior part of intercondylar area. PCL provides posterior stability to the knee joint. The Posterior Cruciate Ligament is more vertical and shorter. PCL is twice as strong and is double the thickness of the normal ACL. It has two bundles the anterolateral bundle which comprises about 65% of the PCL and the posteromedial bundle comprises 35% of the PCL. Its fibres run obliquely upward, forward and medially and attached to the anterior part of the lateral surface of the medial laterally and attached to the posterior part of medial surface of the lateral femoral. It is taut during the flexion of knee and prevents the anterior dislocation of femur on tibia and posterior dislocation of tibia on femur. The vascular supply to the PCL is from the middle genicular artery. The synovial tissue around the PCL is also a major blood source for the ligament. The base of the PCL is supplied by capsular vessels arising from the popliteal and inferior genicular arteries (Carolyn krisner; Lynn Allen Colby).

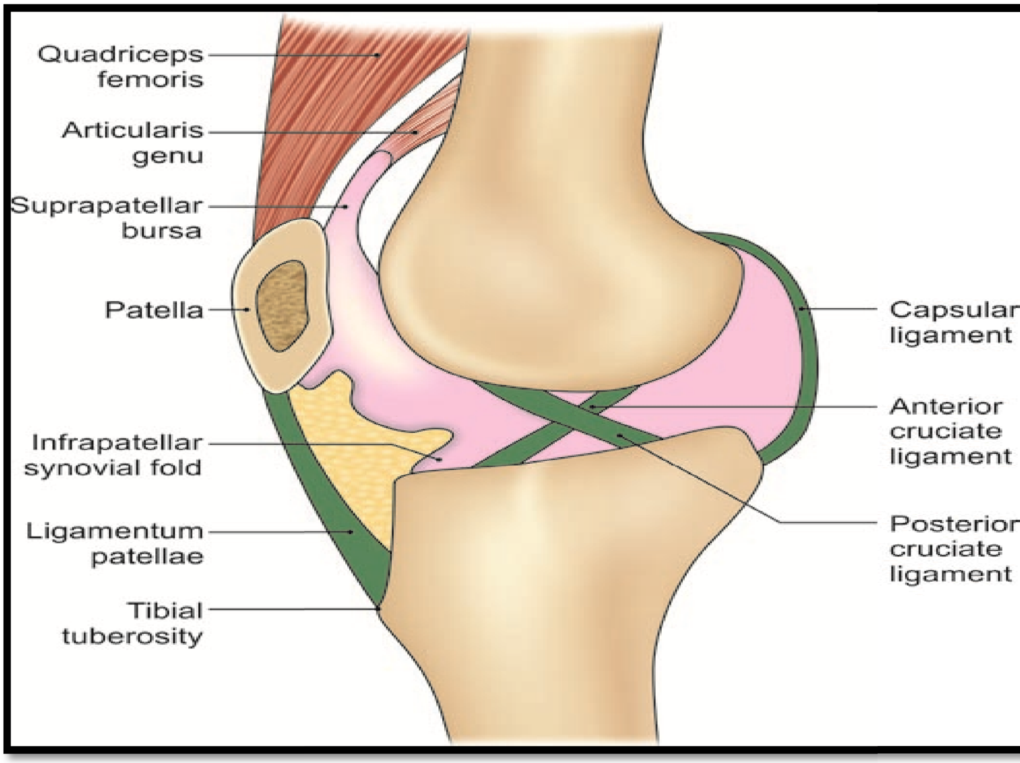

Figure 1.9: Cruciate Ligaments of knee joint

Source: Gosling; (Color Atlas and Textbook of Human Anatomy).

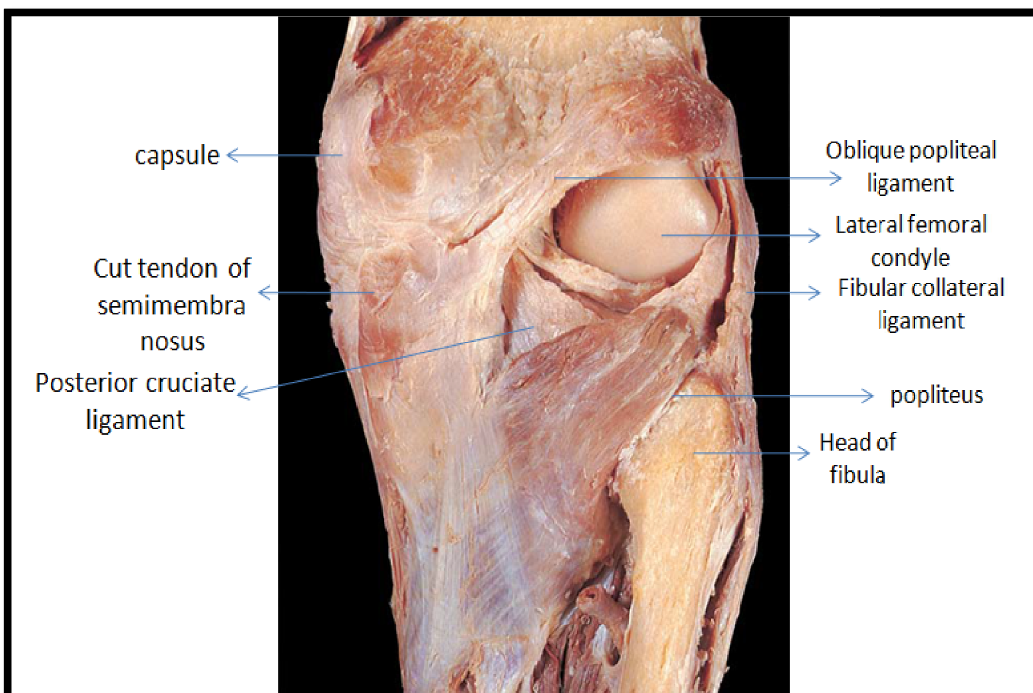

Figure 1.10: Ligaments of posterior knee joint capsule Source: Gosling; (Color Atlas and Textbook of Human Anatomy).

7. OBLIQUE POPLITEAL LIGAMENT (OPL)

The posteromedial corner of the capsule is reinforced by the semimembranosus muscle, by its tendinous expansion called the oblique popliteal ligament. It runs upward and laterally superficial to the capsule of knee joint and attached to the intercondylar line of the femur. It blends along with capsule and strengthens the capsule of knee joint posteriorly. It is pierced by middle genicular nerve, middle genicular vessels, and posterior division of the obturator nerve (Carolyn krisner; Susan Standring).

8. ARCUATE POPLITEAL LIGAMENT (APL)

The posterolateral corner of the capsule is reinforced by the arcuate ligament. It is a Y-shaped fibrous band having stem and limbs. The stem of the band is attached to the styloid process of the fibula. The large posterior or limb of the band arches over the tendon of popliteus and is attached to the posterior border of the intercondylar area of the tibia. The small anterior limb is often deficient and passes deep to the fibular collateral ligament and is attached to the lateral condyle of femur (Carolyn krisner; Lynn Allen Colby, Susan Standring).

1.7 SOFT TISSUES SURROUNDING TO KNEE JOINT

Soft tissues around the knee plays very important and key role in stabilizing the joint; which includes superficial fascia, deep fascia, surrounding ligaments and muscles. These structures are components of popliteal fossa as well.

POPLITEAL FOSSA

The popliteal fossa is a diamond-shaped intermuscular space lies on the posterior aspect of knee joint. Its boundaries include semimembranosus and the overlying semitendinosus superomedially; biceps femoris superolaterally; medial head of gastrocnemius inferomedially and the lateral head of gastrocnemius with the underlying plantaris inferolaterally. Os fabella bone of knee develops under the tendon of lateral head of gastrocnemius. Posteriorly, the fossa is covered by the popliteal fascia, which forms the roof of fossa and it is pierced by the sural nerve and short saphenous vein. The floor of fossa is formed by the popliteal surface of femur, the oblique popliteal and the posterior aspect of the proximal tibia covered by popliteus and the fascia overlying it (Susan Standring).

Contents of the popliteal fossa includes the tibial nerve, popliteal vessels, common peroneal nerve, sural nerve, posterior femoral cutaneous nerve, short saphenous vein, an articular branch from the obturator nerve, popliteal group of lymph nodes and fat. The tibial nerve runs vertically and lies centrally, crossing the vessels posteriorly from lateral to medial. The common peroneal nerve runs laterally immediately medial to the tendon of biceps femoris. Popliteal vessels are deeply located and held together by dense areolar tissue. They lie on the floor of the fossa; the popliteal vein lies superficial to the artery. Proximally, vein lies lateral to the artery, crossing to its medial side distally. Six or seven popliteal lymph nodes are embedded in the fat, one under the popliteal fascia near the termination of the short saphenous vein, one between the popliteal artery and knee joint, the others around the popliteal vessels (Susan Standring).

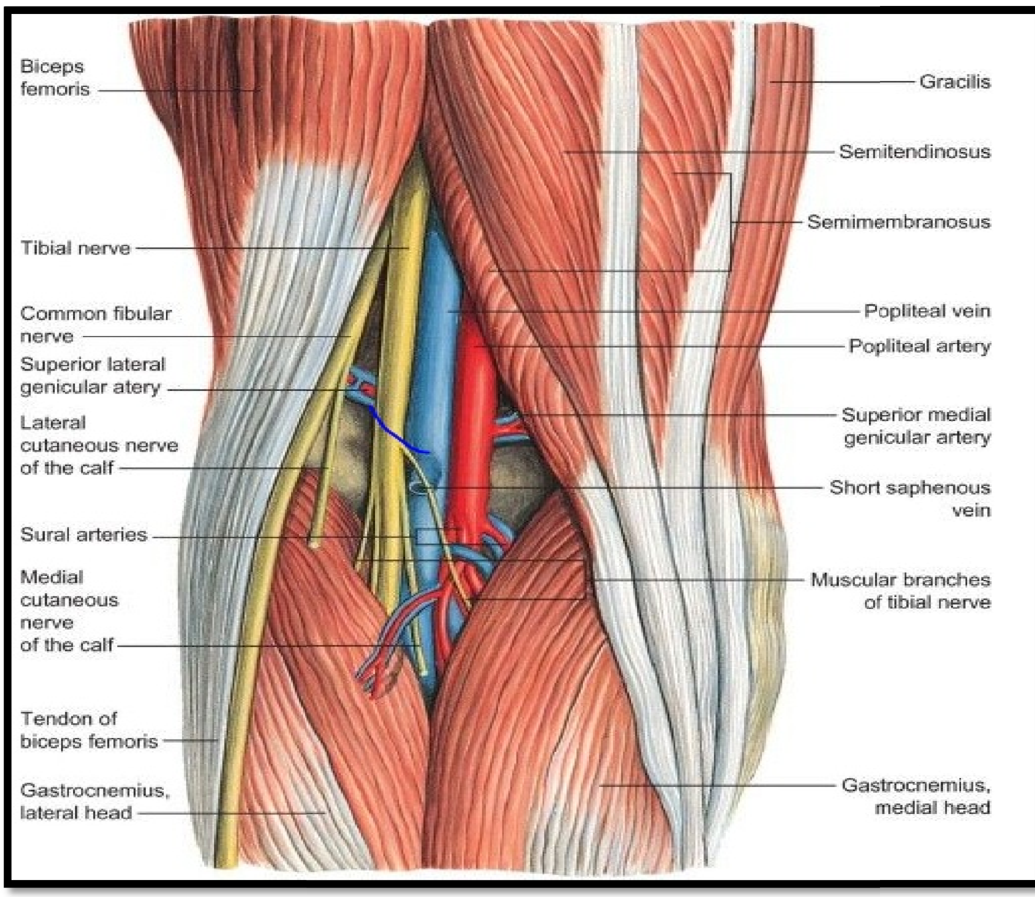

Figure 1.11: Soft tissues surroundings to the knee: Popliteal fossa: posterior aspect of knee joint; Source: Gray's Anatomy; (The Anatomical basis of clinical practice)

1.8 BURSAE RELATED TO KNEE JOINT

The ligaments and muscles crossing the tibiofemoral joint, in combination with the large excursions of bony segments, sets up the potential for substantial frictional forces among muscular, ligamentous, and bony structures. Numerous bursae, however, prevent or limit such degenerative forces. There are about 12 bursae around the knee, four anterior, three lateral, three medial, and two posterior.

Anteriorly lying subcutaneous prepatellar bursa (housemaid's knee), Subcutaneous infrapatellar bursa between the skin and smooth lower part of the tibial tuberosity, Deep infrapatellar bursa between ligamentum patellae and tibial tuberosity and suprapatellar bursa between the anterior surface of lower part of the femur and deep surface of the quadriceps femoris.

Posteriorly lying the bursa between the lateral head of gastrocnemius and capsule of the joint and the bursa between the medial head of gastrocnemius and capsule of the joint (Brodie's bursa).

Medially lays the bursa, which separates the tendons of the sartorius, the gracilis, and the semitendinosus from each other and from the tibial collateral ligament (anserine bursa), the bursa between the tendon of semimembranosus and medial collateral ligament, the bursa between the tendon of semimembranosus and medial condyle of the tibia which may communicate with the knee joint.

Laterally lays the bursa between the fibular collateral ligament and tendon of biceps femoris, the bursa between the fibular collateral ligament and tendon of popliteus, the bursa between the tendon of popliteus and lateral condyle of femur. This bursa is really a synovial tube around the tendon of popliteus; hence it communicates with the joint cavity.

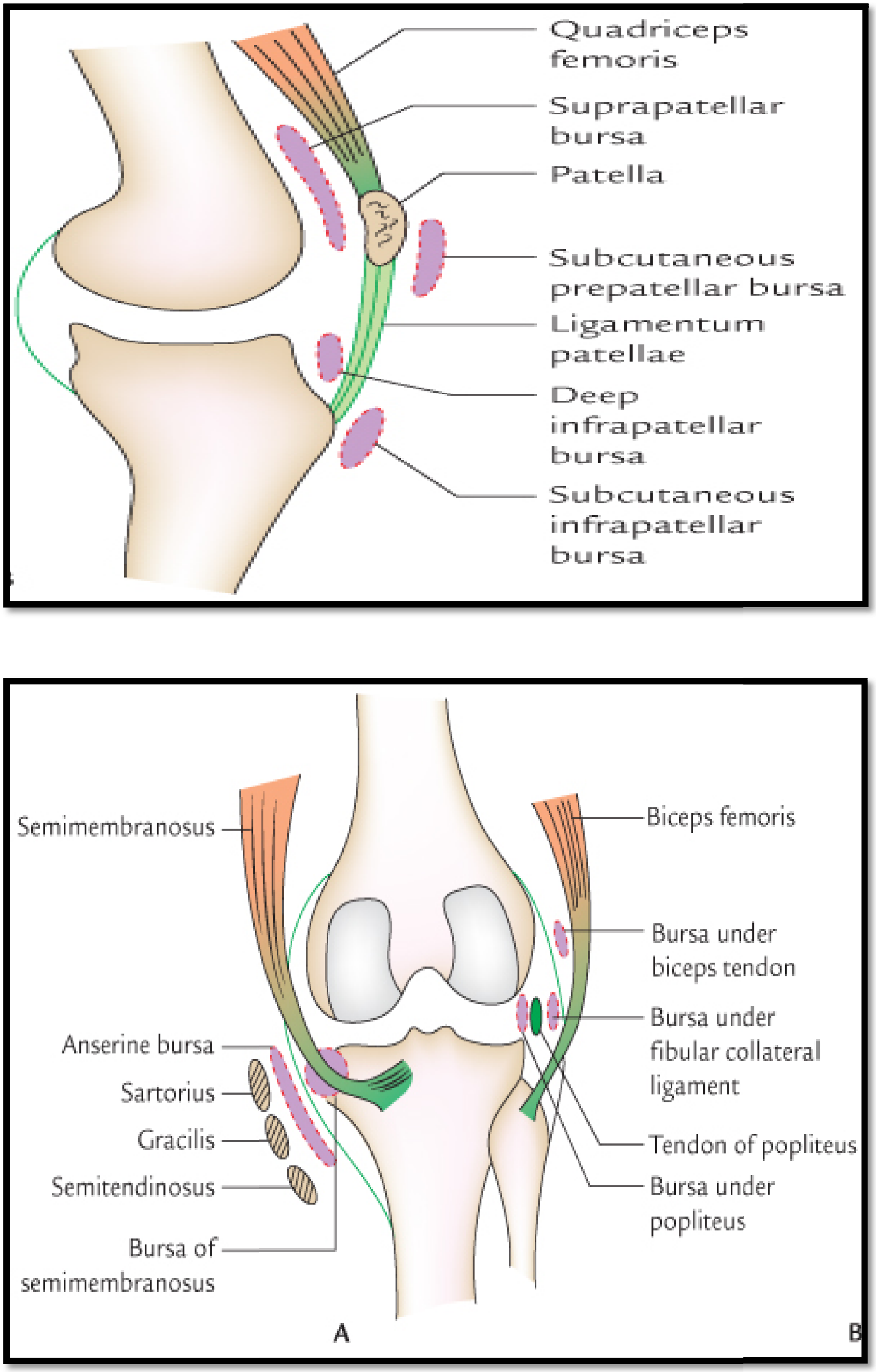

Figure 1.12.: Bursae related to knee joint. Source: Vishram singh

1.9 RELATIONS OF KNEE JOINT

Anteriorly the knee is related to the tendon of the quadriceps femoris, patella, ligamentum patellae, patellar plexus of the nerves, and prepatellar synovial bursa. Anteromedially it is related to the medial patellar retinaculum. Anterolaterally it is related to lateral patellar retinaculum and iliotibial tract. Posteriorly it is related to popliteal vessels, tibial nerve, and oblique popliteal ligament. Posteromedially it is related to sartorius, gracilis, semimembranosus, and semitendinosus in the upper part, medial head of gastrocnemius and popliteus in the lower part. Posterolaterally, tendon of biceps femoris and common peroneal nerve in the upper part, lateral head of gastrocnemius and plantaris in the lower part(Susan Standring).

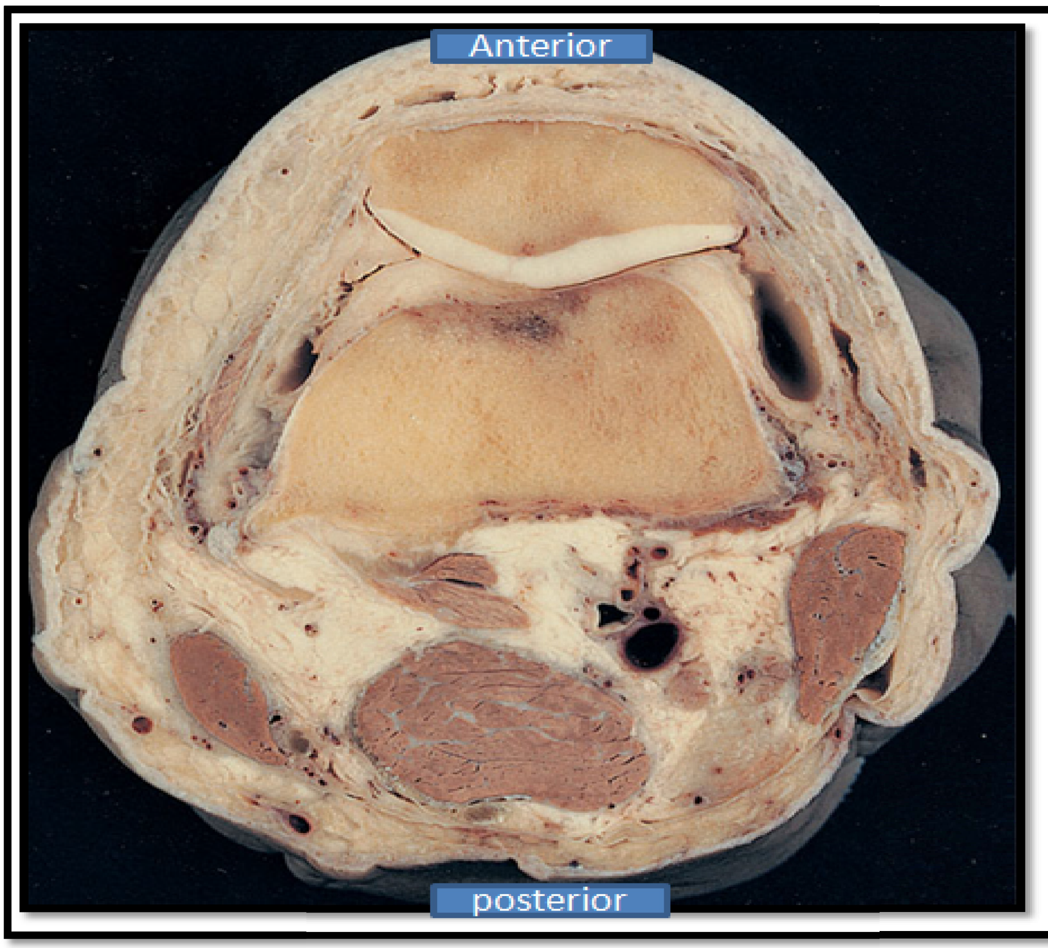

Figure 1.13: Relations of knee joint. Source: Gosling; (Color Atlas and Textbook of Human Anatomy)

1.10 SKIN

1.10.1 CUTANEOUS VASCULAR SUPPLY

The arterial supply of skin covering the knee is from the cutaneous branches from the neighboring large vessels which include genicular branches of the popliteal artery, the descending genicular branch of the femoral artery, and the anterior recurrent branch of the anterior tibial artery, and small contribution is from the arteries to vastus medialis and the hamstrings. Cutaneous veins are tributaries of the vessels that correspond to the named arteries (Susan Standring).

1.10.2 CUTANEOUS LYMPHATIC DRAINAGE OF KNEE

Cutaneous lymphatics are initially drained to the superficial inguinal nodes, and possibly also to the popliteal lymph nodes and thence to the deep inguinal group of lymph nodes.

1.10.3 CUTANEOUS INNERVATION

INFRAPATELLAR BRANCH OF THE SAPHENOUS NERVE

Skin over the knee is supplied by Infrapatellar branch of the saphenous nerve. It reaches the anterior aspect of the knee from the medial side (Susan Standring).

PERIPATELLAR PLEXUS

The subcutaneous network of communicating nerve fibres surrounding to the patella is known as peripatellar plexus. Proximal to the knee, the infrapatellar branch of the saphenous nerve connects with branches of the intermediate femoral cutaneous nerves, medial femoral cutaneous nerves, and lateral femoral cutaneous nerve. Distal to the knee it connects with other branches of the saphenous nerve (Susan Standring).

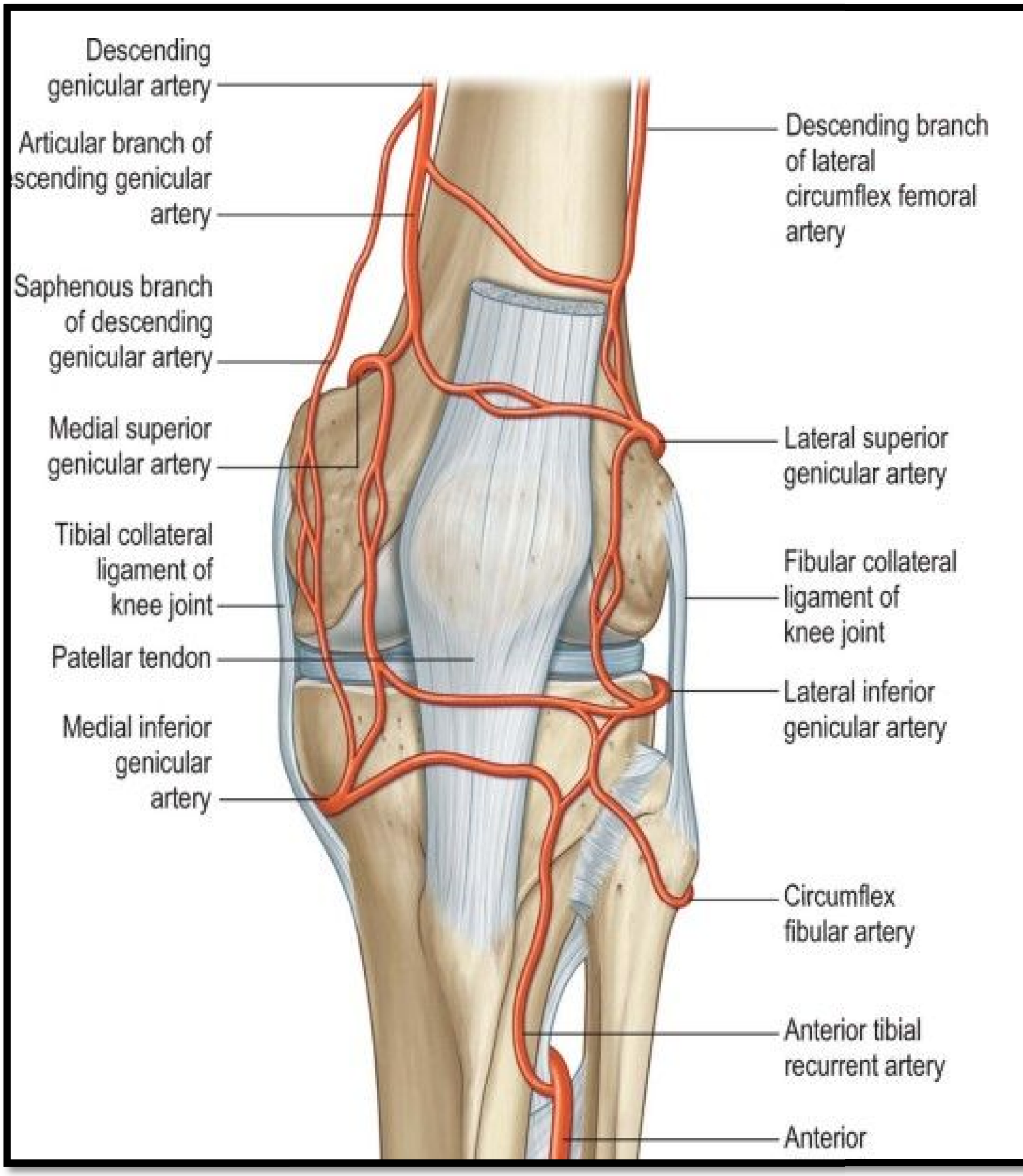

Figure 1.14: Blood supply of knee joint;

Source: Gray's Anatomy; (The Anatomical basis of clinical practice).

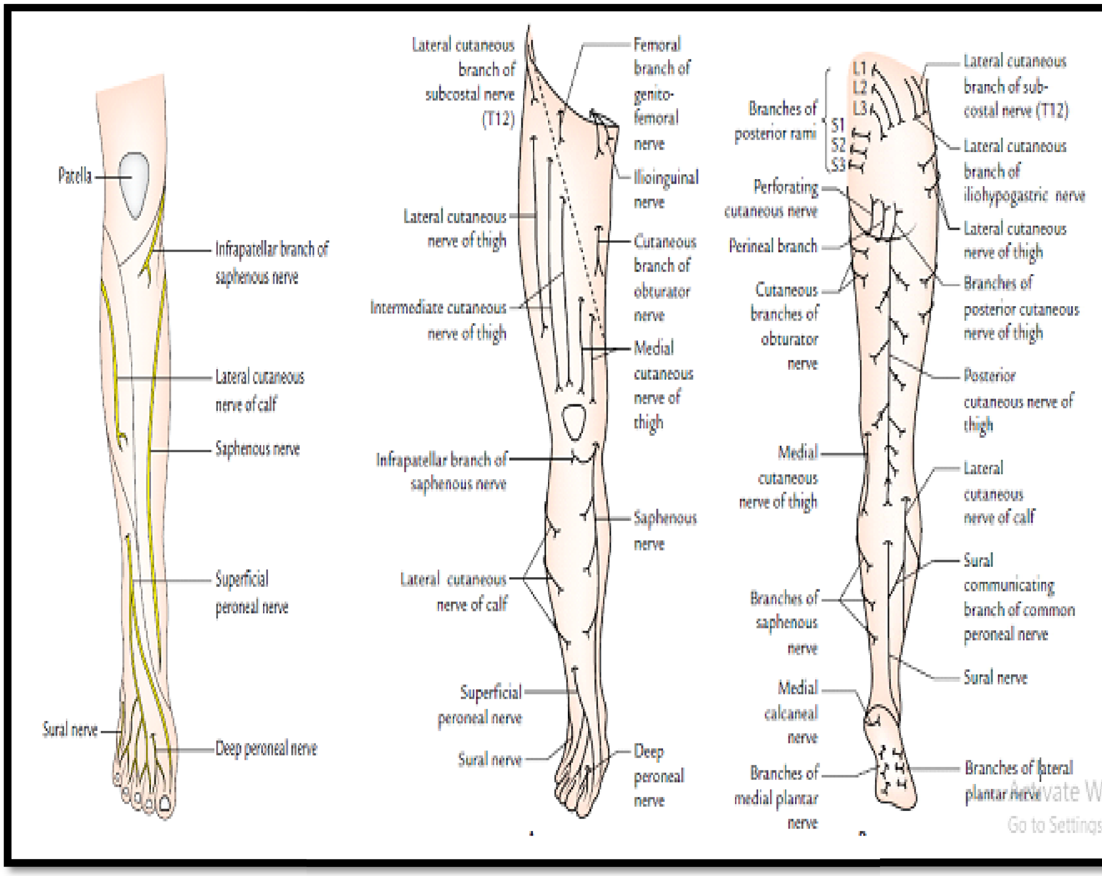

Figure 1.15: Nerve supply of knee joint;

Source: Vishram Singh; (Textbook of Anatomy Abdomen and Lower limb).

1.11 MOVEMENTS AT KNEE JOINT

Flexion, extension, medial rotation, and lateral rotation are all active knee movements. The main movements are flexion and extension, which take place in the upper compartment of the joint, above the menisci. Medial rotation of the femur occurs during the last 30° of extension, and lateral rotation of the femur occurs during the initial stages of flexion.

Flexion of knee: When back of thigh and back of leg come in approximation.

Extension of knee: When thigh and leg are in straight line as in standing (Carolyn krisner, Lynn Allen Colby, David J. Magee).

Flexion/Extension Range of Motion

Many of the muscles acting at the knee are two joint muscles crossing not only the knee but also the hip or ankle joint. Therefore, the position of hip joint can influence the ROM of knee joint. Passive range of knee flexion is 130º to 140º. During an activity such as squatting both the hip and knee are flexed, hence the knee flexion may reach to 160º. The range of knee flexion requires during normal gait on ground is 60º to 70º. While, during ascending stairs about 80º, sitting down and arising from a chair requires 90º. An accessory or passive movements can be performed in a partially flexed knee. These movements include a wide range of rotation, antero-posterior gliding of the tibia on the femur, some adduction and abduction, some separation of the tibia from the femur (Carolyn krisner, Lynn Allen Colby, David J. Magee).

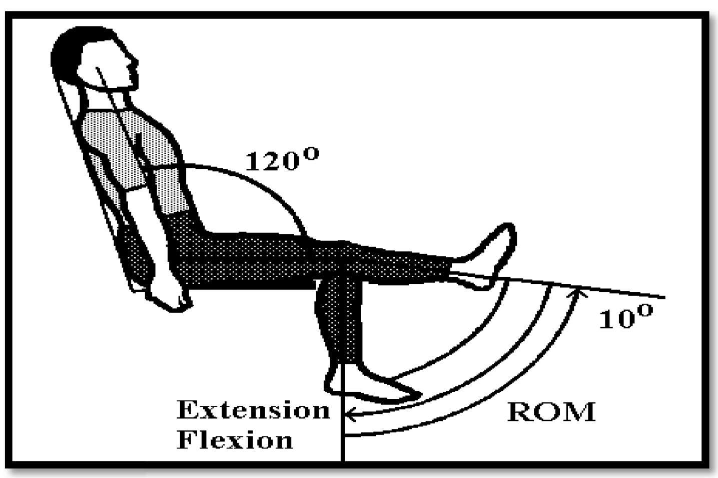

Figure 1.16: ROM of flexion and extension of knee joint;
Source: I. Pontaga; (Hip and knee flexors and extensors balance in dependence on the velocity of movements; Biology of Sport; Vol. 21N 3, 2004; 261-272).

1.12 LOCKING & UNLOCKING MOVEMENT OF KNEE JOINT

Locking is a mechanism that allows the knee to remain in the position of full extension as in standing without much muscular effort. Locking occurs as a result of medial rotation of the femur during the last stage of extension. There is an obligatory lateral rotation of the tibia that accompanies the final stages of knee extension that is not voluntary or produced by muscular forces. This coupled motion (lateral rotation with extension) is referred to as automatic or terminal rotation or locking of the knee.

The antero-posterior diameter of medial articular surface of the knee is longer (has more articular surface) than the lateral articular surfaces. Consequently, during the last 30º of knee extension (30º-0º), lateral condylar articular surface is fully 'used up' by extension and completes its rolling-gliding motion before the longer medial articular surfaces, part of the medial condylar surface remains unused. As the extension continues (referencing non–weight-bearing motion of the tibia), the longer medial plateau continues to roll and glide anteriorly after the lateral side of the plateau has halted (Susan Standring, Carolyn krisner; Lynn Allen Colby).

This continued anterior motion of the medial tibial condyle results in lateral rotation of the tibia on the femur, with the motion most manifest in the final 5ºof extension. Increasing tension in the knee joint ligaments as the knee approaches full extension may also contribute to the compulsory rotational motion, bringing the knee joint into its close-packed or locked position. The tibial tubercles become lodged in the intercondylar notch, the menisci are tightly interposed between the tibial and femoral condyles, and the ligaments are taut.

Consequently, at this stage, the lateral condyle serves as an axis around which the medial condyle rotates backwards, i.e., medial rotation of the femur occurs, so that the remaining part of the medial condylar surface is also 'taken up'. This movement locks the knee joint. This automatic rotation is also known as the locking or screw home mechanism of the knee (Susan Standring, Carolyn krisner; Lynn Allen Colby). This automatic rotation or locking of the knee occurs in both weight-bearing and non–weight-bearing knee joint function.

1.13 MUSCLES PRODUCING MOVEMENT AT KNEE JOINT

The muscles responsible for producing the movements at knee joint are belong to either the anterior, posterior or medialcompartment of the thigh.

EXTENSOR MUSCLES OF KNEE JOINT

The quadriceps femoris muscle is made up of the four extensor muscles of the knee. Rectus femoris with three vasti muscles (vastus lateralis, Vastus medialis, and Vastus intermedius) make up the quadriceps femoris. The quadriceps femoris is the only muscle group in the knee that crosses anterior to the axis and is the primary mover in knee extension. The rectus femoris is the only quadriceps muscle that crosses both the hip and knee joint (Susan Standring).

The knee joint is an intermediate joint in a closed chain during the standing and stance phases of gait. Through the reverse muscle pull on the femur, the quadriceps muscle controls the amount of flexion at the knee and also promotes knee extension. When the gravity line falls anterior to the axis of motion in an upright position and the knee is locked, the quadriceps femoris does not have to work. In this moment, tension in the hamstring and gastrosoleus tendons supports the posterior capsule. In additional, the ACL and hamstrings muscle group counters the anterior translation force of quadriceps muscle (Susan Standring; Carolyn krisner; Lynn Allen Colby).

MUSCLE	ORIGIN	INSERTION	NERVE SUPPLY	ACTION
Rectus femoris: -Straight head -Reflected head	Straight head- arises from the upper half of AIIS. Reflected head- arises from the dorsal surface of the ilium above the acetabulum.	Base of patella and tibial tuberosity via patellar ligament	Femoral nerve (Posterior division)	Extension of knee joint & flexion of hip joint.

Vastus lateralis	-Highest fibres arises from the upper part of intertrochanteric line -Anterior and inferior border of greater trochanter of femur -Lateral lip of gluteal tuberosity -Upper half of lateral lip of linea aspera.	-Base of patella in its lateral part. -Upper one-third of the lateral border of patella - expansion to the knee joint capsule, tibia & IT band	Femoral nerve (Posterior division)	Extension of knee joint
Vastus Intermedius	Upper $3/4^{th}$ of anterior and lateral surface of shaft of femur	- Base of patella	Femoral nerve (Posterior division)	Extension of knee joint
Vastus medialis	-Lower part of intertrochanteric line, -Spiral line, -Medial lip of linea aspera, -Upper $3/4^{th}$ medial supracondylar line	-Base of patella in its medial one-third part -Upper $2/3^{rd}$ of medial border of patella -Expansion to the knee joint capsule	Femoral nerve (Posterior division)	-Extension of knee joint -Prevents lateral displacement of patella -Pivotal role in maintaining stability of knee joint
Articularis genu	In the lower part of anterior surface of femur below the vastus intermedius as two slips.	Suprapatellar bursa of knee joint	Femoral nerve (Posterior division)	Pulls the synovial membrane up during extension of knee

TABLE- 1.1: EXTENSOR MUSCLES OF KNEE JOINT

FLEXOR MUSCLES OF KNEE JOINT

The hamstring group of muscles is the primary knee flexors and also influences the rotation of tibia on the femur.

There are seven muscles that flex the knee joint. These are the semimembranosus, semitendinosus, biceps femoris, sartorius, gracilis, popliteus, and gastrocnemius muscles. The plantaris muscle may be considered an eighth knee flexor, but it is commonly absent. All the knee flexors are two-joint muscles; hence works more efficiently with effective force at the knee is influenced by simultaneous flexion of hip and knee except to short head of the biceps femoris and the popliteus (Susan Standring; Carolyn krisner; Lynn Allen Colby).

The muscles on the medial side of the joint (semimembranosus, semitendinosus, medial head of the gastrocnemius, sartorius, and gracilis) have the ability to medially rotate the tibia on a fixed femur and thus can generate varus moments. While, the lateral muscles (biceps femoris, lateral head of the gastrocnemius, and the popliteus) are capable of producing valgus moments at the knee (Susan Standring; Carolyn krisner; Lynn Allen Colby).

The semitendinosus, semimembranosus, ischial head of adductor magnus and the long heads of the biceps femoris muscles are collectively known as the hamstrings. These muscles each attach proximally to the ischial tuberosity of the pelvis, distally to the leg bone, innervated by tibial part of sciatic nerve and perform flexion of knee. The semitendinosus muscle attaches distally to the anteromedial aspect of the tibia by way of a common tendon with the sartorius and the gracilis muscles. The common tendon is called the pes anserinus because of its shape (pes anserinus means “goose’s foot”) (Susan Standring; Carolyn krisner; Lynn Allen Colby).
The gastrocnemius muscles are also the knee flexors, but its primary function at the knee comes to play the role to support the posterior capsule of knee against the hyperextension force. The popliteus muscle on the back of knee supports the posterior knee joint capsule and acts to unlock the knee joint. The pes anserinus group of muscles; provides medial stability to the knee joint and affects rotation of tibia in a closed chain (Susan Standring; Carolyn krisner; Lynn Allen Colby).

MUSCLE	ORIGIN	INSERTION	NERVE SUPPLY	ACTION
Semimembranosus	Superolateral part of ischial tuberosity	Groove on the posterior aspect of medial condyle of tibia	Tibial part of sciatic nerve	Flexion of leg at knee joint (when pelvis is fixed) -Extension of hip joint - preventing the pelvis rolling backwards on the head of the femur
Semitendinosus	Inferomedial part of ischial tuberosity	Superomedial aspect of upper part of tibia, behind the sartorius, below and behind the gracilis	Tibial part of sciatic nerve	
Biceps Femoris	Long head - Infero-medial aspect of ischial tuberosity -Sacrotuberous ligament Short head- linea aspera of femur	Common tendinous insertion attached at the head of fibula	Long head - Tibial part of sciatic nerve Short head- Peroneal part of sciatic nerve	
Gastrocnemius	Medial head – posterior aspect of medial condyle of femur	Through tendocalcaneus into the middle one-third of posterior surface of calcaneus	Tibial part of sciatic nerve	Strong plantar-flexion of foot (in walking, running, jumping) -Helps in flexion of knee joint -It steadies leg on foot
Plantaris (Freshmen's muscle, vestigial muscle)	Lower part of lateral supracondylar line if femur	Long thin and slender tendon attached to the medial margin of tendocalcaneus	Tibial part of sciatic nerve	weak plantar-flexion of foot (in walking, running, jumping)

Sartorius	-ASIS -Upper half of the notch below the spine	Upper part of medial aspect of knee	Anterior division of femoral nerve	-Flexion of thigh -Flexion of leg
Gracilis	Medial margin of pubic arch including body of pubis, inferior ramus of pubis and ramus of ischium	Upper part of medial aspect of knee behind the sartorius	Anterior division of Obturator nerve	-Flexion of leg -Medial rotation of thigh - Adduction of thighs
Popliteus	Tendinous origin from anterior groove part on posterior aspect of lateral condyle of tibia	Triangular area on the upper posterior surface of shaft of tibia	Tibial part of sciatic nerve	-Rotates tibia medially on the femur (leg is off the ground) - rotates femur laterally on tibia (unlocking of knee joint) (leg is on the ground) -It pulls lateral meniscus backward during lateral rotation of femur.

TABLE- 1.2: FLEXOR MUSCLES OF KNEE JOINT

1.14 BIOMECHANICS OF KNEE JOINT

The Knee joint is a complex joint both anatomically and biomechanically. It is functionally a trochoginglymos i.e., gliding hinge joint (a pivotal hinge joint), which permits flexion and extension as well as a slight internal and external rotation. It functions to control the centre of body mass and posture in the activities of daily living. This necessitates a large range of movement in three dimensions coupled with the ability to withstand high forces. These conflicting parameters of mobility and stability are only achieved by the interactions between the articular surfaces, the passive stabilizers and the muscles that cross the joint (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

The surfaces of the tibia and femur are not as conforming as those of the relatively congruent hip joint although, this variation in the geometry permits motion to occur in six degrees of freedom.

The sagittal plane is the predominant plane of motion for the knee, with the transverse plane having just a minor role. As a result, the knee joint can be defined simply as a modified hinge joint that allows flexion–extension and some rotatory motion. Starting from 0° (neutral), when the tibia and femur are in line in the sagittal plane, knee motion is generally characterized. When the person is standing motionless, it is critical that the knee achieves the neutral position in extension because this permits the leg to support the body weight like a simple pillar. If the knee is flexed while the person is standing upright, the vertical line of action of the body weight passes posterior to the knee's centre of rotation, causing the body to tilt posteriorly. To counterbalance this, continuous quadriceps femoris contraction is required, causing expenditure of energy (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

Such deep flexion is frequently accompanied by tibial medial rotation, allowing the buttocks to rest on the feet when the person is kneeling. The lateral tibial plateau is carried anteriorly in this action, avoiding contact with the femoral lateral condyle in deep knee flexion. The femoral condyle passes behind the lateral meniscus and rides over its horn. When walking, the most common knee movement is squatting (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

TIBIOFEMORAL JOINT FUNCTION:
OSTEOKINEMATICS AND ARTHROKINEMATICS

The primary angular motion of the tibiofemoral joint is flexion/extension, although both medial/lateral (internal/external) rotation and varus/valgus (adduction/adduction) motions can also occur to a lesser extent. The joint incongruence and variations in ligamentous elasticity causes smaller anteroposterior and medial/lateral displacements in the normal knee. Although these translation movement seems undesirable, but it is necessary for normal joint motions to occur. However, any excessive translational motions should be considered abnormal and indicates some degree of ligamentous incompetence (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

The medial and lateral articular surfaces, commonly known as the medial and lateral compartments of the knee, characterise the double condyloid knee joint. For an understanding of the mobility of the knee joint, as well as the functions and typical dysfunctions of the joint, a thorough investigation of the articular surfaces and their relationships to one another is crucial(Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

The tibiofemoral joint is a joint with three degrees of freedom of angular (rotatory) motion in three planes namely sagittal, transverse and frontal planes (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

1. SAGITTAL PLANE:

The flexion and extension movement of knee occurs in the sagittal plane around a coronal axis, which passes through the epicondyles of the distal femur.

Flexion/Extension

The transepicondylar axis for flexion and extension movement of knee is not truly fixed; rather it shifts throughout the ROM. Much of the shift in the axis can be attributed to the incongruence of the joint surfaces as large femoral condyles relative to the smaller tibial condyle, which causes femoral flexion on the fixed tibia.

Active knee flexion is limited to about 130° flexion due to the apposition of the soft tissue masses (posterior thigh and calf). Passive flexion can be as high as 160 degrees. This is essential in persons who kneel frequently in their daily lives, and it presents a difficulty for knee prosthesis designers. The rolling of the femoral condyles on the tibia, which brings the contact of the femoral condyles posteriorly on the tibial condyle, is the primary cause of knee flexion (0^o to 25^o). As flexion continues, the rolling of the femoral condyles is accompanied by a simultaneous anterior glide to prevent femur run out of tibia; that is just sufficient to create a nearly pure spin of the femur on the posterior tibia with little linear displacement of the femoral condyles after 25^o of flexion. The extension of knee from flexion is essentially a reversal of this motion. Tibiofemoral extension occurs initially as an anterior rolling of the femoral condyles on the tibial plateau, displacing the femoral condyles back to a neutral position on the tibial plateau. After the initial forward rolling, the femoral condyles glide posteriorly just enough to continue extension of the femur as an almost pure spin of the femoral condyles on the tibial plateau(Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

The femur moves on a stationary tibia during a squat, according to the interdependent osteokinematics and arthrokinematics. During seated knee extension or the swing phase of walking, the tibia moves on a stationary femur. The tibia rolls and slides posteriorly on the comparatively fixed femoral condyles when it flexes on a fixed femur. Anterior roll and glide of the tibial plateau on a fixed femur are included in tibia extension on a fixed femur (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

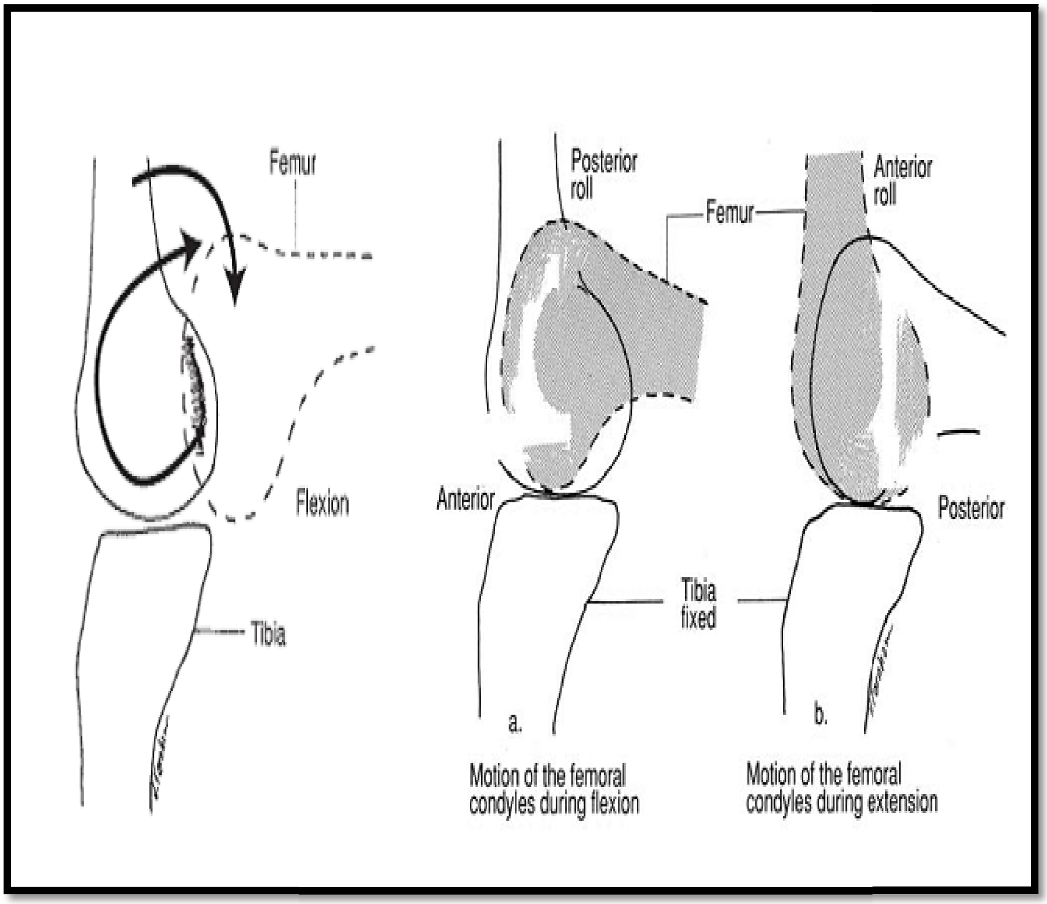

Figure 1.17: Schematic illustration of pure rolling of the femoral condyles on a fixed tibia, a schematic representation of rolling and gliding of the femoral condyles on a fixed tibia, Motion of the femoral condyles during extension; Source: Pamela K. Levangie, Cynthia C. Norkin; (Structure and Function- A Comprehensive analysis)

2. TRANSVERSE PLANE:

The medial and lateral (internal/external) rotation of knee occurs in the transverse plane about a vertical axis through or close to the medial tibial intercondylar tubercle (Pamela K. Levangie, Cynthia C. Norkin).

Medial/Lateral Rotation

Medial and lateral rotations of knee joint are angular motions of the tibia on the femur. The medial condyle acts as the pivot while the lateral condyles move through a greater arc of motion, regardless of the direction of rotation.

As the tibia laterally rotates on the femur, the medial tibial condyle moves only slightly anteriorly on the relatively fixed medial femoral condyle, whereas the lateral tibial condyle moves a larger distance posteriorly on the relatively fixed lateral femoral condyle. During tibial medial rotation, the medial tibial condyle moves only slightly posteriorly, whereas the lateral condyle moves anteriorly through a larger arc of motion. During both medial and lateral rotation, the knee joint's menisci will distort in the direction of movement of the corresponding femoral condyle and, therefore, maintain their relationship to the femoral condyles. When tibia medially rotates (femur laterally rotates on the tibia), the medial meniscus will distort anteriorly on the tibial condyle to remain beneath the anteriorly moving medial femoral condyle, and the lateral meniscus will distort posteriorly to remain beneath the posteriorly moving lateral femoral condyle. So, the menisci continue to reduce friction and distribute forces without restricting motion of the femur (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

Axial rotation is permitted by articular incongruence and ligamentous laxity. Therefore, the range depends on the flexion/extension position of the knee. When the knee is in full extension, little axial rotation is possible as the ligaments are taut, the tibial tubercles are lodged in the intercondylar notch, and the menisci are tightly interposed between the articulating surfaces. The maximum range of axial rotation is available at 90ºof knee flexion. The total medial/lateral rotation available is approximately 35º, with the range for lateral rotation being slightly greater (0ºto 20º) than the range for medial rotation (0ºto 15º) (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

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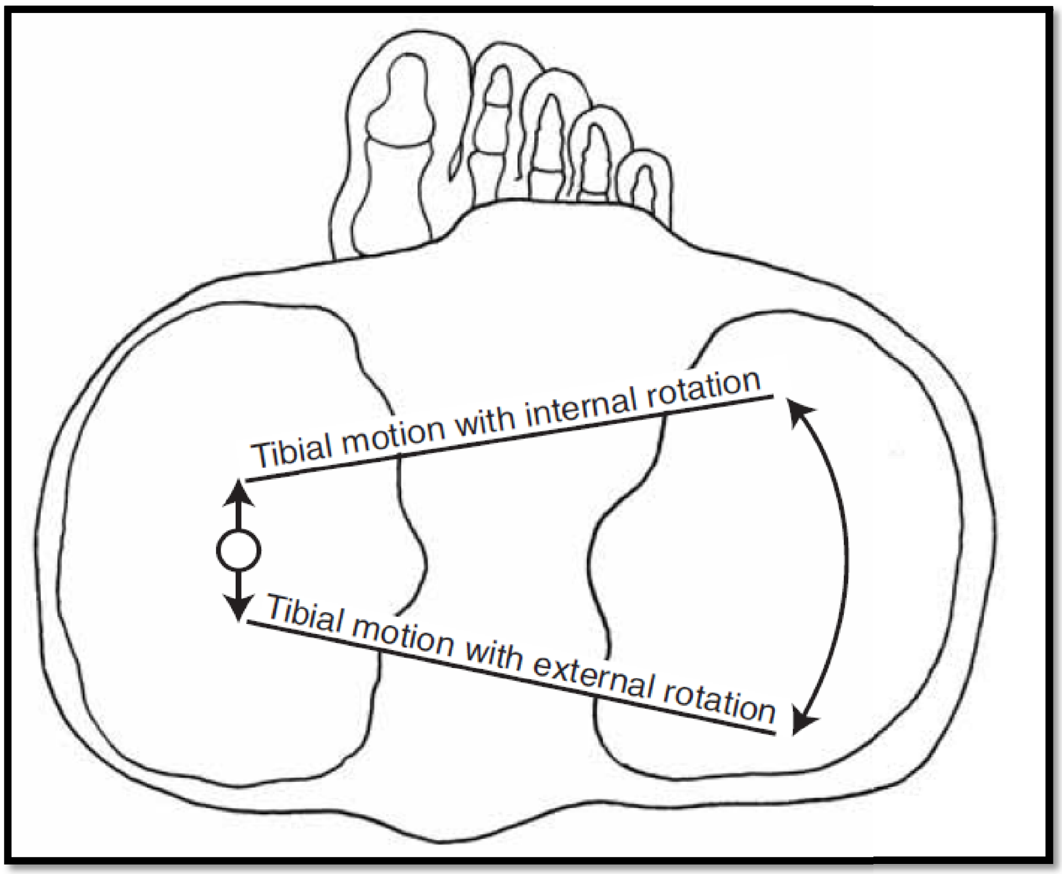

Figure 1.18: Schematic illustration of shows with internal/external rotation of the tibia, more motion of the lateral tibial condyle than of the medial tibial condyle in both directions; Source: Pamela K. Levangie, Cynthia C. Norkin; (Structure and Function- A Comprehensive analysis)

3. FRONTAL PLANE:

The abduction and adduction occur in the frontal plane around an anteroposterior axis.

Valgus (Abduction)/Varus (Adduction)

It is the lowest among the three and the maximum range of 13º is possible at 20° of knee flexion and 8° only at full extension; any excess movement indicates ligamentous laxity.

Coupled Motions

The true flexion/extension axis is not parallel to the femur and tibia shafts. As a result, flexion and extension do not occur as pure sagittal plane motions, but rather as "coupled motions" that includes frontal plane components ; similar to coupling that occurs with lateral flexion and rotation in the vertebral column. As previously stated, the medial femoral condyle is slightly distal to the lateral femoral condyle, resulting in a physiologic valgus angle in the extended knee that is comparable to that encountered at the elbow. With knee flexion around the obliquely oriented axis, the tibia moves from a position oriented slightly lateral to the femur to a position slightly medial to the femur in full flexion; that is, the foot approaches the midline of the body with knee flexion just as the hand approaches the midline of the body with elbow flexion. Flexion is, therefore, considered to be coupled to a varus motion, while extension is coupled with valgus motion (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

PATELLOFEMORAL JOINT FUNCTION:
OSTEOKINEMATICS AND ARTHROKINEMATICS

Motions of the Patella

Through joint motion, the patella simultaneously moves and rotates on the femoral condyles as its contact with the femur changes. Patella movements are influenced by and reflect the patella's relationship to the femur and tibia. Accordingly, the actions can appear quite complex. When the femur is fixed and the tibia is flexing, the patella is pulled down and under the femoral condyles; ending with the apex of the patella pointing posteriorly in full knee flexion. This sagittal plane rotation of the patella as the patella travels (or “tracks”) down the intercondylar groove of the femur is termed patellar flexion. After knee extension, the patella will return to its original position in the femoral sulcus, with the apex of the patella pointed inferiorly at the end of the normal range of motion. As a result of this motion, the patellar joint extends (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

In addition the patella rotates around a longitudinal axis and tilts around an anteroposterior axis. It is termed as medial or lateral patellar tilt and is named for the direction in which the anterior surface of the patella is moving. When the tibia medially rotates beneath the femur during axial rotation, the patella must remain in the intercondylar groove during the relative lateral rotation of the femur. This relative motion of the femur forces the patella to face more laterally; this is termed lateral rotation (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

Rotation of the patella about an anteroposterior axis termed as medial or lateral rotation of the patella; and it is, like patellar tilt, necessary in order for the patella to remain seated between the femoral condyles as the femur undergoes axial rotation on the tibia (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin)..

Because the inferior aspect of the patella is “tied” to the tibia via the patellar tendon, the inferior patella continually points toward the tibial tuberosity while moving with the femur. Therefore, when the knee is in some flexion and there is medial rotation of the tibia on the fixed femur, the inferior pole of the patella will point medially; this is termed medial rotation of the patella. In lateral rotation of the patella, the inferior patellar pole follows the laterally rotated tibia. The patella laterally rotates approximately 5ºas the knee flexes from 20º-90º(Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

There is a simultaneous medial-lateral translation of the patella that accompanies the superior-inferior glide that is referred to as patellar shift. The patella shifts as the knee moves from full extension into flexion. Failure of the patella to slide, tilt, rotate, or shift appropriately can lead to restrictions in knee joint ROM, to instability of the patellofemoral joint, or to pain caused by erosion of the patellofemoral articular surfaces. Therefore, passive mobility of the patella is often assessed clinically to determine the presence of hypermobility or hypomobility of the patella with respect to the femur (Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

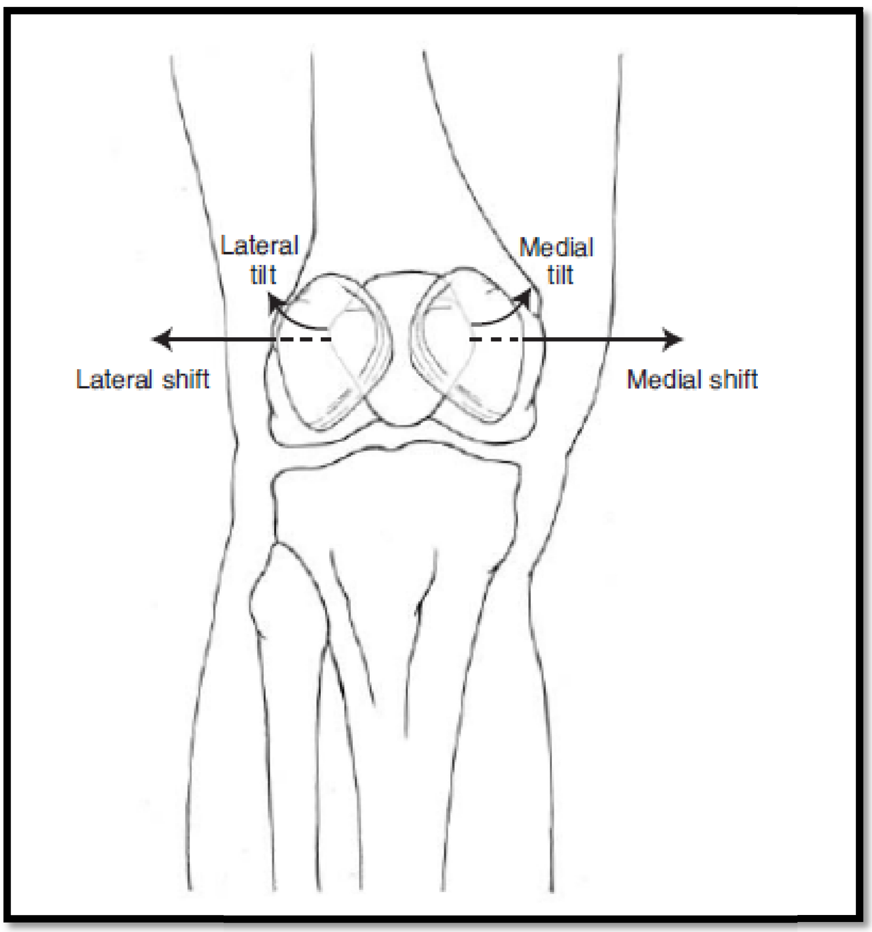

Figure 1.19: Medial and lateral shift of the patella; Source: Pamela K. Levangie, Cynthia C. Norkin ;(Structure and Function- A Comprehensive analysis)

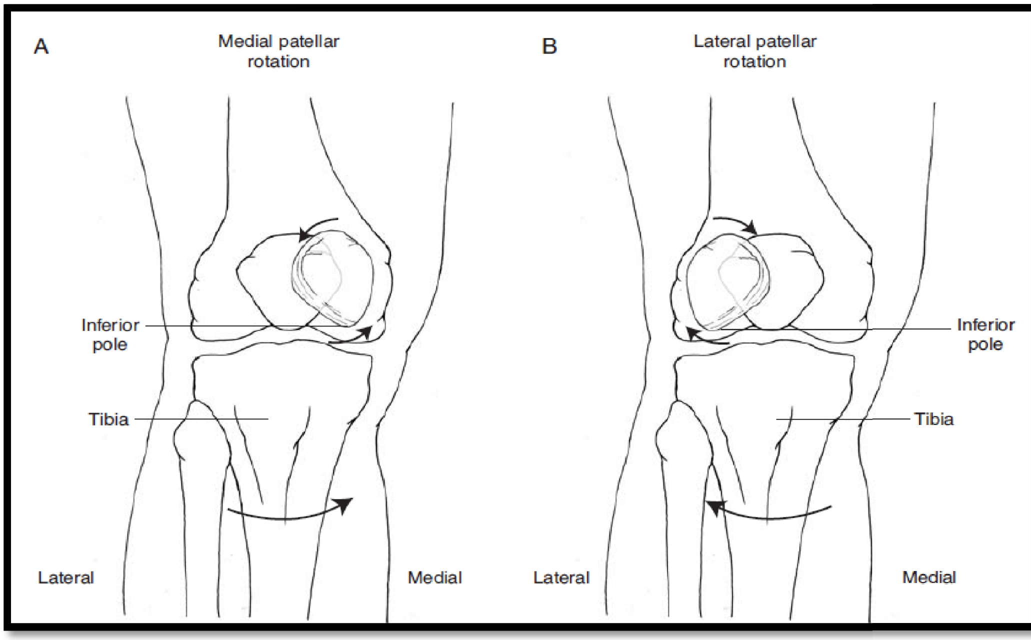

Figure 1.20: Medial and lateral rotation of the patella; Source: Pamela K. Levangie, Cynthia C. Norkin; (Structure and Function- A Comprehensive analysis)

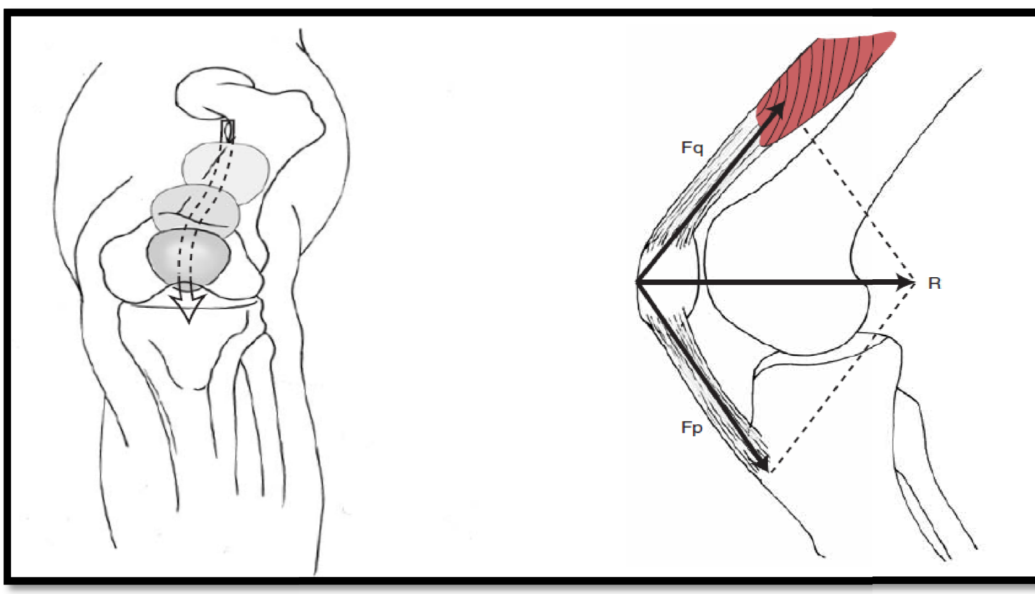

Figure 1.21: The patella shifts medially during early flexion and then either remains there or shifts slightly laterally with deeper flexion; Patellofemoral joint reaction. Source: Pamela K. Levangie, Cynthia C. Norkin; (Structure and Function- A Comprehensive analysis).

1.15 KINEMATICS OF KNEE JOINT

The knee complex is one of the most often injured joints in the human body. The myriad of ligamentous attachments, along with numerous muscles crossing the joint, provide insight into the joint's complexity. This anatomical complexity is necessary to allow for the elaborate interplay between the joint's mobility and stability roles. The knee joint works in conjunction with the hip and ankle joints to support the body's weight during static erect posture. Dynamically, the knee complex is responsible for moving and supporting the body during a variety of both routine and difficult activities. The fact that the knee must fulfill major stability as well as major mobility roles is reflected in its structure and function (David J. Magee, Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

The main principle of knee joint kinematics is: rolling, gliding and rotation. The knee joint offers a six degrees freedom of range of motion. Rotational movement consists of flexion–extension, internal– external rotation and varus–valgus. Translational movement is possible in anterior–posterior and medial–lateral direction as well as by compression and distraction of the knee joint. All these six freedoms of motion are in combined complex function within the envelope of motion(David J. Magee, Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

The delicate balance between the stability and mobility varies as the knee is flexed from full extension toward increased flexion. Bony congruence and overall ligament tautness are maximal in full extension, representing the close-packed position of the knee joint.

In knee flexion, the periarticular passive structures tend to be lax, and the relative bony incongruence of the joint permits greater anterior and posterior translations, as well as rotation of the tibia beneath the femur (David J. Magee, Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

In the sagittal plane, rolling and gliding are the main elements.

1.16 SOFT TISSUE MECHANICS

The knee joint relies on active (musculotendinous) and passive (ligamentous) restraints to maintain its stability. The muscles provide the loading to move the joint: quadriceps femoris, hamstrings and gastrocnemius control both flexion/extension and medial–lateral rotation. However, they also cause anterior–posterior shear forces that are resisted primarily by the cruciate ligaments. This tethering effect is critical in allowing the joint to move physiologically, maintaining congruency and stability (David J. Magee, Susan Standring; Pamela K. Levangie, Cynthia C. Norkin).

Passive stabilizers of the knee joint acts by resisting the unwanted displacements between the bones. This may be to control the path of motion or to limit the range of motion. When the muscles or some other external force (due to body weight or impact) cause the bones to displace, the ligaments are stretched, and so develop tensile forces that resist the displacement and allow the joint to maintain its stability. Disruption of any of these passive restraints may cause a mechanical instability, which is an abnormally increased displacement due to an applied force (in biomechanical terms this is called excess laxity)(David J. Magee, Susan Standring; Pamela K. Levangie, Cynthia C. Norkin)

1.17 THE KNEE AND GAIT

Gait is the style, manner, or a pattern of walking. The walking pattern or style may differ from individual to individual. It depends on the age, sex, mood, of an individual and may be due to some diseases. The head, neck, upper limb and trunk contributes of 75 percent of body weight, among this head and upper limb contributes 25 percent of the total body weight, neck and trunk contributes 50 percent of the body weight, and lower extremity contributes 25 percent of the body weight. This activity requires more coordination, balance, kinesthetic sense, proper muscle strength (Susan Standring). Gait cycle is the activity, which occurs between the points of the initial contact of the same extremity two times. Gait cycle consists of two phases:

1. Stance phase: The action that takes place when the foot makes contact with the ground. It accounts for 60% of the gait cycle in normal walking.
2. Swing phase: The activity, which occurs during the foot when is not in contact with the ground. It accounts for 40% of the gait cycle in normal walking.

There is the coordinated movement of the trunk, upper limb, head to render the good gait pattern. The components of gait determinants include: Lateral pelvic tilt, Knee flexion, Knee, ankle, foot interaction, Pelvic forward and backward rotation and Physiological valgus of knee (Susan Standring).

The muscles of the knee play an important role during the normal gait cycle, as the knee goes through a range of 60° (0° extension at initial contact or heel strike to 60° at the end of initial swing). There is also some medial rotation of the femur as the knee extends at initial contact and just prior to heel-off .Because the knee is the intermediate joint between the hip and foot, problems in these two areas can interfere with the knee function during gait (Carolyn krisner Susan Standring).

Chapter Summary:

Given the various range of possible problems that can occur in the knee joint, an exhaustive anatomical discussion is beyond the scope. The knee is one of the most commonly injured joints. The stability of the joint is dependent on several muscles; it includes wide range of specialization and superspeciality in the medical field. There are several authors, thousands of books and millions of publications as well articles available on the knee joint. Therefore, including anatomical and clinical aspect of knee joint as a whole is beyond the scope of this thesis. In the present section of the study, we made an attempt to highlights the very few of them. Many clinical implications along with anatomical significance has been attempted to draw in the respective session.

A thorough anatomical knowledge of normal structure and functions, however, can be used to predict or understand the immediate impact of a specific injury and the secondary effects on intact structures. The variety of forces transmitted through the knee complex arises from the gravity, weight bearing forces, muscles, ligaments, and other passive soft tissue structures. Any alteration in the anatomy of knee can substantially influence these forces and can have a dramatic impact on the function of the knee joint. Damage to the tibiofemoral joint or the patellofemoral joint can result from either a large rapid load or the accumulation of smaller repetitive loads. An understanding of both the primary and secondary effects of injury is important in order to gain a full appreciation for the pathogenesis of knee disorders.