Questions About The Differences In Position.

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The purpose of this chapter is to answer parents' Questions about the Differences in Position they see in the legs and feet of growing babies and young children **(*Intoeing, Flat Feet, Bowlegs, and Knock-Knees*)** and explain how most children "grow out of it" to develop mature leg and foot alignment.

Is My Child Growing Normally?

Each child grows in an individual way, and is a unique combination of heredity and environment. Most children, however, follow fairly predictable patterns of growth.

These patterns, especially involving the legs, feet, and walking, may look different from adult posture and gait. Family members may look at these differences and worry that something is wrong. Most of the time, however, these differences are normal in the developing child and are a predictable part of how a curled up baby in the womb becomes a strong and active child.

Why Do My Baby's Feet Turn In?

Toeing in can come from the foot, the lower leg, or the hip. In the infant, the problem is usually from the foot and is called metatarsus adductus. In the toddler, it most often occurs in the tibia or **"Shin Bone**" and is called internal tibial torsion. In the preschooler, toeing in usually comes from the hip and is known as femoral anteversion. Each of these conditions has a different cause, and resolves over time in almost all cases.

What Is Metatarsus Adductus?

Metatarsus adductus is a turned-in position of the front of the foot in relation to the rest of the foot. There is usually a **C-shape** to the outside of the foot, often a crease on the bottom and inside of the foot, and sometimes an increased space between the big toe and the second toe. It is usually present at birth and is thought to be caused by crowding in the uterus, especially with firstborn babies, large babies or twins. Sleeping on the belly with feet tucked up under the baby's bottom may add to the persistence of this positioning. This condition can affect one or both feet.

The purpose of the orthopaedic examination is to rule out other conditions that may resemble metatarsus adductus, and to evaluate the flexibility of the foot. The examiner will also usually check the baby for other conditions that are sometimes seen with metatarsus adductus, such as torticollis **(Wryneck)** and hip dysplasia **(** Abnormal Development Of The Hip **)**.

Depending on how flexible the foot is, stretching exercises at each diaper change may be recommended. Occasionally casting of the feet is necessary; in very few cases surgical correction is recommended for a foot that is resistant to other treatment.

What Is Internal Tibial Torsion?

Internal tibial torsion is the most common cause of intoeing in the toddler. It is an inward twist of the tibia **(Shin Bone)** and is also thought to be caused by the baby's position in the womb.

When the toddler stands or walks, the foot points inward, but the patella **(Kneecaps)** point straight ahead. Although it is usually seen in both legs, one is often worse than the other.

Parents often notice that the intoeing is worse at the end of the day, when the child is tired.

Internal tibial torsion is most often present when the child is **from 3 to 24 months of age** [71].

The purpose of the orthopaedic examination is to rule out other conditions that have internal tibial torsion as an element. It usually resolves itself without any treatment by two years of age. In rare instances, bracing may be recommended. In very rare cases, severe torsion may persist in the older child, and surgical correction may be suggested.

What Is Femoral Anteversion?

Femoral anteversion is an inward twisting of the top part of the femur **(Thigh Bone)** and is the most common cause of intoeing in preschool aged children **(3-5 Years).**

This twisting causes increased internal rotation at the hip, and decreased external rotation.

When the child stands, both the feet and the knees turn in. This condition is more common in girls, usually occurs in both legs, and appears more pronounced at the end of the day, when the child is tired. Children with femoral anteversion are noted to sit frequently in the "**W" position.**

The goal of the orthopaedic evaluation is to exclude other hip conditions. Femoral anteversion may persist into childhood, but rarely interferes with normal physical activity. In fact, the child with femoral anteversion may run faster than peers! Encouraging the child to Taylor sit, with legs crossed may help. Only very rarely is surgery needed to realign the bones.

Why Are My Child's Feet Flat?

In flat feet, also known as pes planus, there is loss of the normal arches of the foot.

When the child stands, the normal space between the floor and the arch on the inside of the foot may not be seen. Sometimes the arch is simply hidden by the fat pad in the young child's foot. Often the arch will appear when the child sits with feet dangling, or stands on tip toe.

Often, children with flat feet also have looseness of other joints, especially the knees and elbows. If the feet are painful or lack full motion, then orthopaedic evaluation should be considered. Feet with a very high arch or clawing of the toes, especially if they are worsening, should also be evaluated. Most flat feet are painless and cause no interference with growth or physical activities — and treatment **is not needed.**

Why Is My Baby Bowlegged?

As the legs grow and develop from birth to adulthood, they normally go through a period of being bowlegged, also known as genu varum. This period is usually from birth to **18 months**, and involves both legs. If the baby stands or lies with feet together, there will be a space between the knees. This space can be measured by how many adult fingers fit between the knees. The bowlegs usually straighten out with no treatment. Orthopaedic evaluation is recommended if the bowlegs **:-**

- **Are severe**
- **Are getting worse**
- **Develop after age 5 years**
- **Involve only one leg**
- **Are in combination with severe intoeing**
- **If the child is very short.**

Why Is My Child Knock-Kneed?

After the bowlegs improve at about **18 months**, many children go through a period of mild knock-knees, also known as genu valgum. This period usually lasts from about **18 months to 3 or 4 years of age**. If the child stands with knees together, there will be an open space between the ankles. The genu valgum can be measured by how many adult fingers fit between the ankles. Knock-knees spontaneously correct almost all of the time, and there is no evidence that braces, special shoes, or exercises are helpful. If they are severe, get worse, involve only one leg, or if the child is very short, or has a history of injury to the knees, orthopaedic evaluation is recommended.

Growing Out Of It....

Intoeing, flatfeet, bowlegs, and knock-knees are very common in children. Sometimes, further evaluation is needed to make sure that there's no serious problem, but most children grow out of these positional conditions without treatment.

Remember, **NO Question** about your child's health is too trivial, so please discuss your concerns with your child's healthcare team.

ANATOMY OF THE PATELLOFEMORAL JOINT.

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EMBRYOLOGY:

The basic characteristics of the human knee were present almost **300 million years ago** [72].

In the evolution of the knee, there were four major osteologic events; the Jurassic period, 180 million years ago; the Mesozoic era, in which the head of the fibula receded distal to the tibiofibular joint line; the development of the patella, 65 to 70 million years ago, in the early Genozoic era; and, in the late Genozoic period, [73,74,75] the evolution of the knee to a valgus alignment, allowing a bipedal gait.

The staging system for embryology development depends on the external appearance of the embryo and not on its length or age [76,77].The staging system includes 23 stages or horizons. The bud appers during the 13 th horizon **(28 days)** . In horizon 18**(37days),** chondrification of the femur, tibia, fibula beging, along with early differentiation of the patella and patella ligament. The knee joint arises in the last 10 days of the embryologic period from the blastemal interzone. The patella, anterior cruciate ligament ***(ACL),*** posterior cruciat ligament ***(PCL)*** , and both menisci develop in horizon 22 **(45 days)**. The epiphyses of the distal femur and the proximal tibia are both present at birth.The proximal fibular epiphsis and the patellar ossification center are not present until age 3 years in the female and age 4 in the male.

BONY ARCHITECTURE:

The Femur, Tibia, and Patella are the three bones forming the knee joint articulation, which is often described in term of three distinct compartments; medial, lateral, and patellofemoral **.**

The Patella, is the largest sesamiod bone in the body **(** i.e., a bone that develops within the tendon of the quadriceps femoris muscle in front of the knee joint **).** It is triangular at its anterior superficial surface and more oval on its posterior or articulating surface. Its triangular shape at its widest proximal portion tapers inferiorly at the origin of the patellar ligament, the inferior pole**.** The articular surface of the patella, varying in thickness from about 2 to 5.5 mm, is divided into seven facets. The medial and lateral facets are divided into equal theirs, superiorly and inferiorly. The seventh facet is the most medial portion, called the odd facet. **Wiberg,** [78,79] who is credited with the oldest classification of the patellar articular surface, identified three shapes based on the position of the vertical ridge.

- **In the type one, there** are roughly equal medial and lateral facets.
- **In the type two**, the most common , the medial facet is only half the size of the lateral facets.
- **In the type three,** the medial facet is so far medial that the central ridge is barely noticeable.

Due to the variation in the patellar shape and distal femoral sulcus position, the patellofemoral joint is the most incongruous joint in the body.

The blood supply originates from as many as **12 nutrient arteries** at the inferior pole, which run upward on the anterior surface of the bone in a series of furrows.

The Femur has two condyles, separated posteriorly by a deep notch, but fusing anteriorly into a trochlear groove for articulation with the patella.

The lateral ridge of the trochlear groove is very prominent. The curve of the femoral condyles is **CAM-SHAPED. (**In lateral profile); it is flatter on the end of the femur and more highly curved at the free posterior margin of each condyle .The distal surface of the medial condyle is narrower, longer and more curved than the lateral condyle; this is for ***the screw-home movement*** .

The anterior surface of the femur that articulates with the patella is termed the sulcus or trochlear groove.When viewed in a flexed position, the lateral condyle projects more superiorly and is thought to act as a restraint against patella subluxation or dislocation.

The lateral condyle has a greater anteroposterior length **(long axis)** and medial lateral width than the medial condyle. Both converge at the posterior outlet of the intercondylar notch. The intercondylar notch houses the origins of both curciate ligaments, the ligamentum mucosum, and the ligaments of Humphrey and Wrisberg.

The posterior cruciate ligament arises from the lateral aspect of the medial femoral condyle, whereas the anterior cruciate ligament originates on the posteromedial aspect of the lateral femoral condyle. The most superior aspect of the notch, seen best in the flexed position, is the origin of legamentum mucosum. The distal femor articulates with proximal tibia throughout its range of motion in what appears to be another incongruous situation.

The Tibia is the large weigth-bearing medial bone of the leg. It articulates with the condyles of the femur and the head of the fibula above, and with the talus and the distal end of the fibula below at the upper end is the lateral and the medial condyles **(sometimes-called lateral and medial tibial Plateaus),** which articulate with the lateral and medial condyles of the femur, the lateral and medial menisci intervening.

The lateral condyle possesses on its lateral aspect a small circular articular facet for the head of fibula. The medial condyle shows a groove on its posterior aspect for the insertion of the semimembranosus muscle.

Menisci (Semilunar Cartilages):

Embryologically [88], the mensci are clearly defined by **the 8 th week** of development. At this stage, the meniscus is primarily a collection of fibroblasts; with further development, it becomes more collagenous, gradually allowing for the circumferential orientation of the collagen bundles. **The menisci or semilunar cartilages** are **C-shaped** lamellae of fibrocartilage, which are triangular in cross-section. The peripheral border is thick and convex and attached to the capsule, and the inner border is thin and concave and formes a free edge. The upper surfaces are concave and are in contact with the femoral condyles. The lower surfaces are flat and in contact with the tibial Condyles.

The Medial Meniscus: is nearly semicircular, **10mm** and is much broader behind than infront. The anterior horn is attached to the anterior intercondylar area of the tibia and is connected to the lateral meniscus by a few fibers called **the transverse ligamental** the posterior horn is attached to the posterior intercondylar area of the tibia. The peripheral border is attached to the capsule and the medial collateral ligament of the joint, and because of this attachment the medial meniscus is relatively fixed.

The Lateral Meniscus : is nearly circular, **12-13 mm** , and is uniformly wide throughout. The anterior horn is attached to the anterior intercondylar area, immediately in front the intercondylar eminence.The posterior horn is attached to the posterior intercondylar area, immediately behind eminence. A band of fibrous tissue commonly leaves the posterior horn and follows the posterior cruciate ligament to the medial condyle of the femur. The peropheral border of the cartilage is separeted from the lateral collateral ligament by the tendon of the popliteus, a small part of the tendon being attached to the cartilage.The result of this arrangement is that the lateral meniscus is less fixed in position than the medial meniscus. Their function is to deepen the articular surfaces of the tibial condyles to receive the convex femoral condyles; they also serve as cuchions between the two bones.

- **The blood supply** to the menisci originates from the lateral and medial superior and inferior genicular arteries.

Synovial Membrane:

The synovial membrane line the capsule and is attached to the margins of the articular surfaces and to the peripheral edges of the menisci. On the front of the joint it forms a pouch, which extend up beneath the quadriceps femoris muscle for 3 figerbreadths above the patella, forming the suprapatellar bursa.

At the back of the joint the synovial membrane is prolonged downward on the deep surface of the tendon of the popliteus, forming the popliteal bursa. A bursa is interposed between the medial head of the gastrocnemius and the medial femoral condyle and the semimembranosus tendon ; this termed the **semimembranosus bursa** and it frequently communicates with the synovil cavity of the joint.

The synovial membrane is reflected forward from the posterior part of the capsule around the front of the cruciate ligaments .

The synovial membrane is reflected backward from the posterior surface of the ligamentum patellae. This fold , **the infrapatellar fold**, converges to form a band, which is attached to the intercondylar Fossa of the femur.The base of the synovial fold is filled by **the infrapatellar pad of fat**; the free Borders of the fold are termed **the alar folds.**

CAPSULE :

This is attatched to the margine of the articular surfase and surrounds the sides and posterior aspect of the joint .On the front of the joint, the capsule is absent , permitting the synovial membrane to pouch upward beneath the quadriceps tendon, forming the suprapatella bursa. On each side of the patella, the capsule is strengthened by expansions from the tendon to vastus lateralis and medialis. Behind the joint the capsule is strengthened by an expansion of the semimembranous muscle called the oblique popliteal ligament .

EXTRACAPSULAR LIGAMENTS :

- **The ligamentum patellae** is attached above to the lower border of the patella and below to the tuberosity of the tibia. It is in fact, a continuation of the central portion of the common tendon of the quadriceps femoris muscle. It is separated from the synovial membrane of the joint by **the infrapatellar pad of fat** and from the tibia by a small bursa. **The superficial infrapatellar bursa** separates the ligament from the skin. **The lateral collateral ligament** is cordlike and is attached above to the lateral condyle of the femur and below to the head of the fibula. The tendon of the popliteus muscle intervenes between the ligament and the lateral meniscus.

- **The medial collateral ligament** is a brod, flat band and is attached above to the medial condyle of the femur and below to the medial surfane of the shaft of the tibia. It is firmly attached to the edge of the medial meniscus.
- **The oblique popliteal ligament** is a tendinous expansion derived from the semimembranous muscle. It strengthens the posterior aspect of the capsule.

INTRACAPSULAR LIGAMENTS :

The cruciate ligaments are two very strong intracapsular ligaments that cross each other within the joint cavity. These important ligaments are the main bonds between the femur and the tibia throughout the joint's range of movement.

NOTE: that the ligaments are excluded from the synovial cavity by a covering of synovial membrane.

ANTERIOR CRUCIATE LIGAMENT:

This is attached to the anterior intercondylar area of the tibia and pases upward, backward, and laterally, to be attached to the posterior part of the medial surface of the lateral femoral condyle. It is slack when the knee is flexed, but taut when the knee is fully extended. The anterior cruciate ligament prevents posterior displacement of the femur on the tibia. With the knee joint flexed, the anterior cruciate ligament prevents the tibia from being pulled anteriorly.

POSTERIOR CRUCIATE LIGAMENT :

This is attached to the posterior intercondylar area of the tibia and passes upward, forward and medially, to be attached to the anterior part of the lateral surface of the medial femoral condyle. The anterior fibers become slack when the knee is extended, but become taut in flexion. The posterior fibers are taut in extension.

The posterior cruciate ligament prevents anterior displacement of the femur on the tibia. With the knee joint flexed, the posterior cruciate ligament prevents the tibia from being pulled posteriorly.

ANTERIOR COMPARTMENT **:**

The anterior compartment is occupied by the quadriceps muscle group and the extensor mechanism of the knee joint. Traversing both the hip and knee joints, the quadriceps is composed of the rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius. These muscles join in a trilaminar fashion toform quadriceps tendon. The rectus femoris, which is the most superficial component, takes origin from the ilium and narrows to a tendon about **3 to 5 cm superior to the patella.**

The vastus medialis is divided into two groups, the vastus medialis obliquus and the vastus medialis longus.

These muscle fibers continue toward the superomedial border of the patella and become tendonous a few millimeters before the insersion. In contrast, the muscle fiber of the vastus laterales terminate more proximally than the vastus medialis, becoming tendinous about 3 cm from the superolateral border of the patella.

The vastus intermedius lies deep to the other three muscles, and its tendinous fibers insert distally into the superior border of the patella.

The quadriceps tendon widens as it approaches the patella. It is thickest **2 to 3 cm proximal to the patella.** As the quadriceps tendon insert into the superior pole of the patella.

The patellar tendon is primarily drived from the central fibers of the rectus femoris, which extend Over the anterior surface of the patella. The patellar tendon narrows about 15% as it courses to the tibial tubercle. The tendon continues past the tubercle, it blends with the iliotibial band on the anterior surface of the tibia. Tha average length of the patellar tendon is 4.3 to 4.6 cm **(range 2.0 to 6.5 cm)**[80,81] but it may be 2.5 to 4.0 cm wide.

The blood supply to quadriceps tendon, patella and patellar tendon arises from both extrinsic and intrinsic sources . the extrinsic source originates from a vascular anastomosis that, according to **Scapinielli** [82] contains 9 to 12 nutrient artries associated with a venous return.

The intrinsic souece is actually a intratendinous supply [83]

MEDIAL COMPARTMENT:

Hughston and associates divide the supporting structures on the medial side of the knee into ***three parts*** anterior, medial and posterior.

- **The anterior third** of the medial ligament is loose and covered sufficiently by the extensor retinaculum of the quadriceps mechanism.
- **The middle third** is a stong structure supported by the tibial collateral ligament.
- **The thickened posterior third** of the medial capsular ligament is termed the posterior oblique ligament.

- **Warren and Marshall** [84, 85] described and divided the medial side of the knee into three defined layers.

LAYER 1 :

The most superficial facial layer, includes the deep fascia and extended from the patella and patellar tendon anterioly to the midline of the popliteal fossa posteriorly.Anteriorly and distally, layer 1 inserts with the sartorius into the periosteum of the tibia.posteriorly this layer extends as the overlying fascia on the two heads of the gastrocnemius. And the structure of the popliteal fossa.

LAYER 2 :

Is defined by the parallel fibers of the superficial medial ligament. **Brantigan and Voshell** [86] described this ligament as having vertical and oblique portions. Both the vertical and oblique portion insert almost 5 cm below the joint line and posterior to the pes anserinus. Posteriorly the oblique fibers of the superficial ligament blend with the deeper layer within the posterior medial corner, forming the posterior oblique ligament which relax in flexion.

Anteriorly layer **2** joins layer **1** as a conjoint structure that extends to the edges of the vastus mediales. Lying between layer **1** and layer **2** in the posteromedial corner are the tendon of the gracilis and semitendinosus.

LAYER 3 :

Is the true capsule of the knee joint. Deep to the superficial medial ligament, layer **3** thickens and forms a vertically oriented band of short fibers known as the deep medial collateral ligament. This deep ligament extend from the femur to the midportion of the peripheral margin of the meniscus and tibia. The rest of the layer **3** follows the contour of the synovial cavity, extended proximally to the upper end of the suprapatellar pouch. Posteriorly, layer **3** blends with layer **2** as a discrete structure with oblique fiber described as the posterior medial capsule.

Grood and associates [(87)], in a biomechanical study of the cadaveric knee, concluded that the long parallel-oriented fibers of the tibia collateral ligament are the prime medial static stabilizers of the knee that resist medial opening to valgus stress.The pes anserinus is the final common insertion of the sartorius, gracilis, and semitendinosus.

The semitendinosus, originating from the ischial tuberosity, traverses the thigh before it inserts into the upper part of the tibia. Innervated by the sciatic nerve and supplied from profunda femoris and popliteal arteries. The gracilis originates from the pupic symphysis and insertion into the upper part of shaft of tibia on medial surface and supplied by obturator nerve.

The sartorius muscle originating from the anterior superior iliac spine and insertion into the upper medial surface shaft of the tibia and supplied by femoral nerve.

LATERAL COMPARTMENT :

Hughston and colleagues have divided the lateral supporting structures of the knee into ***three parts*:**

- **The Anterior third** is thin and loose and covered sufficiently by the extensor retinaculum of the quadriceps mechanism.
- **The Middle third** of the lateral ligament is composed of the iliotibial band and the capsular ligament deep to it.
- **The Posterior third** includes both capsular and noncapsular ligaments, and receives dynamic reinforcement from the biceps femoris and popliteau muscle as well as the lateral head of

gastrocnemius. **Seebacher ans associates** [(88)] have described the three distinct layers of the lateral aspect of the knee.

LAYER 1

Is composed of the iliotibial tract and its expansion anteriorly and the superficial portion of the biceps and its expansion posteriorly.**Terry and colleagues** investigated the role of the iliotibial tract, iliopatellar band and iliotibial band as both dynamic and static stabilizers of the lateral side of the knee the iliotibial band is anatomically devided into the aponeurotic, superficial, middle, deep, and capsular osseous layers.

Biceps femoris : *origin*: long head;ischial tuberosity and the short head ; linea aspera, lateral supracondylar ridge of shaft of femur.

Insertion: head of fibula

***Nerve supply*:** long head : tibial portion of sciatic nerve.
Short head : common peroneal portion of sciatic nerve.

***Action*:** flexes and laterally rotates leg at knee joint; long head also extends thigh at hip joint.

LAYER 2

Anteriorly is formed by retinaculum of the quadriceps and posteriorly by the two patellofemoral ligaments. The patellar meniscal ligament attaches to the lateral meniscus and terminates inferiorly at **Gerdy's tubercle.** Between the quadriceps retinaculum and the patellofemoral ligaments lie the lateral collateral ligament.

LAYER 3

The deepest layer, is attached to the edges of the tibia and femur. The popliteus tendon passes through a hiatus in the coronary ligament to attach to the femur. The posterolateral capsule is composed of the fibular collateral ligament, the arcuate ligament, and the aponeurosis of the popliteus muscle.

Tria and associates [89] found that the popliteus tendon has no role in the retraction and protection of the lateral meniscus. The posterior lateral aspect of the knee has been termed the oblique popliteal ligament, and **Hughston and Ellers** describe the "arcuate complex" as including the lateral collateral ligament, the popliteus, and the lateral head of the gastrocnemius. The popliteal muscle the last part of the quadrangle complex.the proximal attachement is its tendinous portion; its muscle belly sits distally. Its primary function is internal rotation of the knee and unlocking of the knee.

POSTERIOR ASPECT OF THE KNEE :

The posterior compartment of the knee includes its capsule, the medial and lateral portion of the gastrocnemius muscle, and the plantaris muscle. The posterior capsule originates at the level of the posterior distal epiphyseal plate. In the young adult, the capsule coalesces with the periosteum at this growth plate. Distally, it inserts about 3 or 4 cm below the joint line across the back of the tibia. The gastrocnemius, both the medial and lateral heads, arises from the respective posterior condyles of the femur and capsule of the knee joint. The two heads combine about the level of the knee joint to form the large body of the gastocnemius before it tapers distally into the Achilles tendon. The plantaris muscle originates on the lateral supracodylar line of the femur and the oblique popliteal ligament of the knee joint. Its insertion on the medial side of the calcaneus.

NOTE :

EXTENSOR MECHANISM :

The extensor mechanism includes the quadriceps muscles, quadriceps tendon, medial and lateral retinaculum, patellofemoral and patellotibial ligaments , patellar tendon **(ligament)** and tibial tubercle. Biomechanically, the resulting forces traversing the quadriceps tendon, patella, and patelar ligament often exceed five times body weight.

BLOOD SUPPLY:

Scapinelli described the genicular circulation, which is responsible for virtully all structures about the knee. This genicular anastomosis is formed by, descending genicular , medial and lateral superior genicular, and medial lateral inferior genicular, middle genicular, and anterior tibial recurrent arteries. The descending genicular comes directly from the femoral artery and give off three significant branches : the saphenous , the muscular articular, and the deep oblique. The medial and lateral superior genicular arteries arise directly from the popliteal artery and wrap around thesupracondylar area of the femur.The medial superior genicular artery lies anterior to the semimembranosus and semitendinosus muscles.The lateral superior genicular artery courses deep to the tendon of the biceps femoris and anastomoses with the descending branch of the lateral femoral circumflex.The cruciate ligaments are supplies by the middle genicular artery, a direct branch of the popliteal artery, which traverses the posterior joint capsule at the level of the intercondylar notch.the patella itself is supplied by the midpatellar vessels penetrating the middle third of the anterior surface and the inferior pole vessels that anastomose at the inferior pole of the patella.

INNERVATION (NERVE SUPPLY):

The knee joint is innervated by branches from the **obturator (L 2, L 3 , L 4)** ,

femoral(L 2 , L 3, L 4) and **sciatic (L 4, L 5, S 1, S 2)** trunks. At the level of the knee.

Kennedy and colleagues [90] have demonstrated two distinct groups of nerves innervating joint.

The anterior group , composed of articularbranches of the femoral , common peroneal , and saphenous nerves . The posterior group, which includes the posterior articular and obturator nerves. The anteromedial and anterolateral capsules and asociated structures are usually innervated by the anterior group of afferent nerves.

The common peroneal nerve supplies two articular nerves - the lateral articular and recurrent peroneal. The saphenous nerve, a branch of the posterior division of the femoral nerve , lies between the tendons of the gracilis and sartorius and innervates the inframedial capsule, the patellar tendon, and the skin overlying the anteromedial aspect of the knee.

BIOMECHANICS OF THE KNEE.

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BIOMECHANICS OF THE KNEE :

- The biomechanics of the knee are most complex and in trying to understand them , one must have some knowledge of the ; **GEOMETRY, KINETICS, KINEMATICS AND JOINT STABILITY.**

GEOMETRY :

- **In the coronal (frontal) plane** a line joint the central of the hip and ankle joint passes through the center of the knee joint . This line represents the mechanical axis of the lower limb . Therefore the long axis of the shaft of the femur is inclined at an angle to the long axis of the shaft of the tibia. This tibiofemoral shaft angle normally is $\mathbf{8^0 \pm 3^0}$ and is the angle measured on anteroposterior radiographs of the standing knee joint . This angle has been **physiological valgus .**
- **In the sagittal plane** the femoral condyles have a changing radius of curvature which decreases from before back.The shape of each condyle may equally well be described by two tangential circular arcs.
- **In the transverse plane** the condyle diverge from before back by an angle of 20^0 .

In general terms : the articular surface of the upper end of the tibia is perpendicular to the long axis of the shaft of the tibia in both sagittal and coronal planes . In sagittal plane medial plateau is slightly **concave** while the lateral plateau is slightly **convex .**In the coronal plane both are slightly **concave .**

The menisci distribute load between the femur and tibia by increasing the area of contact. They are capable of changing their shape with knee movement to facilitate this load- bearing action . They are not efficient shock absorbers and act more like washers facilitating lubrication.

Kinetics:

Kinetics is the branch of mechanics that deals with the study of bodies in motion and of the forces that causes those motions .

The resulting motions **(Kinematics)** have been measured as independent quantities from both invasive **(Pin)** and noninvasive surface techniques .

The knee joint dose not conform to any standard classification of joint , having some features of a ginglymus hinge joint, and some of an arthroidal joint, which by definition allows only gliding movement along opposing plane surfaces .

The knee consists of three more or less independent articulations : one between each sphere – like condyle of the femur and a corresponding but more planar condylar surface of the tibia , an interposing meniscus , and a third between the patella and the patellar or trochlear groove of the femur .

The knee joint contain from complex network of ligaments , capsular structures , and contours of the bones themselves . This intricate arrangement of anatomic interrelationships allow the knee **6º of freedom** of motion : **three rotation are** :

- Flexion – extension , large available range .
- Abduction – adduction range , increasingly available with knee flexion .
- Internal – external rotation .

- In general they are much more extensive than the translations.

*** The three translations are :**

- Anteroposterior **(5 to 10 mm) .**
- Compression – distraction **(2 to 5 mm) .**
- Mediolateral **(1 to 2 mm) .**

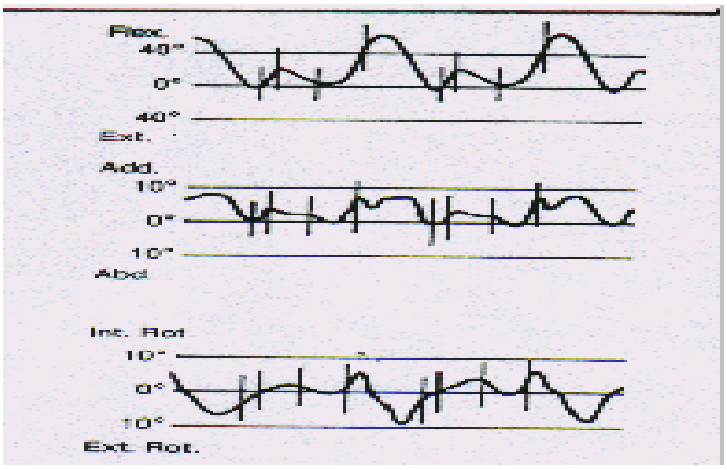
These motions are limited by the ligaments , capsule , and to some degree the intercondylar eminence and are of small magnitudes in the normal knee .

Normal flexion and extension of the knee is variable, ranging from **0^0 to 15^0** of hyperextension to **130^0 to 150^0** of flexion .

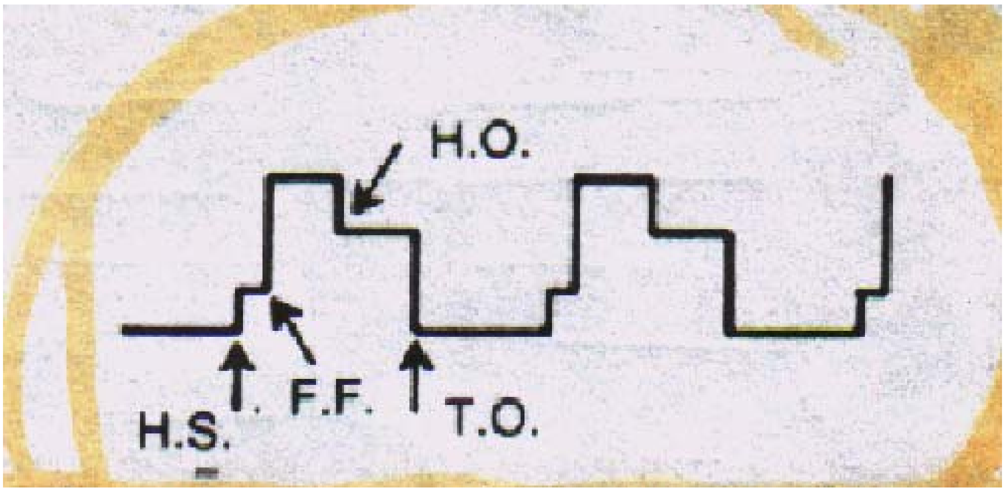
Internal and external rotation range from little or no motion in full extension to **20^0 to 30^0** with knee flexed .

Tightening of the capsular and ligamentous structures , which is greatest in full extension , accounts for this variation .

The mean values for rotations during level walking determined by **Kettelkamp and Coworkers**, using an electrogoniometer , provide insight into the complexity of motion during function of the knee [91] .



(Electrogoniometric patterns of knee motion of a normal knee. The 0 line represents the position in neutral stance (H.S., HEEL strike, F.F., foot flat ., H.O., heel flate . heel of T.O., toe off)
(Kettel. Kamp, D.B., Johonson. R.J., Smidt,G.L., Bone joint surg . 52A : 775, 1970)



(Electrogoniometric patterns of knee motion of a normal knee. The 0 line represents the position in neutral stance (H.S., HEEL strike, F.F., foot flat ., H.O., heel flate . heel of T.O., toe off)
(Kettel. Kamp, D.B., Johonson. R.J., Smidt,G.L., Bone joint surg . 52A : 775, 1970)

The most common motion pattern observed revealed that maximum extension and external rotation occurred just before heel strike; maximum abduction occurred at heel strike and maximum adduction during swing phase; and flexion and internal rotation, which began just before heel strike, continued to increase between heel strike and foot flat.

Similar patterns were observed by Marans and associates using a more sophisticated the electrogoniometric system [92]. they measured not only the rotational degrees of freedom **(flexion-extension, varus-valgus, and internal and external rotation),** but also the translational degree of freedom(**anteroposterior, mediolateral, and superior- inferior).**

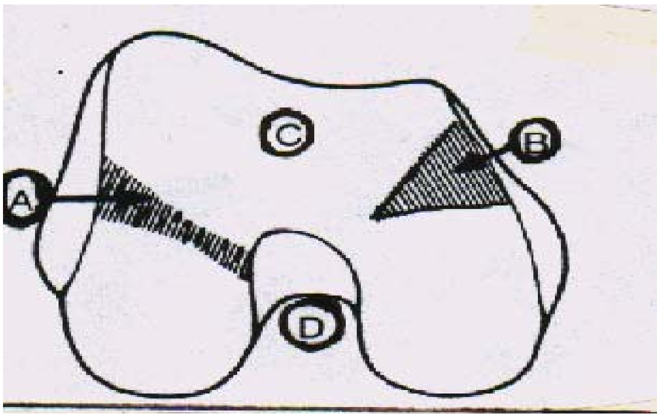
Only with evaluation of anterioposterior translation measurements during level walking were they able to distinguish between a group of normal knees and a group that were anterior-cruciate deficient.

The knees with no anterior cruciate ligament **(ACL)** demonstrated greater anterior translation of the tibia relative to the femur during the swing phase of gait but not during the stance phase.The axes of the rotations of the knee are not fixed in a single plane, thus resulting in a combination of rotations and translations (**Coupled Motions)** through the normal range of motion.

The flexion-extension axes provide the most obvious example. This axes varies because the radii of the lateral and medial femoral condyles are dissimilar, and the tibia plateau topography varies from side to side as well. Viewed from the side the medial femoral condyle has a more constant radius of curvature than the lateral.

Posteriorly, both the condyles have a similar radius, but as one moves forward the lateral condyle rapidly attains a longer radius and appears to flatten out to a greater degree than the medial condyle. Often, near the midportion of the lateral condyle, a lateral groove passing diagonally, anteriorly, and laterally from the anterior aspect of the intercondylar notch produces a distinct indentation.

This lateral groove demarcates the extent of the articular surface of the femur, which articulates with the tibia**.** [93]



Distal end of femur showing lateral A) and medial B) grooves in the articular surfaces of the medial and lateral femoral condyles and the patellar or trochlear surface C) and intercondyloid fossa or notch D) . (Jackson, J.P. : Surgery of the knee joint . In Jackson, J.P., and Waugh, W. (Surgical anatomy. Philadelphia, J.B., Lippincott, 1984, p. 5.) .

All articular surfaces anterior to this area contact only the patella. As viewed from its distal end, the medial femoral condyle extends anteriorly and inclines toward the lateral side, so it is somewhat longer than the lateral condyle. A small **V-shaped** indentation **(medial groove)** delineates the anterior extremity of the articular surface of the medial condyle that contacts the tibia.

The tibial plateau possesses to articular facets. The medial is a good deal longer in the sagittal plane than the lateral.

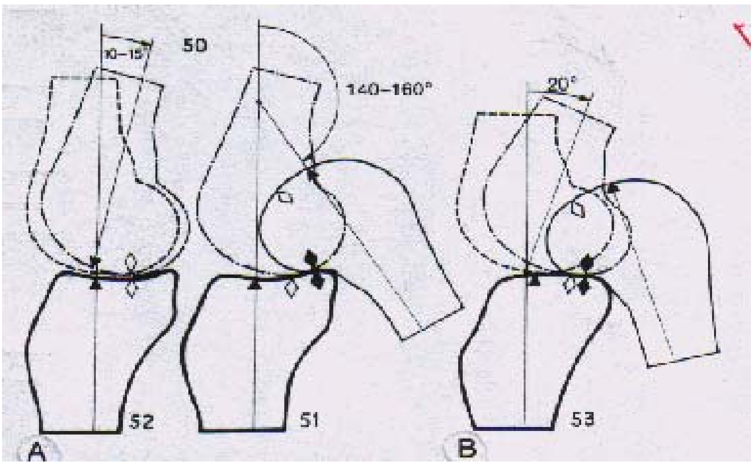
Both facets appear to be slightly concave in the coronal plane, but the lateral facet demonstrates a convexity in the sagittal plane, producing **a saddle shape** [94] . in the lateral compartment of the knee, the rounded femoral condyle rests on a convex surface of the tibia, which contributes to the complexity of stabilization of this joint.

This stabilization is controlled by the interposed meniscus, the surrounding capsular and ligamentous structures, and the muscles crossing the knee joint.

Partially because of the asymmetry of the contact areas of the tibia on the two femoral condyles, the tibia is obligated to externally rotate significantly during the last few degrees of full extension as the tibia rolls further forward on the medial femoral condyle than it can on the lateral side. This ***screw home mechanism*** is also guided by the alignment and tension is the ligaments and capsular structure.

In the fully extended position of the knee, the majority of the ligaments and capsular structures are under tension, thus allowing no further extension or external rotation. With active or passive flexion from full extension, the rotation process reversed with the tibia internally rotating relative to the femur during the first 10^0 to 20^0 .

The motion of femur relative to tibial plateau during flexion is initially a pure rolling motion, but by 10^0 to 15^0 on the medial tibial and by 20^0 on the lateral side, sliding of the femur begins relatives to the tibia and becomes progressively more important until flexion is complete [(95)] .



A) Medial and B) Lateral compartments of the knee demonstrating the amount of rolling and sliding of the femoral and tibial surfaces occurring during flexion . Starting from full extension , the femoral condyles roll without sliding . Sliding movement then becomes progressively more important, so that by the end of flexion, the condyles slide without rolling. For the medial condyle, pure rolling occurs only during the first $10^°$ to $15^°$ of flexion . For the lateral condyle, the rolling continues until $20^°$ of flexion . (From Kapandji, I.A.: The physiology of the Joint , vol . 2 . Lower Limb. Edinburgh, Churchill Livingstone, 1970 .) .

Thus, the contact area between the tibia and femur moves rapidly backward during the first 10^0 to 20^0 of flexion and then slowly progresses posterioly to eventually ride entirely on the posterior horns of both menisci at the extreme of flexion.

PATELLOFEMORAL ARTICULATION:

The patellofemoral articulation provides an isolated articular surfaces for the control of the extensor mechanism of the knee as it glides over anterior aspect of the joint.

The extensor mechanism stabilizes the joint against gravity when the knee is flexed and assists in the forward propulsion of the mass of the body as the knee extends during gait.

The patella contacts the patellar or trochlear surface of the femur during this activities.

Anteriorly, the condyles of the distal femur are separated from one another by this shallow articular depression, averaging **5 to 6 mm in depth**.

Inferiorly and posteriorly, the trochlear surface is continuous with the intercondyloid fossa or notch.

The lateral wall of the trochlear surface of the femur is more prominent than the medial and projects further anteriorly.

The patella has a multifaceted dorsal surface, which articulates with the trochlear groove. A median ridge divides the patella into two large facets. The most frequently, the lateral facet is greater in area than the medial, but large anatomic variation exist, sometimes making these facets nearly equal.

The more medial of these two facets has a more nearly sagittal orientation and contacts the femur along the medial side of the notch only when the knee is flexed past 90^0 .

In full extension the patella does not contact the articular surface of the femur but lies over an area of thin and smooth synovial tissue on the anterior shaft of the femur immediately proximal to the lateral aspect of the trochlear surface. This area is termed the supratrochlear tubercle.

The transition from the articular cartilage to the supratrochlear tubercle is smooth above the lateral aspect of the trochlear groove, but medially it is often a sudden drop off when viewed from the medial side **(Termed Outerbridge's Ridge [96])** This arrangement conveniently allows the patella to ride smoothly above the articular surface in a superior and lateral direction as the knee is fully extended.

The patella thus does not slide over the sharp drop off observed proximal to the medial side of the trochlear groove during normal joint activity.

The articular cartilage on the posterior aspect of the patella near the medial ridge is normally the thickest in the human body. This reflects the large patellofemoral joint reaction force that occurs between the patella and the trochlear surface during normal activities. Loads across the patellofemoral joint are indirectly related to the angle of the knee flexion and directly related to the force generated within the quadriceps
mechanism.

Maquet has shown that by increasing the quadriceps mechanism's moment arm , a 2cm elevation of the tibia tubercle produces a 50 % reduction in the patellofemoral joint reaction force when the knee is flexed 45^0 [97,98] **.**Thus , patellectomy is not advised, and tibial tubercle elevation procedures are effective in the treatment of patellar pain syndromes .

KINEMATICS :

Relative motion between two rigid bodies **(bones)** may be described in terms of translations along and rotations about set of three orthogonal **(mutually perpendicular)** axes.If these axes coincide with standard anatomical planes the **three rotation** are : Flexion / extension – abduction / adduction – rotation **to 90^0 - 30^0-50^0** with knee flexed .

And the **three translation are :**

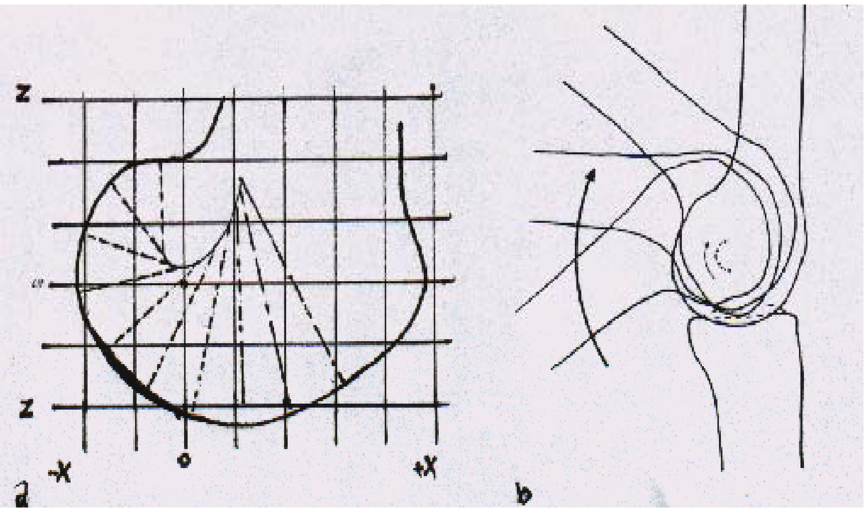
- Compression / distraction – negligible
- Mediolaterl translation - negligible

◆ Anterolateral translation - small available range except in extended knee .

The axes about which motion takes place are not fixed , and vary according to themagnitude and direction of the couples producing the movement .

Frakel and Burstein [99] **(1984)** introduced the concept of ***instant center of motion,*** when all other movements except flexion and extension are ignored .

They showed that axis about which flexion and extension occur shifts backwards in relation to the tibia with increasing flexion . However , the instant center pathway may be very variable even in normal knee but the axis about which flexion and extension occur lies approximately along the line joining the femoral epicondyles and the axis shifts backwards and forwards as the knee flexes and extends **.**



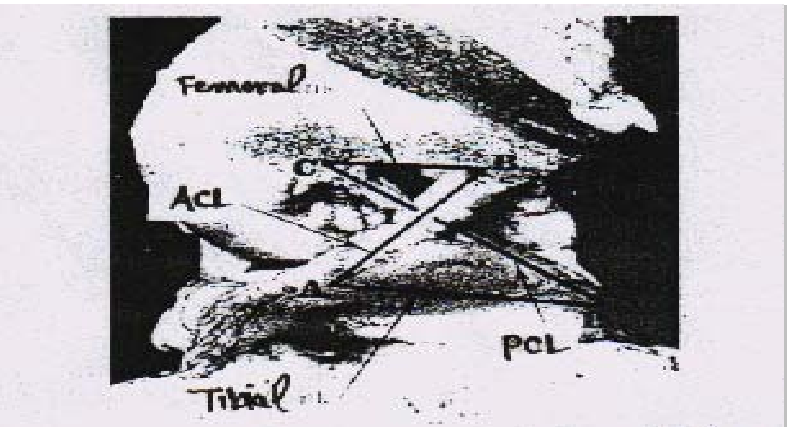
Although superficially the knee appears as a simple hinge, it does not have a fixed axis of rotation since flexion and extension are accompanied by rotations in other senses. There is a ***'screw home'*** external rotation of the tibia in the last **20^0** of extension and internal and external rotation are permitted when the joint is flexed.

Gait analysis has provided information on the range of the knee motion utilized during different activities. ***Kettlekamp*** and ***Chao*** (100) **(1972)** described the range of movement in the knee joint required for common activities.

	Flexion	Abduction/Adduction	Rotation
Level walking	**70^0**	**11^0**	**13^0**
Climbing stairs	**83^0**	**--**	**--**
Sitting and rising	**93^0**	**--**	**--**

The knee joint is maintained in an almost straight position during the support phase of normal walking. Small movement are used as a ‘shock absorber’ to minimize vertical movements of the pelvis. It is during the unloaded swing phase that flexion to about 40^0 is required to clear the foot from the ground.

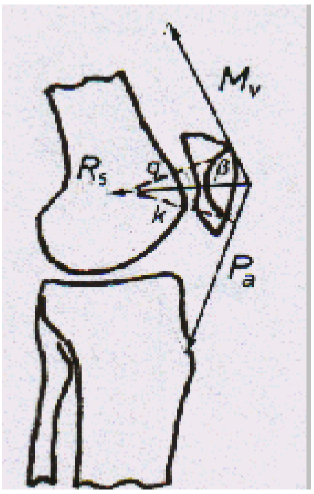
The ligaments of the knee are required to restrain its motion to a well defined path.



Morrison (101) ***1968*** estimated the forces in the cruciate and collateral ligaments during walking, and obtained tension of around one – third of bode weight.

Division of the anterior cruciate ligament produces rapid degeneration of the knee joint in many species of animal, but more gradually in man in the case of untreated injuries. Painful condition of the knee affect the passive (**Unloaded)** and active range of movement of the joint such as walking. **Mukherjee** [(102)] **1976** observed considerable different in the kinematics between the effects of rheumatoid arthritis and osteoarthritis of the knee. Patients with both conditions had reduced passive range of movement (about 90% of normal in clinical examination).

Morrison made a study of the forces in the healthy knee during walking **.**

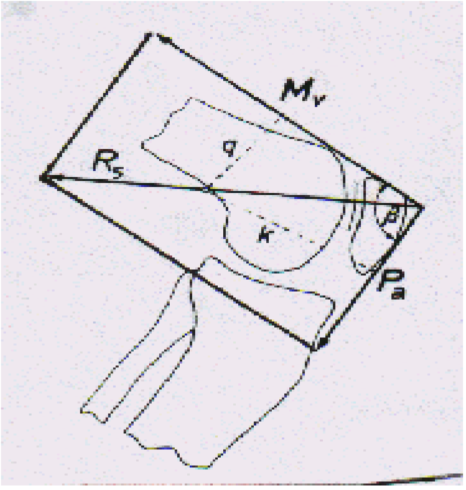


This showed that the tibiofemoral force reached a maximum of about three times body weight in the late stages of foot contact. During the foot contact, higher forces were transmitted through the medial than through the lateral condyle. This study indicated that the cruciate ligaments are subjected to load of about 25% of body weight during walking. All the forces increased with walking speed.

The quadriceps muscle group is not altogether necessary for walking, since the leg can be straightened by a **'flick'** of the thigh prior to heel strike and kept straight during the support phase of the limb, as is down by above-knee amputees with prostheses. However, rising from a chair and climbing stairs required good quadriceps function.

The greater portion of the load is said to be transmitted by medial compartment but the center of joint pressure oscillates between medial and lateral compartments.

Kettlekamp* and *Chao [(100)] ***1972*** described the medial compartment contact area as being 25% greater than the lateral **.**



With varus or valgus deformity distribution of the load is obviously altered.***Maquet*** [(103)] ***1984*** described how a 10^0 deformity will double the load in the affected compartment. ***Walker*** and ***Erkman*** [(104)] ***1975*** described that, at 30^0 of flexion there is two times body weight-loading and the contact area is 12 cm^2 with the menisci intact but only 3.5 cm^2 without menisci.

➨ Joint Stability :

In the normal joint , stability is dependent on the geometry of articulation surfaces , the menisci , ligaments and the capsule , Muscle action stabilizer as well as producing acceleration of body mass .

Gravity and proprioceptive receptors in the capsule , cruciates and ligaments also play major roles.

* Knee stability is provided by muscle and ligaments, which act as: -

1- Static stabilizers:

- Capsule and capsular ligaments.
- Extracapsular ligaments.

2- Dynamic stabilizers – musculotendinous units and their aponeuroses.

Hughston [105] ***et al*. (1976)** and ***Slocum*** [106] ***et al. (1976)*** divided the knee vertically in a sagittal plane in order to relate the anatomical structures to their function.

In the medial compartment, the anterior third is made up of a thin capsule which tightens in flexion and is reinforced by quadriceps aponeurosis.

In the middle third the capsular ligaments are strong and supported superficially by the tibial collateral ligament.

In the posterior third the capsule is thickened, and is called the posterior oblique ligament. Supporting this ligament is the semimembranosus tendon and aponeurosis .There is also dynamic support from pes anserinus and gastrocnemius muscles.

In the lateral compartment, in the anterior third there is a thin capsule.

In the middle third the capsule is strengthened by the lateral capsular ligaments. This is reinforced by the powerful iliotibial tract.

In the posterior third is the arcuate complex, made up of the collateral ligament, arcuate ligament and aponeurotis tendon of popliteus. There is dynamic support from biceps femoris and popliteus and gastrocnemius muscles.

➨ANTERIOR CRUCIATE LIGAMENT (ACL) :

From a cord- like origin on the anterior tibial plateau, fibers turn through 90º to a fan –like insertion on the inner aspect of the lateral femoral condyle.

Furman [107] ***(1976)*** described it as two separate parts anteromedial and posterolateral.

Welsh [108] ***(1980)*** considered it to be a continuum, part being in tension in knee position.

Grood [109]***(1992)*** has reviewed the biomechanics of the ACL and the optimal placement for knee ligament graft. He noted that it is generally agreed that most of the isometric ACL fibers originate anteroproximally on the femur and insert anteromedially on the tibia.

With extension remainder of the fibers become progressively tense, starting with the most anterior and moving forwards to the posterior fibers which are only tens in full extension. It is mechanism is to stabilize internal rotation and extension of the tibia on the femur ***(Furman*** [107] ***1976)***. It is function is multiple in that it limits forward gliding of tibia on femur and limits hyperextension ; it makes significant contribution to lateral stability and limit anterolateral rotation of the tibia on the femur.

Smillie [110] ***(1978)***, stressed the role of the ACL in guiding the tibia in the '***screw home mechanism***' and blocks to this which may cause an 'isolated tear.

➨ POSTERIOR CRUCIATE LIGAMENT (PCL) :

This is stoutest **ligamentous** structure. ***Kennedy*** and ***Fowler*** [111] ***1971*** showed it to be twice as strong as the anterior cruciate and the tibial collaterals.

Isometrically it is under tension throughout the whole range of movement.

Hughston [112] ***1980 and Girgis*** [113] ***1975*** described it as two distinct bands.

It is functions are to limit backward glide of tibia on femur and hyperextension. It tightens in internal rotation of tibia on femur.

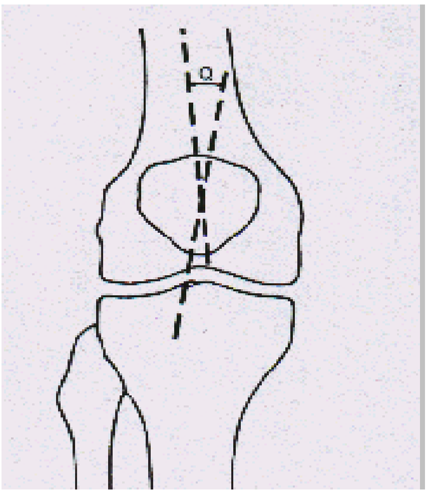
Bandi [114] ***1972*** have stressed that it is the fundamental stabilizers of the knee, being at the axis of flexion – extension and rotation.

Before starting, one must have some Knowledge of the patellofemoral joint .

The Patellofemoral Joint :

A normal patellofemoral joint is necessary for optimal knee function.

The patellofemoral joint is guided by ***the origin of the quadriceps muscle group*** **,(** rectus femoris, the vastus intermedius , the vastus lateralis, and the vastus, medialis.**)** , from the inferior iliac spine, and hip joint **(Q Angle)** .This angle is formed by the intersection of a line drawn from the anterior superior iliac spine to the center of the patella and a line drawn from the center of the patella to the tibial tubercle. This angle is usually 15 degrees or less . An angle greater than 20 degrees is considered definitely abnormal and is frequently associated with patellofemoral pathology **.**



Angle Q

✜NOTE :-

- The quadriceps muscle group,.Together they provide a powerful extensor of the knee joint . Some of the tendinous fibers of the vastus lateris and vastus medialis form bands, or retinacula, that joint the capsule of the knee joint and strengthen it .
- The increased valgus and external rotation deformity of the tibia associated with acute ligament rupture of the knee can , on occasion, rupture the vastus medialis obliquus, causing a patrllar dislocation in a normal knee. Almost always the patient who suffers from patellar instability has a preexisting abnormal patellofemoral articulation or extensor mechanism .
- The patella is subject to potential imbalance between the medial and the lateral aspects of the quadriceps muscle group
- Studies on the patello-femoral joint mechanism have focused particularly on the forces and stresses in the joint and location of the patello-femoral contact area .

FUNCTION OF THE PATELLOFEMORAL JOINT:

FUNCTION OF THE PATELLA:

Most recent reports [114,115,116,117] relating to the function of the patella indicate that thestructure of the patella is highly important; preservation is desirable if at all possible.

The greatest advantage of an intact patella is that it lengthens the moment arm [114,118,115,119,97,120] of quadriceps muscle, thereby diminishing the muscle force necessary for knee extension. This effort is most apparent between 15 and 60 degrees of flexion, the range used for most activities of daily living [121]. In cadaver studies, **Kuafer** [115]showed that 15 to 30 percent more force on the quadriceps tendon was needed to obtain in knee extension after patellectomy as compared with an intact knee.

The patella serves as a protective mechanism for the anterior aspect of the knee. The low friction coefficient of the hyaline cartilage enhances the efficiency of the extensor mechanism. If the patelofemoral relationship is normal, extensor mechanism stability is enhanced. A patella also allows a knee to appear normal.The patella maintains the alignment of the quadriceps complex and patellar tendon and increases the mechanical advantage of the extensor mechanism by displacing its line of action further from the axis of movement of the knee . The patellofemoral joints crucial for satisfactory function of the knee as a whole and its disorders led to considerable disability .

⍀ AREA AND FORCE OF CONTACT :

As the knee flexes, the areas of the patellofemoral contact change, and the amount of contact force increases [114,122]. As the knee flexes, the area of contact on the femoral condyle moves from proximal to distal, whereas on the patella it moves from distal to proximal. For the first 90 degrees of knee flexion, the total area of contact increases, but the increased in total force with increasing flexion is greater than the increased in area, so that the force / unit area increases as flexion increases [123].

The table below shows that the total patellofemoral compression force for various degree of knee flexion; the reason that patellofemoral pain increases in stair climbing becomes evident in that the total calculated force is 2.5 times body weight [124,122,116]. This force has been calculated to reach 5 times body weight if a subject femora approach the horizontal position when the subject standing on both feet [118].

If the patellofemoral joint is painful, isometric quadriceps setting exercises should be performed with the knee in full extension; in this position, the contact force is negligible.

Patellofemoral Compression Force (✕ Body Weight)

Activity	Knee Flexion Angle (Degrees) 5	15	30	45	60
Isometric contraction **(Smidt)** [116]	**0.8**	**1.6**	**2.2**	**2.5**	**2.6**
Static loading **(Perry)** [122]	**0**	**0.2**	**0.6**	**1.2**	**2.1**
Walking **(Morrison)** [124,125]	---	**0.6**	---	---	---
Ramp, up	---	---	**0.9**	---	---
Ramp, down	---	**1.9**	---	---	---
Stairs, up	---	---	---	**2.5**	---
Stairs, down	---	---	---	---	**2.5**

(From Kettelkamp, [121] with permission)

ROLE OF QUADRICEPS :

Lieb and Perry [126] did much to clarify the function of the quadriceps muscle and its separate components. The vastus medialis was considered as two function units, the vastus medialis longus and the vastus medialis obliquus.

The vastus intermedius was found to be the single most effective knee extensor muscle. Almost twice the quadriceps force was needed to achieve the last **15 degrees** of extension against gravity as was needed to achieve extension from **90 to 15** degrees. Contrary to the belief of some investigators, the vastus medialis obliquus provided no extension force; it was concluded that the main function of the vastus medialis obliquus is to stabilize the patella medially, preventing lateral subluxation caused by the vastus latrales.

Mechanical Axis Deviation: Definitions, Measurements and Consequences.

Mechanical Axis Deviation: Definitions, Measurements And Consequences.

Mechanical Axis Deviations In The Lower Extremity are commonly seen in both paediatric and adult orthopaedic practice. This chapter describes, for the trainee, the consequences of such deformity and the methods by which they are quantified. The concept of the weight bearing or "mechanical" axis was described by **Pauwels in 1980** [130]**.** It is a static weight-bearing axis, which can be drawn on a radiographic image of the limb. The ground reaction force line is a dynamic equivalent of the mechanical axis and can be "visualized" using instrumented gait analysis.

The static nature of mechanical axis deviation A measurement implies that they may not describe the full impact of a deformity. It also implies that standardized radiographs are necessary for such measurements. The mechanical axis of the lower limb in the frontal plane is defined as a line drawn from the centre of the femoral head to the centre of the ankle joint. It normally passes just medial to the centre of the knee joint in the frontal plane. This line assumes sphericity in the femoral head and normal anatomy in the subtalar complex. In the sagittal plane the normal mechanical axis runs from the centre of gravity **(in front of S2),** to the centre of the ankle joint. It therefore runs just behind the femoral head **(because the femoral neck is anteverted about 15^0)** and just in front of the knee. Deformity in the limb may occur in any plane, not just the "anatomical" sagittal or frontal planes. The common situation is for deformity to occur between these anatomical planes, that is in an oblique plane. In other words, angular deformity or mal-alignment may occur in any direction; medial or lateral, anterior and posterior or anywhere in between. Furthermore rotational deformity **(** Internal or External **)** and translational deformity may coexist.

Furthermore there may be only one deformity **(** Uniapical **)** or there may be several deformities **(** Multiapical **)** contributing to the overall mal-alignment. The measurement of these deformities is discussed later. **Finally** the possibility of deformity in terms of leg length discrepancy exists.

Much of the discussion on deformity in textbooks, etc., is confusing because of contradictory terminology.

The simplest way to describe a deformity in a long bone is to define its apex and the direction in which the apex lies. Therefore a "Varus" deformity in the tibia **(referring to the distal segment by convention)** is better described as an "Apex Lateral" deformity; that is the apex or bow points laterally although the distal segment points medially. Using "Apex Lateral" or "Apex Posterior" causes less confusion and is more precise **(e.g. Apex 45 Degrees Antero Lateral")** than descriptive terms like varus or recurvatum.

The Normal Coronal Plane Mechanical Axes.

Several Authors have reported on the **"Normal"** or Average Relationships of the Joints to the mechanical axis of the lower extremity [131,132,133] **.** Joint orientation refers to the relationship of the joint surface to the axis of the long bone. "Joint orientation lines" will be described. Joint alignment refers to the colinearity of the hip, knee and ankle. Alignment is determined by the mechanical axis passing from the centre of the femoral head to the ankle. Mal-alignment in the leg is defined by deviation of the centre of the knee from this line, as discussed above.

Joint Orientation Lines.

The hip joint orientation line is defined as a line from the centre of the femoral head to the tip of the greater trochanter. It runs approximately 90^0 to the mechanical axis of the femur but is sometimes measured from the contralateral hip if ipsilateral hip joint deformity exists. The ankle joint orientation line is a line drawn across the dome of the talus. The angle between this line and the mechanical axis of the tibia is variable but by convention is taken to be 90^0 in the normal subject. The knee joint orientation lines reflect the actual joint surfaces, tibial and femoral.

The distal femoral joint orientation line joins the medial and lateral condyles as seen on a standard radiograph, taken with the patellae **(Not The Feet)** pointing forward. This line, on average, subtends a valgus angle of 87^0 (87.8 +/ 1.60**)**[131] with the mechanical axis of the femur. In other words the distal femur is in slight valgus. The tibial joint orientation line runs across the tibial plateau and subtends an angle of 87^0 [132] with the mechanical axis of the tibia. The proximal tibia is in slight varus. The distal femoral and proximal tibial joint orientation lines are normally parallel and as such equate with the transverse axis of the knee joint. The transverse axis of the knee in the frontal plane are therefore about 30 valgus to the perpendicular, with the distal femur in valgus and the proximal? tibia in varus. Interestingly, during the gait cycle, the leg is held in slight (3^0) varus or adduction, which means that the transverse axis of the knee **(which is in 3^0 of Valgus)** runs parallel to the ground [135]**.** Occasionally the tibial and femoral joint orientation lines at the knee are not parallel. This may be more apparent in non-weight bearing or stress films and reflects capsular laxity. Soft tissue contracture or laxity may contribute to **"Dynamic"** mechanical axis deviation.

Normal Sagittal Plane Mechanical Axes.

In the sagittal plane the normal mechanical axis **(**or Ground Reaction Force Vector) runs from the centre of gravity **(**in front of S2**),** to the centre of the ankle joint. It therefore runs just behind the femoral head **(because the femoral neck is anteverted about 15^0)** and just in front of the knee.

At the knee the tibial joint orientation line in the sagittal plane is sloped about 10^0 posterior.

The tibial plafond at the ankle has an anterior slope of about 5^0**.** The anterior cortex of the tibia and femurs are collinear in the sagittal plane with the knee in full extension.

Segmental Mechanical Axes.

The mechanical axis of each segment of the limb may be defined. Because the tibia is normally straight, its mechanical axis is the same as its anatomical axis and runs from the centre of the knee to the centre of the ankle. The anatomical axis of the femur runs from the piriform fossa to the centre of the knee. On average the mechanical axis **(Centre of Femoral Head to Centre of Knee)** runs at an angle of 6^0 to the anatomical axis [132,133] **.** The intersection of the femoral and tibial mechanical axes at the knee subtend an average of 1.3^0 varus (+/ 2^0) [133] and as mentioned this intersection is just medial to the centre of the joint [132]**.** If a uniapical deformity exists in one bone then that bone will have two segments and each segment will have its own mechanical axis.

The mechanical axis of the distal femur segment **(**with Femoral Deformity**)** will have a normal alignment with the proximal tibia if the knee is uninjured and therefore the tibial mechanical axis may be extrapolated to the distal femur to define this axis. Similarly if there is a deformity in the tibia, the mechanical axis of the proximal tibial segment may be defined by extrapolating the femoral mechanical axis.

The mechanical axis of the proximal femoral segment should be at a tangent to the hip joint orientation line and the distal tibial segment's mechanical axis should be at a tangent to the ankle joint orientation line. If there is joint deformity then the relevant joint orientation lines may be copied from the contralateral **(** Normal **)** limb.

Deformity Assessment.

Any angular deformity should be described in terms of its magnitude, direction, plane and apex location. The distance from the centre of the knee joint to the deviated mechanical axis line will reflect the size of the moment arm created at the knee by any such deformity. This distance, by definition, is the Mechanical Axis Deviation in millimetres. An important observation is that the size of the mechanical axis deviation **(**At The Knee**)** increases as the apex of a given deformity approaches the knee. Thus a 20^0 varus deformity in the lower tibia produces a lesser mechanical axis deviation than a 20^0 varus deformity in the upper tibia. Therefore the lower tibial deformity is less damaging to the knee than the upper tibial deformity. Similarly upper tibial deformities, such as occurs following certain fractures or **in Blount's Disease**, are relatively poorly tolerated and require correction ever before knee arthritis develops.

Rotational mal-alignment in the lower extremity has been reviewed recently by **Eckhoff** [(141)]**.** Rotational mal-alignment is not readily appreciated in two dimensional and static radiographs but may cause significant morbidity. Furthermore rotational mal-alignment can alter the apparent axial deformity. A combination of flexion of the knee and external rotation of the leg results in an apparent varus deformity. Similarly flexion with internal rotation will create the illusion of valgus.

Several authors have cited real rotational mal-alignment as a cause of joint degeneration. Tonnis ascribes pain and osteoarthritis of the hip to "diminished femoral antetorsion syndrome" [(142)] and **Yagi** [(143)] linked tibial torsion with knee arthritis. **Echoff** [(144)] described malrotation between the femur and tibia occurring through the knee joint, calling it "knee version" and linking it to degenerative change. Rotational deformity is clinically assessed and is not easily quantified using plane radiographs. CT scans can be used to measure rotation in a long bone deformity.

Translational deformities, in the absence of other rotational or axial deformity, are of less significance because they have a relatively small impact on the mechanical axis. Nevertheless these deformities can be quantified using plane films and this becomes more critical when there are coexisting deformities in the limb.

Finally it must be realized that the true magnitude of an oblique plane deformity is always greater than it appears on both AP and lateral radiographs. This point is clarified further below.

The Mal-Alignment Test.

The following is a brief summary of the practical ways in which lower extremity deformity can be assessed and quantified. The process is perhaps not necessary in every clinical case but going through the process is a good discipline and may change the way you approach deformity correction in traumatic and reconstructive procedures.

This process becomes more essential if exact deformity correction is required. The procedure, the mal-alignment test [145, 146] is based on the principles discussed above and quantifies static but not dynamic deformity.

A fuller description is available **in the July, 1992 edition of Clinical Orthopaedics,** referenced below.

Every deformity can be quantified in the following terms;

1) . Magnitude (Degrees)

2) . Level (s) = Apex or CORA (Centre of Rotation of Angulation)

3) . Plane (Coronal , Sagittal, Oblique or Transverse.)

4) . Direction

The overall effect of any such deformity on the limb is reflected in the size of the mechanical axis deviation in millimetres.

The first requirement is good quality standardized weight bearing **AP** and true lateral radiographs. The AP film is taken with the patellae **(Not The Feet)** pointing forward. It is preferable to capture the entire limb on one film. The test involves drawing the mechanical axis of the limb and the mechanical axes of the individual segments within the limb and the joint orientation lines at the hip, knee and ankle. Any deviation from normal will be apparent. The deformity apex, or the **"CORA"** may be identified and the true magnitude and direction of the deformity can be measured graphically.

To begin, the mechanical axis of the limb is drawn from the centre of the femoral head to the centre of the ankle on the AP film. This normally passes just medial to the centre of the knee joint. If not then a mechanical axis deviation is present in the limb. The perpendicular distance from the middle of the knee joint to the mechanical axis line is measured on the AP and lateral x rays. This distance is the Mechanical Axis Deviation in millimetres at the knee **(** in the Frontal Plane and in the Sagittal Plane**)** and quantifies the deformity **(** in The Frontal and Sagittal Planes only **) .** Remember that the true extent of the deformity is not visible in these views but that the oblique plane deformity can be calculated from these two x rays.

The mechanical axis of the femur **(Centre of Femoral Head to Centre of Knee)** is drawn. The mechanical axis of the tibia **(Centre of Knee to Centre of Ankle)** is drawn. If deformity exists in either bone then the mechanical axes of each segment **(** proximal and distal to the deformity **)** are drawn separately. This is done by drawing tangents to the joint orientation lines at the hip and ankle.

If one bone is straight then its mechanical axis may be extrapolated into the adjacent segment of the next bone to identify that segment's axis. The joint orientation lines are drawn for the hip, knee and ankle as described above. If deformity exists and is uniapical then the apex of the deformity will be situated where the mechanical axes intersect. This point is not necessarily on the bone. It is know as the centre of rotation of angulation's or **"CORA".** As a rule deformity correction occurs through an axis, which is perpendicular to the plane of the deformity. For example consider a prosthetic knee joint, which bends in the sagittal plane, or front to back. The axis of rotation, or the hinge runs perpendicular to this, in the frontal plane, or medial to lateral. For example, consider a pure varus **("**Apex Lateral**")** deformity in the mid femur following a fracture.

The **"CORA"** is at the apex of the deformity, in this case on the shaft of the bone. The direction or plane of the deformity is pure Varus, which is seen in the coronal or frontal plane **(**or AP x ray only**).** The axis of correction of this deformity is perpendicular to the coronal plane, i.e. in the sagittal plane. Deformities are rarely confined to the frontal or coronal planes but tend to exist between these planes. Thus the deformity is visible in both AP and lateral radiographs. Neither of these radiographs show the true extent of the deformity. An **(**Oblique**)** x ray taken at a tangent to the deformity will do so however and an **(**Oblique**)** x ray taken parallel to the deformity will not demonstrate any abnormality.

Therefore, if an angular deformity is visible on both AP and lateral radiographs the deformity actually exists in an oblique plane and the magnitude of the deformity, in degrees, is greater than is apparent in the AP and lateral films.

The simplest way to define exactly the direction and magnitude of such a deformity is to reproduce the deformity on paper and use some basic trigonometry. Consider a deformity in the shaft of a malunited right tibia. It measures **20 degrees** "Apex Lateral" on the AP film **(**Lateral Bow or Varus Deformity**)** and **20 degrees** "apex anterior" **(**Anterior Bow or Procurvatum**)** on the lateral x ray.

What is the exact direction and magnitude of this deformity **?** Draw a set of X/Y axes and draw a right foot at the centre, as if looking down at your own foot.

The big toe is to the left! Graduate the axes in millimetres **(1 mm = 1 Degree)** Assign directions to the axes; medial, lateral, anterior and posterior, relative to the foot in the centre. Next place the measurements from the AP and lateral radiographs on the axes. In this example there is a 20-degree varus deformity and 20-degree anterior deformity. Next complete the parallelogram and a point is found in the anterolateral quadrant. This point defines the direction of the deformity exactly. Its angle can be measured from the graph. In this case it measures 45 degrees from the X-axis or coronal plane. The length of the line from this point to the centre, in millimetres, is the magnitude of the deformity in degrees**?**

The magnitude may be measured from the graph directly in millimetres or can be calculated using the Pythagorean theorem for right angle triangles; the square of the hypotenuse equals the sum of the square of the other two sides**....** thus the magnitude of the deformity equals the square root of the X-axis deformity squared plus the Y-axis deformity squared. Therefore this oblique plane deformity can be quantified in terms of its true direction **(**45 Degrees Antero lateral**)** and true magnitude (28.8 degrees).

A translational deformity may be assessed separately but using the same graphical method. Consider a **20mm** lateral translation at the apex of the deformity on the AP film and **20mms** anterior translation on the lateral film (with bone segments parallel for simplicity). Again X and Y-axes are drawn and named **(** Relative To The Right or Left Foot **).** The measurements are plotted and the parallelogram completed and calculations performed as above. The result would be a **28.8 mm** translation in an oblique **(**45 degree antero lateral**)** plane. The method is repeated if there is another deformity in the limb or segment (multiapical deformity). Thus each deformity can be quantified in the following terms;

1) . Magnitude (Degrees)

2) . Level (s) = CORA (Centre of Axis of Rotation)

3) . Plane (Coronal , Sagittal, Oblique or Transverse.)

4) . Direction.

- Note that this procedure does not quantify length discrepancies nor rotational deformity and these elements must be assessed independently.

Some Consequences Of Mal-alignment.

The most obvious consequence of mal-alignment in the lower extremity is abnormal load distribution across the involved joints. Such abnormal loads contribute to cartilage wear, which eventually leads to degenerative arthropathy [127]**.** An example of this phenomenon is uni-compartmental knee arthropathy associated with varus, apex lateral, mal-alignment of the tibia [128,129]**.** As yet the exact cause of cartilage breakdown in this situation is unknown but the association with mal-alignment is clear. Deformity in the frontal **(**Coronal**)** plane will increase the distance from the centre of the knee to the mechanical axis and thus create a moment arm at the knee joint. This increases the load on the joint compartment nearest the mechanical axis.

Thus a varus deformity in the tibia results in increases loads on the medial compartment of the knee.

It has been estimated that up to 70% of body weight passes through the medial knee compartment in single leg stance and this increase to 90% if a 4,6 degree varus mal-alignment exists [132]**.**

Remember the knee is normally in about 3^0 of valgus and thus 6 degrees of varus actually means 9 degrees of deformity. Thus with even slight varus at the knee, most of the body weight passes through the medial compartment. This creates an adduction moment at the joint, stressing the lateral capsule and may be reflected during gait as a "lateral thrust" [139,140]**.**

If the body is swayed over the affected knee during gait the medial compartment may be unloaded to some degree.

Another possible compensation for this adduction moment at the knee is a manoeuvre, which brings the centre of the knee joint under the centre of gravity of the body, i.e. closer to the mechanical axis line **(**or Ground Reaction Force Line**).** By turning the foot out, the hindfoot is placed closer to the midline during gait and equally the knee joint is brought closer to the ground reaction force line. Therefore the frontal plane deformity is reduced and the adductor moment at the knee is lessened. Patients with degenerative arthrosis in the medial knee compartment commonly walks with an externally rotated leg.

However if one considers a static radiograph taken in mid stance when the knee is slightly flexed and externally rotated as suggested above, the apparent result is a varus deformity **(**seen from the front; use a bent paper clip to demonstrate this apparent deformity **!).**

Therefore externally rotating the leg in the presence of a real varus deformity at the knee will increase the apparent varus and may therefore be thought to increase the deformity. In reality however externally rotating the leg medialises the hindfoot and reduces the adductor moment arm at the knee, thereby decreasing the load on the medial compartment. This contradiction illustrates the limitations of static radiographic assessment of these deformities and importance of gait analysis in assessing dynamic mal-alignment.

From a practical point of view the objective during deformity correction, total knee arthroplasty or high tibial osteotomy is to replace the centre of the knee on the mechanical axis of the leg, thus equalizing load sharing in each compartment. Again it is stressed that occasionally static deformity correction is insufficient because of persisting dynamic deformity. Good outcome following high tibial osteotomies has been observed only in those patients with low dynamic adduction moments measured with gait analysis prior to surgery [139 ,140]**.** Obviously the ball and socket hip joint can normally adapt to mechanical axis deviations and the ankle position can be adjusted by the subtalar joint, which leaves the knee joint to accept most of the consequences of frontal plane mal-alignment in the lower extremity. However a stiff subtalar joint exposes the ankle to greater loads [134]**.** A triple arthrodesis is associated with ankle osteoarthrosis at a later date [136,137,138]**.** Similarly a stiff hip contributes to knee joint arthrosis. Medial compartment disease in the knee was a common consequence of hip arthrodeses in the past, when the hip was placed in abduction. When the hip is fused in a neutral position in the frontal plane the knee survives better.

Summary.

An awareness of the three dimensional nature of deformity is essential if correction is to be achieved. This applies to all aspects of orthopaedics, from total joint arthroplasty **(** The Knee In Particular **)** to fracture management.

Deformities in the lower limb comprise static and dynamic components. Instrumented gait analysis is the ideal modality for assessing dynamic components of deformity, such as the lateral thrust, which accompanies genu varum. Static deformities are commonly in an oblique plane and may comprise elements of translation and rotation and length discrepancy. Each element of the deformity may be measured individually and precisely and the mal-alignment test described is of value in this regard.

INFLUENCE OF TORSIONAL ABNORMALITIES IN THE KNEE PATHOLOGY.

INFLUENCE OF TORSIONAL ABNORMALITIES IN THE KNEE PATHOLOGY.

The radiological and clinical study of the Knee Pathology has been historically carried out through a two-plane vision **(Anteroposterior and Mediolateral),** so that hardly any attention has been focused on the third dimension **(Saggital plan – Torsion)**[151,155]. The last years of the eventies witnessed the emergence of the first clinical researches linking torsional abnormalities and the knee pathology [5,159]**.** However, thesis researches did not achieve great repercussion in the daily clinical practice and only after the eighties torsional abnormalities were retrieved and taken into account as an etiological condition of the knee pathology [157,158,160]

Human beings and precisely their lower extremities must be considered as three-dimensional structures. The third dimension is the one we measure when taking as reference the longitudinal axis of the lower extremity, called torsion. The torsional parameters that could have grater influence on the knee pathology is This Two**: -**

1) **- Anteversion of femoral neck (AVF)**
2) **- External tibia torsion (ETT).**

Development of new screening systems such as **Computed Tomography (CT)** allowed us to improve quantification and classification of torsion.

We have to bear in mind, as suggested by **Ballester** and **Cols**, which lower limbs can be classified into five torsional groups [68,69]

---- Group I: Normal femoral anteversion **(AVF),** Normal external tibia torsion **(ETT)**

---- Group II: AVF 15 -30^{0} ETT 35-50^{0}

---- Group III: Normal AVF, tibia torsion >35^{0}

---- Group IV: AVF 15^{0} . ETT>50^{0}

---- Group V: AVF <10 ^{0} . ETT <25^{0}

However, we find very little research and few studies in available literature linking the knee pathology with torsional abnormalities.

The purpose of this chapter is to demonstrate how torsion exerts its influence on the knee pathology and which are the most relevant works on the matter in current literature.

Influence of Torsional Abnormalities in the Extensor Apparatus Pathology.

A). PATELLAR CHONDROMALACIA: ANTERIOR PAIN OF KNEE

Also known as PFPS /Chondromalacia patellae /patellar migraine/excess lateral patellar pressure syndrome.

The Patellar Chondropathy **(Patellar Chondromalacia)** is one of the most prevalent pathologies in orthopaedic surgery. Its etiopathogenesis is multifactorial, existing a never-ending list of etiological causes. All etiologies have the consequence of increasing pressures exerted over the patella cartilage, so that its biochemical, histological and mechanical features become altered,provoking thus pain and muscular atrophy of the quadriceps.

We could divide those mechanisms provoking a pressure increase in **:-**

1- Morphological alterations of the patella, or the femoral throclea.

2- Alterations in ligamentous structures, or the stabilizing elements of the extensor apparatus.

3- Mechanical alterations of the extensor apparatus. Axis alterations of lower extremities.

As we have previously mentioned, the shape of the patella and femoral throclea exerts great influence in originating anomalous pressures on the patellar cartilage. But in spite of anatomical factors, which are intrinsic to the extensor apparatus, the position they adopt in space can also modify pressures to which the patella is subject to [148,150,157,158,160,162,163]

Axial deviations produce modifications on the **Q angle**, and these modifications on the Q angle produce kinetic imbalances over the patella and at the same time generate pressure changes over it and constitutes the genesis of patellar chondropathy.

The patella is a passive element within the extensor mechanism of the knee **(149)** while dynamic elements depend on the position of its anatomic insertion **(154)** It seems obvious those alterations in the femur morphology can produce changes in the insertion location of proximal dynamic elements **(Quadriceps Tendon)** as a consequence of which we observe alteration in patellar pressures **(153)**.

In the Eighties, various clinical researches released then fundamentally linked AVF with anterior pain of the knee. In **1985 Takai** credited an increase in the incidence of femoropatellar arthrorsis for patients with increased AVF**.** Even authors such as **Fulkerson and Hungeford in1990** **(154)** believed that there was a relation between patellar chondropathy and torsional abnormalities although they did not study this relation thoroughly in any clinical series.

These clinical observations were confirmed by the work carried out by **Lee and his colleagues in 1994.** These authors executed an experimental research on a cadaver knee by means of measuring femoropatellar pressures modifying the AVF in a positive or negative manner 0^0-10^0-20^0-$30^0$and concerning the flexion they executed the measurements a 30^0 ,60^0 ,90^0 , 120^0 , For pressure measurements they used a Fuji Prescale Film (Fuji Film, Tokyo, Japan). These results showed that variations in AVF have as a consequence an increase in femoropatellar pressures in the contralateral compartment of the deformation direction. Therefore, an increase in AVF of pressure produce increases in medial compartments and vice versa. These experimental findings prove that femoropatellar pressures are modified with changes of femoral anteversion, and thus theories by other authors, which based their arguments on clinical observations, were confirmed.

On the other hand, it seems logical to think that and increase in AVF shall produce relevant alterations in femoropatellar angles and in distal morphology of the femur; **Eckhoff and col.in 1994** [149] carried out a research in which they assessed 20 individuals **(10 with anterior painof the knee and 10 asymptomatic).** All of them were subject to quantification by three-dimensional computed tomography (CT) of the AVF, measuring also the patellofemoral lateralangle, the angle of the throclear throat and the angle of patellar congruence. The research did notaccount for relevant differences between both groups regarding measures of femoropatellar angles.

On the other hand, they actually found relevant differences in the AVF degree, being higher with $p<0.01$ in patients with anterior pain of the knee.

Therefore the **Eckhoff** research proves that the AVF increase produces an increase in anterior pain of the knee **(** Patellar Chondromalacy **)** but it does not produce any alterations in distalmorphology of the femur and in the femoropatellar angular relationship. As indicated by Eckhoffin his work, the study by CT cannot assess dynamic elements influencing femoropatellar kinematics such as the quadriceps contraction and thus they must be carefully construed.But the extensor apparatus possesses another factor that could exert an influence on the Q angle.

Location of anterior tibia condyle **(ATC)** can provoke variations on the value of the Q angle and thus on pressures suffered by the femoropatellar joint. However, this assertion is not reflected in the literature, as there are not any published researches on the influence of tibia torsion and femoropatellar pressure. As explained in previous chapters the majority of tibia torsion cases are produced at the level of proximal metaphysis. An increase in external tibia torsion **(ETT)** causes a lateralisation of ATC and an increase in the Q angle, increasing basically patellar pressures on the external compartment, and as a consequence of it anterior pain on the knee appears.

Taking everything stated before into account we believe that when facing any anterior pain on knee it is necessary to carry out a three-dimensional study of the limb and not be limited by the sole research of two planes.

Aetiological Factors Include:

1. Pathologic patellofemoral alignment secondary to an increased Qangle, patella alta,VMO insufficiency, muscle tightness (amstrings, ITB, vastus lateralis and lateral retinaculum or rectus femoris) and excessive pronation.
2. Trauma. A single traumatic episode to the Patellofemoral joint may initiate the condition.

   As with the clinical signs the pathological changes of the articular cartilage is variable from no abnormality to extensive chondral lesions.

Management is largely conservative involving VMO retraining, patellar taping, stretching tight structures and relative avoidance of aggravating activities. Surgery is reserved for certain chondral lesions and where significant malalignment of the PF joint exists and patellar subluxation/dislocation coexists.

B) . FEMOROPATELLAR INSTABILITY

Patellar instability is one of the causes of pain in the knee that deserves special attention because, apart from provoking pain it can also produce alterations in the knee mechanics, reaching the maximal degree constituted by habitual dislocation of the patella.

Patellar stability is conditioned upon the balance between destabilising factors **(Basically Q angle and Greater Thickness of External Aileron)** and stabilising factor such as: greater height of external throclear side, distal insertion of the internal vastus, and strength of reflex element.

All authors agree [147,152,154,156,161] that determinant factors in Imbalances are **:-**

- Fibrosis and retraction of external aileron
- Insufficiency of vastus medialis
- Lateral position of ATC
- Throclear dysplasia

Few authors have included torsional abnormalities as the cause for patellar laxity. Is the reason for this exclusion the fact that they really do not have any influence at all or is it that the torsion parameter has not been studied yet**?** We state that the answer is the second one. The majority of authors do not include in their clinical and radiological studies torsional research as a work routine. The truth is that certain authors have found in there series a close relationship between the degree of external tibia torsion and patella instability [5,6,147,149,164]. Work carried out by **Balleste**r [5,6] is classical because we find in it a statistical relationship between habitual dislocations of the patella and increase of external tibia torsion and of AVF. **Turner (1981)** [164] in a research carried out on 101 patients suffering form pathologies of the knee found an increased value of the external tibia torsion **(ETT)** in patients with external instability **(** 50% with values >25^{0}being 19 ^{0} the control group **).**

As mentioned in many occasions, tibia torsion is generated basically at a proximal metaphyseal level. An increase of external tibia torsion produces a lateralisation of ATC provoking an increase of the Q angle and have the external forces that tend to dislocate the patella. We have been unable to find in available literature any experimental work in which pressure changes suffered by dynamic elements for torsional changes are studied.

We ignore if an increase in ETT influences the pressure increase of the external aileron, but we have observed that alteration in ATC position has an influence on the function of dynamic stabilizing elements of the patella.

- Regarding the treatment of femoropatellar instability we could divide it in **:-**
  - Proximal realignment: Interventions that act at proximal level, basically patellar aileron and vastus medialis.
  - Distal realignment: Interventions modifying collocations of ATC
  - Mixed interventions: Act both at a proximal and at a distal level.

The therapeutic decision has to stem from a detailed and complete study in which we cannot ignore **"Torsional Research".**

Some groups carry out interventions of proximal realignment systematically without taking into account what is happening in the other side of the joint. We agree with other authors that opening the external aileron must be an accompanying gesture in all surgery of patellar instability, and if it constitutes a sole gesture it shows little effectiveness.

Interventions of distal realignment have the aim of medialising ATC and patellar tendon in order to achieve a decrease in the Q angle. Classically they are appointed for TA-GT values not exceeding 16 mm**.** The available literature does not provide for any work studying the relation existent between TA-GT value and tibia torsion. Patients with a high ETT value subject to a medial transposition of ATC will probably improve there anterior pain on the knee and their patellar laxity but we will not have modified tibia morphology.

Tibia torsion not only influences the ATC position but also has a fundamental role on the individual gait. If we want to study it in depth we have to take into account that walking patterns **(**Gait**)** are influenced by ETT, but most accurately by the torsional group [68,69] possessed by the individual. If we do not correct excessive tibia torsion, even though we medialise ATC we will not have corrected the walking pattern **(**Gait**)** so that ground reaction forces will be transmitted in an anomalous way, reverberating on the femorotibial and femoropatellar joint. Therefore, we consider appropriate to carry out a reiterative osteotomy in those patients presenting a normal mechanical axis with ETT increase in order to medialise ATC and correct the walking pattern (Gait). **Regarding interventions of distal realignment (transposition of ATC) they actually modify the Q angle but they do not correct tibia morphology so that distribution of charges and walking pattern (Gait) remain unmodified as well.**

C) . ENCHONDROSIS OF TRACTION OSGOOD SCHLLATER DISEASE

First described by **Paget in 1891** and later by **Osgood and Schlatter in 1903.**Traction injury to the apophysis where patella tendon inserts **(**some of patella tendon inserts on either side of the apophysis**)** The Osgood Schllater disease is an illness of ATC physis characterised by its fragmentation.

Turner and **col. 1981** [164] found that the 47% of patients taking part in their study, which suffered from Osgood Schllater disease, showed and increases of ETT being the average percentage of 26% (d.e. 7^0) A higher value of ETT provokes an increase in the Q angle, conditioning an increase of pressures suffered in the enthesis area of the patellar tendon.

Recurrent traction's over a non-mechanically adapted zone provoke fragmentation of physary cartilage and then it becomes a vicious circle with difficult solution. No experimental researches were found in literature that might corroborate this clinical observation. As we pointed out in previous sections the torsional study of lower extremity must be included as a working system in patients with Osgood Schllater disease.

Note:-

Osgood-Schlatter's disease:-

- Is very common
- Is an apophysitis.
- Diagnosis is not difficult as the history and examination are classical.

The child **(10-13 years)** will present with gradual onset of localized pain at the tibial tubercle. The pain will be exacerbated by exercise (especially distance running and jumping), squatting, stair climbing and stretching the quadriceps.

On examination there is marked tenderness at the tibial tubercle with often a bony prominenc with overlying soft tissue swelling. The Quadriceps and hamstrings are invariably tight and there may be intercurrent PF malalignment and anterior knee pain.

Sinding-Larson Johansson Disease:-

Traction apophysitis of the distal pole of the patella.

Patella ligament is partially avulsed from the lower pole of the patella → Traction tendonitis develops.

Similar pathology to Osgood Slatters disease of the tibial tuberosity and usually resolves spontaneously .Is a similar condition to **OS disease** but affects the distal patellar apophysis and the associated proximal patellar tendon. Localised tenderness occurs at this point.