(En el nombre de Alá, el Compasivo, el Misericordioso !)

(In the Name of Allah, the Compassionate, the Merciful)

علم الانسان ما لم يعلم

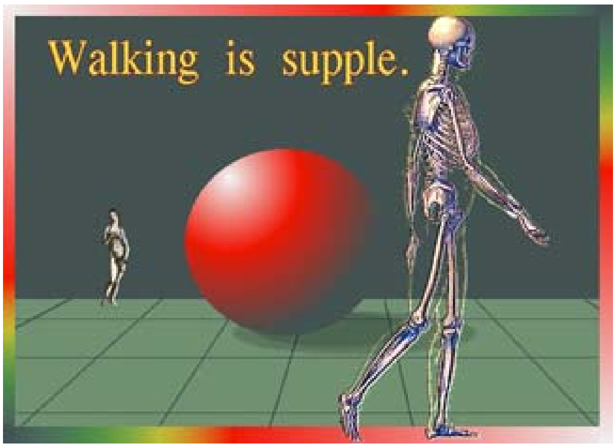
Ha enseñado al hombre lo que no sabia

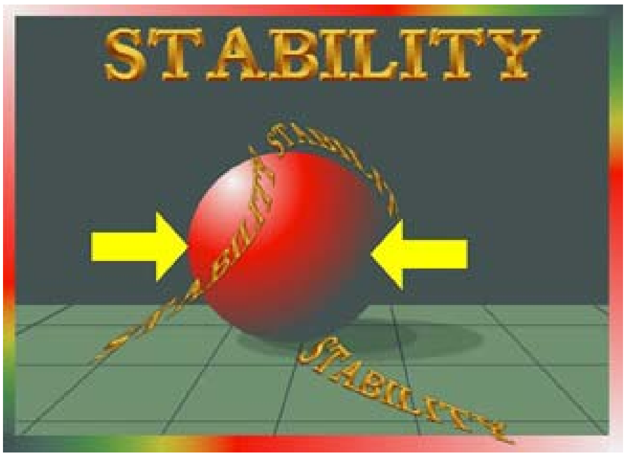
Taught human what he does not know

To the four most important people in my life who made this work possible;

- **My Father Mr. Sami EL.Kabbani & My Loyal Mother.**
- **My Father – in – law Mr. Abdel Fatah Al Houh & My Mother – in – law.**
- **My Devoted Wife & My Attractive Childs. (Sami & Nadim).**
- **My Teacher’s; Prof. Jorge Ballester Soleda & Dr. P. Álvarez Díaz.**

The Bones of the knee, the Femur and the Tibia, meet to form a hinge joint. The joint is protected in front by the Patella (Kneecap).





The Key to normal movement is supple motion with easy short muscular contribution. When that fails, momentum ceases to be an effective mechanism and mechanisms must stabilize. Stabilizing Mechanisms Call on Stabilizing Linkages.

INFLUENCE OF ABNORMAL FEMORAL TORSION ON PATELLOFEMORAL JOINT.

"MEASUREMENT BY USING STRAIN GAUGES".

Thesis Submitted For The Fulfillment Of Doctorate Degree In Orthopaedic Surgery And Traumatology.

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Index.

INTRODUCTION.

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The Human Body Is Built For Motion. Human locomotion is a complicated process. The attainment of normal gait in humans is also a complicated process, involving not only physical maturation, but also learning. It is not simply the result of inborn reflexes, although re flexes contribute to balance and efficiency.

It requires an intact musculoskeletal system as well as an intact neuromotor system. Muscles and bones are motors and levers designed to allow movement in many planes. Muscles are necessary not only for propulsion but also for deceleration and shock absorption. The human body also is designed for efficiency in movement. Because of the unique design of the human body for bipedal locomotion, relaxed standing requires minimal energy, and human beings naturally assume a rate of speed of locomotion that is most efficient for them. Human locomotion is also affected by changes in development such as physiological processes affecting neuromotor control, growing and maturing body segments, variable rotation of limbs and joints about an axis of motion, and changes in posture. The attainment of locomotors skills is a complicated process dependent upon an intact neuromotor and forty percent of adult body mass is muscle with proportionally **more in the lower extremities.**

Lower Extremities Of Human Beings, like the rest of their anatomy, are subject to profound changes from their foetal period until they reach the adult age, and these changes not only affect their size but also their morphology, proportion and special orientation. Racial and inheritance factors play a primal role in predefining what the final morphology of lower extremity will be, although it might receive influences from an enormous quantity of endogenous and exogenous factors, which could also even modify, within certain limits, the definitive theoretical result.

This multiplicity of congenital or acquired factors justify the appearance of a huge number of structural variants at the end of the individual's growing period, which derive from the alignment combinations of the different anatomical segments of the three spaces plane. This set of alignments defines the shape of the limb and, therefore, its biomechanical behaviors towards different physical demands during its function. Hence, when dealing with the influence of biomechanical aspects in the etiopathogenesis of all lower extremities conditions, from a statistical viewpoint, it is esteemed absolutely necessary to gather beforehand the different subjects submitted to the study into certain predefined groups, in order to randomize them properly. These predefined groups are going to be called morphotypes.

When revising the existing literature regarding the possible participation of lower extremity alignment as a mechanical factor tending to develop a certain pathology, we are seized by the fact that whereas we find abundant information on the influence of misalignments on the frontal plane and some fewer on the saggital plane, publications related to the influence of torsional alignments are very scarce, especially when referring to knee disorders.

The patellofemoral joint is one part of the knee joint, comprising the large curved condyles of the femur **(*Femoral Sulcus*)** and the facets of the patella**.** The femoral sulcus is flatter proximally and deeper distally, and this creates greater chance for the patella to sublux laterally when the knee is near full extension. The quadriceps efficiency, displacing the patellar tendon away from the tibia throughout movement and increasing the patella tendon moment arm**.** The patella, along with the quadriceps muscle group and the patellar ligament, makes up the extensor mechanism of the knee.

The patellofemoral force system is considered to have a strong correlation with patellar disorders, such as chondromalacia and subsequent arthrosis.

Chondromalacia of the patella is thought to be much more prevalent than is usually recognized as the primary precursor to arthrosis of the knee.

The cause of chondromalacia of the patella can be any condition in which the normal rhythm of the quadriceps mechanism is disturbed, resulting in abnormal stress distribution on the articulating surface of the patellofemoral joint.

These aberrations in the patellofemoral joint force system can ultimately lead to painful degenerative joint disease. For example, high magnitudes of the patellofemoral contact pressures are thought to be an initiating factor for chondromalacia and subsequent arthrosis.

- This type of disorder may result from abnormally high stresses on the articular surface of the patellofemoral joint caused by **angular and torsional deformities of the femur.** Despite it’s being an important part of the knee, little attention has been given to the biomechanical study of the patello-femoral joint.

An understanding of the dynamic functional anatomy of the structures comprising and crossing the knee joint is of critical importance if the practitioner is to appreciate the pathomechanics of overuse injuries of the knee and their subsequent management. Many overuse injuries of the knee are caused by excessive subtalar pronation motion during athletic activities. Due to the increased force with which the foot strikes the ground, and due to the natural running limb varus which occurs in running, there is an increased pronation moment **(i.e. Torque)** placed on the Subtalar joint during the first half of the support phase of running. The increased Subtalar joint pronation moment causes the subtalar joint to pronate at a faster rate and with larger magnitudes than seen in walking activities. Since subtalar joint pronation acceleration, velocity and magnitude leads to **increased tibial internal rotation.**

- So also the study of the biomechanics of the human Patello-Femoral Joint is necessary to understand or solve clinical problems such as chondromalacia, the lateral patellar compression syndrome, and recurrent subluxation or dislocation. To address these problems, many experimental and analytical studies have been performed.
- **As I mentioned in my Master Degree latter** that the patellofemoral joint is bonanza and also is very important subject and lower extremity segments likened to a column that supports a roof. So I decided after I took the permission from **Prof / Ballester Soleda** to complete my research **(Doctorate)** in the same topic.

Objective From Thesis.

Objective From Thesis.

The Study Of Orthopaedic And Traumatology is so encouraging. Furthermore, both the use of new methodologies and research paths and the inter disciplinary work, which appears to be absolutely necessary nowadays, are fostering the research processes and creates an atmosphere of bonanza for enchanting research methods and our performance in general. Therefore, it is obvious that in such a positive climate to improve our techniques, our methods and our performances requires us to make every effort in order to obtain the most efficient and optimal procedures.

This need comes from a society that is everyday more demanding, offering new possibilities and expecting better results. And in this sense, researchers and practitioners feel highly motivated and satisfied, since the fruit of our work has the whole world as recipient.

So, during my residency and after finish my Master Degree with the support of my chief, **Professor / Jorge Ballester Soleda,** concerned by the degenerative pathology of patellofemoral joint and torsional abnormalities, we started this thesis devoted to the linkage of both diseases and their possible surgical solutions. And too we have to keep trying and trying until we achieve the best solution, which realize the benefit for the patient. For such purposes we enjoyed availability of facilities and support from the **IMIM of Barcelona. (Pompeu Fabra University of Barcelona).**

In This Thesis we intend to study empirically the solicitations produced in the patellofemoral joint during flexo-extension, the changes occurred when increasing their femoral. And also we used **Strain Gauges** as a new technique for study of influence of abnormal femoral torsion on patellofemoral joint. The study carried out on whole fresh knees, non-phormolised, using several experimental methods.

Historical Review of Studies on Patellofemoral <u>Arthrosis and Torisional Abnormalities</u>.

HISTORICAL REVIEW OF STUDIES ON PATELLOFEMORAL ARTHROSIS AND TORISIONAL ABNORMALITIES.

***In The previous article on Patellofemoral* (PF) *problems*,** I alluded to the idea that restoring normal balance to the patella was the main approach to conservative treatment of patellar function. Restoring normal balance to the patella mechanism automatically assumes that we must also take into account not only patellar position and motion but also all of the peripheral possibilities that may affect PF mechanics.

Symptomatically, most patients with chronic PF problems complain of knee pain when squatting, climbing and descending stairs, getting up after sitting a while **(Movie Sign),** popping, giving way, crepitating and possible mild parapatellar effusion.

Whether the diagnosis is loose bodies trapped in the PF joint, synovial plica impingement, patellar subluxation, patellar tendinitis, chondromalacia, lateral compression syndrome or patellar malalignment syndrome, to name a few, if the following functional examination and treatment is performed; a clinician should be able to markedly improve most of the PF conditions. The prime purpose of examination is to determine the source of the pain; and while tenderness to palpation may reveal a biomechanical stress, a functional examination is needed to reveal where treatment should be directed. The examination should comprise both a static and dynamic point of view [2].

Is the pelvis level or oblique**?** Pelvic obliquity and fixation may affect the hamstrings, quadriceps, and hip joint. An anterior pelvic tilt due to tight hip flexors may be associated with hyperextension of the knees and abnormal knee joint mechanics**. (1)** A posterior pelvic tilt due to hamstring tightness would create excessive stress on the quadriceps. Is there increased internal torsion of the femur? (Excessive Anteversion) causing the patellae to be more medial **("Squinting")?**

Formal retroversion causing laterally pointing patellae**?** Is there genu valgum **(causing an increased Q angle and resulting in abnormal patellar tracking during knee flexion)**, genuvarum **(a cause of compensatory subtalar joint pronation)**[4], tibial rotation that should be increased internally with pronation and externally with supination, all of which affect PF mechanics**?**

Unfortunately, there is not too much that can be done for structural deformities such as hip coxa valga or vera, femoral rotations or genu valgum and varum.

Foot orthotics and stretching of associated tight muscles and strengthening of associated weak muscles might help to compensate. Finally, in the standing position we would check for foot and ankle alignment. Foot pronation is definitely related to PF problems**.** **(2)** Observing the standing patient from the side might reveal a genu recurvatum, which may be associated with general ligamentous laxity or patella alta (High-Riding Patellae).

Do the patellae point towards the ceiling **(Alta)** instead of straight ahead, or do they appear to be displaced inferiorly **(Baja)?** Patella alta means that the patella is not protected by the higher lateral femoral sulcus and may be more prone to lateral subluxation. Patella baja and alta does not allow normal patella contact and is subject to poor stability and function.

Patella tracking should be observed as the patient flexes and extends the knee. Look for abrupt patellar deviation (Covered In Previous Article) and popping. Abnormal patella tracking may refer to recurrent subluxation, chondromalacia, excessive lateral patella stress, plica syndrome or a chondral or osteochondral defect. Your treatment of these conditions will be based on the functional findings found during the examination. The vastus medialis obliquus **(VMO),** an extension of the vastus medialis, which inserts into the patella, should be observed to see if it is dysplastic or atrophied. Atrophy will reveal a large superomedial patella dimple as the sitting patient extends the knee 45 degrees**.** The lower the VMO inserts on the medial patella the more stability it provides. Structural or static evaluation in the supine position would include measurement of the Q angle. If the quadriceps angle is abnormal and is due to structural or functional abnormalities, such as genu valgus, VMO atrophy, etc., the angle is considered pertinent. An abnormal Q angle by itself is not necessarily diagnostic [3].

The next phase of the PF examination relates to the dynamics of the lower extremity. Related muscles must be tested for tightness, which may inhibit normal PF function. Muscle strength should also be tested since muscle imbalance may have an effect on PF joint mechanics.

Beckman et al [1] state that the medical hip rotators are often found stronger than the lateral hip rotators, resulting in increased femoral rotation and affect normal tracking of the PF articulation, especially when the knee is near extension.

A dynamic evaluation of the lower extremity could prove to be invaluable. Observing the patient descending stairs or performing single-leg squats might show increased genu valgus due to increased medial femoral rotation and adduction of the femur due to weak abductors and external rotators (Posterior Gluteus Medius and Piriformis). When the patient descends the stairs observe the flexing weight-bearing knee to see if valgus occurs causing increased stress on the medial retinaculum. The patient's gait should be observed with respect to femoral rotation, position of the patella and foot, and ankle pronation and supination.

When reviewing existent literature regarding the possible participation of lower limb alignment as a mechanical factor tending to develop a particular pathology, it is astonishing to see that whereas there are plenty of information on the influence of frontal plane misalignments and slightly less information on the saggital plane, publications regarding the influence of torsional alignment are scarce, especially referring to knee disorders [5, 6]**.**

It is not until 1982 and afterward, when the monographic subject of the **SOFCOT Congress** was published, and a little earlier with the works of the **Belgium Orthopaedic Act in 1979,** that we start to witness the modest emergence of works linking specific pathologies of the lower limb to its different torsional morphotypes [7,8,9,10,11].

Borelli (1682) describes structural variants of lower limbs in torsion or in rotation, following influences of descartes **(1649). Von Haller (1708-1777) in Mid-XVIII th.** century deals in his treatise certain aspects such as position or function variation of lower limbs according to their longitudinal axis and according to the action of muscles provoking torsion or a rotation.

Pavie Quotes that Antonio Scarpa (1806) was the first one to assert the existence of torsional abnormality in the tibia of a knock-kneed foot. Later on, **in 1856 Bouvier** studied and confirmed external tibial torsion in the case of an evolved knock-kneed foot.

Guérin (1868) presents a tibia twisted outwards belonging to a subject suffering from a Knock-Kneed foot. **In 1882 Dubreuil** distinguishes between rotation and torsion of the lower limb, and **in 1888 Schwartz** describes variants of external tibial torsion and provides for the notion of external torsion of the lower limb, defining it as congenital or acquired. On the other hand, **in 1989 Kirmisson** describes external torsion observed in adult knock-kneed feet.

On the contrary, Anglo-Saxon authors point out the internal torsion of the leg. **Johann Mikuloicz in 1878,** when studying the desiccated femur, found a variability of torsion ranging between +37 and –25, quoting authors of the same period such as **Eschricht (1852), Von Volkmann (1836), Kocher (1896) and Nasse (1897).**

- **The first edition of the Hoffa (1868)** Orthopaedics treatise comes out describing the internal rotation of the tibia.

- **Holmes (1870) In U K,** recommends use of orthopaedic detorsion devices, whereas **Adam (1873), Grattan (1891), Tubby (1894) and Swan** insist upon the notion of internal tibial torsion.

- **Twosend In U.S.A.** described this the phenomenon and followed by **Waitman (1903).**

All along the firs half of the XX th. century, a great amount of authors showed interest in tibial torsion. **In 1905 Nove-Josserand** considers internal tibial torsion as frequent and defends its conservative treatment. **Nicod in 1908** goes further on and states that tibial torsion is spontaneously corrected, whereas **Purkhauer in 1911** stands for systematic osteotomy, arguing the need for persistence of the internal torsion despite correction of the knock-kneed foot, a viewpoint followed by the German school. In Sweden the results for osteotomy were published by **Wahren (1930).**

- **In 1912 the Lamy Surgery Congress,** inspired by Jalaguier, states the frequency of internal tibial torsion and the need for an active orthopaedic or surgical treatment, whereas **Broca (1914)** stands against such idea by casting doubt on the notion of internal tibial torsion as a complication of the knock-kneed foot.

- **The Belgium Van Neck in 1942** denies the existence of internal torsion, whereas **Mr. Lance in 1932** thinks that torsion of the lower limb disappears by itself.

- **Aberle in 1933** studies the torsional problems according to the knee varus or valgus deviations.

Therefore, in **1931,** intrigued by the contradictory literature, **Victor Depuis** begins a series of studies on tibial torsion, whose results see the light through the publication of the monograph, “Tibial Torsion” **in 1951.**

Regarding femoral anteversion and previously to the afore mentioned work carried out by **Mikulicz, Julius Worlf published in 1868** the first study of the architecture of the femoral neck and defined the notion of superior femoral torsion. After **Mikulicz, Broca** points out **in 1896** a variability of +38 to +2 degrees of anteversion, whereas **Bradford in 1903** shows in his study an average anteversion of 14.3 degrees. **Pearson and Bell in 1919** show an average fermoral torsion angle of 15.3 degrees.

- **In 1972 Harris** [12] argued that there were two types of rotational deformities, the simple ones affecting only one segment and the mixed ones having a torsional abnormality in a segment and the contrary in the other segment. Besides, he stated that there were different aetiologies, some intrauterine and some positional others **(Sleep/Sit Down),** quoting that an increased anteversion in abnormal external torsions emerged, so that corrections of femoral anteversion after the Age of 8 were possible, although it was not the case for abnormalities in feet or tibia, which required corrective osteotomy in certain occasions.

- **Judet in 1977** [13] started to refer to the triple deformation including: an exaggerated anteversion of the fermoral neck, an external rotation of the leg and a genu varum. He explained that such triple deformation was a complex mechanism to fight internal rotation imposed by femoral anteversion, rotating the leg outwards, and coupled with a valgus flat foot. Thus he justified a surgical treatment in order to prevent from emergence of arthrosis.

- **Goldberg 1991** [14] described the patella as slides in a groove or gutter formed on the lower end of the femur or thighbone. If the patella moves incorrectly through this groove, it is termed abnormal tracking of the patella. Anatomic and biomechanical factors producing abnormal tracking of the patella with knee motion are believed to be the principal cause of this knee pain.

The patella is a triangular-shaped bone, which is controlled by numerous muscle groups, ligaments, and fascia. The mechanics of the patello-femoral joint are therefore determined by muscles, soft tissue attachments, and the shape and position of the patella within the femoral groove.

Micheli and Stanitski (1981)[15] have suggested that patello-femoral joint stability depends upon patello-femoral congruency, static and dynamic stabilizers. An imbalance in patello-femoral mechanics may be due to tightness in the lateral structures (Iliotibial Band And Lateral Retinaculum Complex); decreased flexibility of the quadriceps, hamstrings, hip flexors, and calf muscles; and increased weakness of the knee extensor mechanism **(Quadriceps-Vastus Medialis Obliquus).** These factors contribute to increased compression under the patella and lateral tilt of the patella.

Malalignment of the patella will result in inappropriate loading of the articular cartilage of the patella and the resulting diffuse pain around the patella **(Micheli and Stanitski 1981).** An increase in femoral anteversion, tibial torsion, forefoot pronation, genu valgum, genu varum, and genu recurvatum have all been suggested as contributing factors to the abnormal tracking of the patella. **Grana (1985)**[16] suggests that a decrease in hamstring flexibility, which increases the load applied to the patello-femoral joint, results in increased patellar compression and lateral tracking. Excessive forefoot pronation can change the rotation in the lower leg and subsequently alter the tracking of the patella. Foot ortheses have been successfully used to diminish patello-femoral knee pain when forefoot pronation was a contributing factor **(Eng 1993, James 1979)** [17,18]**.** The lumbar spine or low back can refer pain to the medial side of the knee alone with the athlete having no specific complaints of back pain. Hip problems such as Legg-CalvŽ- Perthes disease in children and slipped capital femoral epiphysis in the adolescent can present as knee pain alone **(Baxter 1986)** [19]**.** Although knee pain may be the only symptom, the cause must be assessed thoroughly.

Watanabe reported that, at twenty to twenty-four weeks, femoral anteversion ranged from 10 to 30 degree. In addition, he found that marked internal rotation of lower extremity was associated with increased femoral anteversion whereas external rotation was associated with femoral retroversion. External rotation of the lower limbes was more common in males and internal rotation was more common in females, but specific numbers were not given.

Watanabe noted that femoral anteversion develops during the second half of pregnancy and reaches an average of 35 degrees by the time of birth.[20] **Eskhoff** [21] found a similar association between femoral anteversion and osteoarthritis of the knee. Increased femoral torsion also has been documented in patients who have pain or osteoarthritis of the knee and patellar instability [22,23] .

External torsion of the tibia is a clinical finding that is observed frequently, although not consistently, in patients with increased femoral anteversion. **Six-Year –Old Girl** with markedly decreased femoral anteversion and externally rotated femoral characterized by patellae pointing outward, medial rotation of the knees until the patellae were parallel brought the feet into a Toeing-in position suggesting internal tibial torsion. Another patient, a nine-year-old girl with increased femoral anteversion and internally rotated femoral characterized patellae pointing inward, lateral rotation of the knees until the patellae were parallel brought the feet into a Toeing-out position suggesting external tibial torsion [24]. Therefore, it is possible that there may be some compensatory process at the knee and leg in response to a proximal deformity, resulting in a torsional deformity of the leg.

Swanson et al [25]**,** identified decreased femoral anteversion as one of several potential causes of an internal or external rotational deformity of the lower extremity, which they defined us an excessive range of movement of at least 20 degrees in either direction. The total range of internal and external rotation is normally between 80 and 90 degrees**,** but this range decreases with the early development of osteoarthritis of the hip, four of the fifty-nine patients complained of diffuse pain around the knee, ten complained of pain at the patellofemoral joint, and four complained of pain in the sacroiliac region [26] **.** We attempted to determine whether this finding was due to compensatory external tibial torsion in response to a high angle of femoral anteversion with increased internal rotation of the knee or to compensatory internal tibial torsion in response to a low angle of femoral anteversion with increased external rotation of the knee. The extremities were divided into three groups on the basis of the degree of internal or external rotation of the knee with the feet parallel: 0 to 5 degrees **(Group 1),** 6 to 10 degrees **(Group 2),** and more than 10 degrees **(Group 3).**

Computerized Tomography **(CT)** showed that, with internal rotation of the knee, the average femoral anteversion increased from approximately 9 Degrees **(Group1)** to approximately 16 degrees **(Group 3);** this increase apparently was due to the increasing degree of external tibial torsion. With external rotation of the knee, femoral anteversion decreased from approximately 6 degrees **(Group 1)** to 3 degrees **(Group 3).** Therefore, the increase in external rotation of the knee and internal rotation of the tibia was due to the decrease in femoral anteversion.

Kizinguer in 1977 [27] when talking about lower limbs torsion defects employed the following definitions of torsion and anteversion: ***Torsion*** is the deformation when fixing a solid and exerting a transversal rotating movement on one of its parts, leaving the rest of the parts fixed or subject to a movement on the opposite sense**(Robert),** and ***Anteversion,*** the external rotation of the upper half of the femur, head and neck onwards, and the greater trochanter backwards **(Virenque, Pasquie, Salanova).** Furthermore, he carried out a literature review from the evolutionary tables of femoral anteversion made by several authors, such as **Dunlap, Shands, Gaul, Streit and Holliester (1957), Ryder and Crane (1953).** He concluded that during the sixth month of intrauterine life the condyles and the femoral neck are placed at the same frontal plane, and from then to the birth the femur suffers torsion until it reaches 40 degrees of femoral anteversion. Later on, the growth path gradually diminishes until it reaches a normal value of 15 degrees on adult age, although spontaneous correction of an exaggerated anteversion at the age of 12-13 is quite common **(Voutey).**

Whereas tibial torsion, according to **Giannestras (1967), Hutter, Scott and Depuis (1951),** is +2 degrees at birth, and it turns to 10 degrees during the first year of life, it keeps like this until 3 - 3 ½ years old, increasing up to 20 degrees at 4 years old. However, we must take into account that there is always a variation margin around 20 degrees, that there are races such as the Japanese where internal torsion frequency is clearly higher. In fact, all combinations are possible, even the association of a unilateral external torsion to a contralateral internal torsion. **Hutter** and **Scott** even stated that acquired torsion at the age of 7 is the definitive one.

Regarding pathologic tibial torsion **Kizinguer** [27] states that the secondary deformation in external rotation occurs after the age of 4 in children affected by an anteversion of a foetal type, such as compensation for internal rotation of the thigh, and that the external tibial torsion is associated to a genu varum and to the persistence of an exaggerated anteversion.

- **Blaimont also in 1977** [28] described two cases of gonarthrosis associated to a defect of internal tibial torsion **(** one congenital and the other acquired **)**, ensuring that in such cases gonarthrosis was not explained by deviation in the frontal plane, or by alterations of the external flying buttress, but that the patient when performing gait carried the foot towards correction with a small external rotation carried out through an external femoral rotation, submitting condyles to an abnormally wide movement of internal rotation and to dynamic solicitations of external rotation of the tibia. He concluded that children’s torsional abnormalities should be studied in the future, assessing the possibility of preventive corrective osteotomy. Furthermore, he operated on the congenital case performing a flat-curved osteotomy with excellent results in gait, mobility and pain.

- **Turner and Smille in 1981**[29] Measured Tibial Torsion in 1200 adult patients suffering from gonalgia, and in their study they obtained an increase of external tibial torsion in injuries of the extensor apparatus (Patellar Instabilities and Osgood-Schlatter). Besides they perceived the frequency of a weak external tibial torsion in cases of panarticular gonarthrosis, although they emphasised the need for deeper study on this link. On the other hand, monocompartmental arthrosis were associated to a medial tibial torsion comparable to the control group's one.

- **Taussig** [30] **in 1982** when talking about rotation abnormalities of lower limbs indicates those abnormalities are found out during childhood by a gait alteration or by a patellar pathology. He defined ***Torsion*** as the movement produced in the bone, in itself around the longitudinal axis, and ***Rotation*** as the movement of a bone regarding the adjacent bone, around a longitudinal axis. This movement is carried out in the joint by turning both bones.

- **Bedouelle** [31] states that femoral anteversion, which is a unique feature of humans, evolutes from intrauterine life until adult age and may be normalised **(10-15 Degrees)** until the age of 14-15. Clinically the increase of femoral anteversion shows gait in internal rotation **(** Toeing in **)**, frequently accompanied by a genu varum, existing a limitation of the external hip rotation and an exaggerated internal rotation. This favours spontaneous correction of anteversion, so that knee rotation and external tibial torsion can be avoided. Adjacent segments of the lower limbs affected by an increased femoral anteversion are **: -**

1- Valgum Flat Foot.

2- Initially there is a knee rotation compensating for the internal rotation of the femoral segment. At **5-7** years old it is attached also to an external tibial torsion, and at **7-9** years old an excessive external torsion of the lower limb may appear. The ATT can moves so that it favours external luxation of the patella and later femoral anteversion can be normalised though exaggerated external tibial torsion may persist.

3- Lumbar Hyperlordosis.

Consequently, exaggerated anteversion of the femoral neck can unchain a great amount of knee or rachis problems or the possibility of a hip arthrosis.

- **Cirotteau** [32] links the osseous structures of the hip and concludes that the exaggerated anteversion is only compatible with certain positions of the hip, such as a shallow cotyle, retroposition of the femoral neck and a relevant limitation of the external rotation, and he states that femoral torsion is settled essentially on the upper metaphysiary area.

- **Taussig** [33] in his study on tibial torsion explains that they can be isolated or secondary to an exaggerated femoral anteversion. Besides he points out that the main difference stems from the fact that such tibial torsions present an exaggerated internal rotation of the hip, considering that and exaggerated external tibial torsion is the one exceeding 40 Degrees. Furthermore, when dealing with its evolution, he points out that it can be compensated by an internal rotation of the femoral condyle and the patella, which looks inwards, and that external tibial torsion is usually detected before the age of 4 years and stabilised from the age of 4. On internal tibial torsion he mentions that it is abnormal from the age of 4, weather acquired or congenital, and that exaggerated internal rotation during the first months of life are corrected by deambulation.

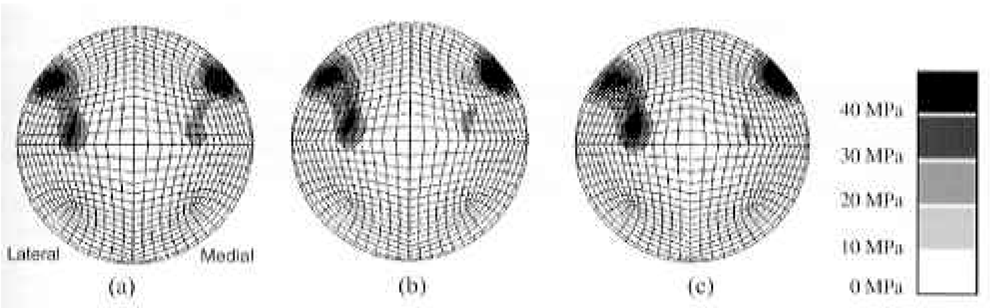
Patellofemoral problems are common complications after total knee replacement. In order to investigate the effect of an increase in the patellar thickness on the kinematics of the knee joint, four intact embalmed cadaveric knee specimens were prepared to control the thickness of the patella and to measure: **1)** the excursion lengths of the quadriceps muscles during knee flexion using a linear voltage displacement transducer; **2)** patellar tracking and patellofemoral contact pressure using pressure sensitive Fuji prescale film; and **3)** patellar movement during knee flexion using an image processing system. As the patellar thickness increased from the original dimension to a 7-mm increment, the excursion lengths of the quadriceps muscle during knee flexion did not vary significantly, but lateral patellar subluxation was clearly demonstrated by an increase in the patellofemoral contact pressure on the lateral femoral condyle and by lateral displacement of the patella. Increased patellar thickness in a total knee replacement is considered to be one of the causes of lateral subluxation. The importance of monitoring the patellar thickness using a patellar cutting jig is stressed [34].

Although Total Knee Arthroplasty (TKA) has become a very common procedure, patellar problems remain a major cause of disability. Patellar thickness is one of the most challenging factors. The influence of patellar thickness on patellofemoral kinematics and contact a characteristic following TKA was investigated. Seven unembalmed whole lower extremity cadaver specimens were used [35]. The kinematics was measured with a magnetic tracking device **(3Space Tracker System, Polhemus Navigation Sciences Division, Colchester, VT).** Contact area was calculated from the kinematic data and the digitized joint surface geometric based on a theoretical method. The patellofemoral joint contact force was measured directly using a uniaxial force transducer. Kinematically, the influence of patellar thickness on patellar flexion, rotation, and proximodistal shift was not significant. Orthopaedic surgeons are often challenged by derangement of the patellofemoral joint, especially following TKA. It is commonly assumed that restoration of overall patellar thickness is most desirable. A thin patella can reduce the contact force, but it also poses the potential risks of stress fracture and anteroposterior instability. Increasing patellar thickness might be expected to increase the effective quadriceps moment arm at low flexion angles of the knee, but potentially reduces the range of motion of the knee and predisposes to patellar subluxation. Either a thicker or a thinner patella had a smaller contact area than intact and normal-thickness patella. Therefore, the surgical technique of patellar resurfacing during **TKA** should attempt to reproduce the original patellar thickness.

A large Q angle induced by technical error such as an internally rotated femoral component causes patellar failure after total knee arthroplasty. The effect of medial displacement of the tibial tubercle to decrease the Q angle for patellar tracking was studied by evaluating the patellar position relative to the patellar groove on the femoral component in cadaver specimens**.** A 5 degrees internally rotated femoral component caused the patella to shift medially about 5 mm, and also caused the tibia to rotate internally about 3 degrees at full extension [36]. With a 5 degrees externally rotated femoral component, normal patellar tracking occurred. The distance of medial displacement was determined so that the patellar tendon was parallel to the longitudinal axis of the tibia at full extension. This allowed the quadriceps tendon, the patella, and the patellar tendon to form a straight line. The average distance of medial transposition of the tibial tubercle was 9.32 mm. Medialization of the tibial tubercle caused the patella to shift about 2 mm medially from the patellar groove. The transfer also caused an external rotation of the tibia **(2 Degrees-5 Degrees).** Medial transfer of the tibial tubercle changes patellar kinematics and corrects the tendency toward lateral patellar dislocation caused by internally rotating the femoral component; however, it also creates minor patellar and tibial kinematic changes that may have a clinical effect.

Patellofemoral instability following total knee arthroplasty remains one of the major complications requiring operative intervention. In spite of recent advances in technique and instrumentation, the rate of this complication remains disturbingly high. A comprehensive analysis of cause reveals malalignment of any of the components to be potentially responsible, particularly valgus or internal rotation malalignment of either femoral or tibial component, as well as lateral displacement of the patellar component. Under resection of the patella or over sizing the femoral component may also contribute to excessive lateral retinacular tightness. When confronted with patellofemoral instability, the surgeon must first look for and correct the cause. Component malalignment requires component revision. Extensor mechanism imbalance requires either proximal or distal realignment. Lateral release alone invites recurrence of the problem.[37] Replacement is considered to be one of the causes of lateral subluxation. The importance of monitoring the patellar thickness using a patellar cutting jig is stressed.

In University of Pittsburgh, **Pennsylvania, U.S.A. Anthony J. Miller, 1998**. Described the effect of femoral Component rotation on the stresses in **AN UHMWPE Patellar Prosthesis** - A Finite Element Study. External rotation of the femoral component led to increased contact area laterally and increased contact traction medially. **Peak von Mises stress** was unchanged laterally but increased on the medial margin.



Fringe plots showing the von Mises stress distribution on the articulating surface of the button (for a left leg) at 90-knee flexion with (a) 0, (b) 2.5, and (c) 5 of external femoral component rotation

The patella tilted laterally and shifted laterally with femoral component rotation. Normal force on the button was unaltered by component rotation and plateau at 75 of Flexion**.** After 45 of flexion, the medial-lateral force on the button was medially directed, was increased in magnitude, and was further increased by component rotation. On the other hand some authors described torsional abnormalities and also the effect of femoral Component rotation on the stresses in polyethylene knee prosthesis by new design simulator type II. With 5 Hydropneumatic cylinders[38] .

External rotation of the femoral component maintained good patellar tracking but increased **von Mises Stress** on the patellar button. The change in patellar tilt directly followed the change in femoral component rotation, indicating stable patellar tracking. The plateau in the patellar normal force showed that the contact of the quadriceps tendon began at 75 of flexion**.** Although the patellar tracking remained good, the increased medial-lateral force indicated that the tendency toward subluxation increased with femoral component rotation. One approach to improve patellar tracking is to medialize the patellar button on the bony patella. This technique would probably reduce the magnitude of the medially directed force because lines of action of the quadriceps tendon and patellar tendon would be more closely aligned. Future work will address this issue.

- **Jaquemier** [(39)] in his analysis of torsion defects in children by computed tomography **(CT).** States that the investigation of such abnormalities has enormously benefited from **(CT);** its results in children are divided in two different groups: some of them suffered a femoral anteversion from 15 up to 25 degrees, and an external tibial torsion compensating the leg exceeding or equal to 20 degrees, and others with an excessive femoral anteversion exceeding 25 degrees and a compensating external tibial torsion exceeding or equal to 20 degrees. Concluding that the modification of the torsion defects is carried out between the age of 2 and 9, that the lack of medical consultation between the age of 9 and 14 is due to the standards of this period, that an internal rotation of the femur lower limb appears in the CT**.**, and he mentions that it is from the pelvis (fixed element) where torsional abnormalities are initiated.

- **Heripret** [(40)] carried out a research on radiological measurements and femoral and tibial torsions. There were no differences among different measurement methods on femoral torsions, taking into account an average error of 5 degrees, which was always positive, i.e., values were always higher than normal values, whereas in tibial torsions there was no way too find any sufficiently reliable radiological method, since there is an error variability of **+/-** 10 degrees, so that the CT. is recommended for higher precision.

Chrestian [41] in his work on techniques and results of unrotational osteotomies in children, considers that before the intervention it is essential to carry out a curve of torsional measurements with values taken every 6 months**.** He obtained the best results in femoral disrotation at the age of 9, because at such age femoral alterations are fixed and they are not yet compensated by the tibiae.
Regarding tibial disrotations he only esteems necessary a fibula's osteotomy when disrotation is higher than 30 degrees**,** which must be performed between the middle third and the upper third of the tibia. He could not draw any conclusions from the results due to the heterogeneity of techniques and abnormalities.

Bedouelle [42] talked about therapeutic indications of torsional abnormalities in children. He rejects orthopaedic treatments, because there is no study proving them to be efficient. He recommends only postural treatments favouring or preventing the deformity correction and he states that only a 10 % are suitable for surgery. Such conclusion stems from considering three basic rules for surgery suitability: having performed 3 or 4 successive controls in 1 year, functional abnormalities marked with an alteration of rotations caused by the absence of external rotation **(** Less than 10 degrees in extension **)** and generally do not perform any intervention before the age of 4 years.

Lerat [43] carried out a clinical examination of the adult's axis by means of a **CT.,** based on the fact that tibial torsion is very variable within the population, but that the CT**.** allows very high precision in torsional measurements. The examination was carried out with the knees inwards, both feet placed parallel. The average anteversion obtained was of 14º +/- 7º and the average tibial torsion was 34º +/ - 8º, with an average TA-GT of 12.6 cm. In his conclusions he stated that the CT. allows us to perform a comparison between more precise clinical measurements and less precise ones, confirming, thus, that certain clinical measurement methods are acceptable, especially the measurement of thecondyle-malleolar angle, being such clinical methods insufficient for tibial torsion yet valid for femoral anteversion, although they might be slightly imprecise.

- **Lerat** [44] in his research on morphotypes of adult's lower limbs states that due to the great variability in population and even between both lower limbs of the same patient, where inherited, race, mechanical, muscular, positional and other factors take part, since there is no absolute correlation between femoral torsional and tibial torsions, there is the possibility to find any alteration associated each other. In order to be able to compare the groups he defined the Index of femoral-tibial torsion as the difference between anteversion and external tibial torsion, allowing us to classify the functional morphotype in **:-**

- **Strong Tibio-Femoral Indexes (** ***Greater Than 20º*** **),** where external tibial torsion is higher than femoral anteversion with two subgroups, one with normal or weak femoral anteversion and another one with a very relevant anteversion.

- **Weak Tibio-Femoral Indexes (** ***Lower Than 20º*** **),** where the torsions balance through weak torsions or strong torsions.

Concerning the consequences of femoral anteversion in the hip, **Jaeger** [45] declares that even though retroversion leads to degenerative lesions at the level of the joint, giving as an example the secondary coxarthrosis to an epiphysiolysis, it is not possible to state the same as in increased femoral anteversion. However, there are some studies, such as those by **Merchant (1965),** that show experimentally how forces transmitted on the femoral head during the support phase are strongly increased when the gait is performed with an external exaggerated rotation of the hip. He concludes that if the increase of femoral anteversion is coupled with an internal rotation gait; an instinctive protection of the hip is produced, though it might not be evident or manifested by the existence of associated external tibia torsion.

On the contrary, if increased anteversion is coupled with an external rotation gait, and hyperpressure of the former part of the joint is unchained, the consequences might be the development of a coxarthorsis.

Lerat [48] also studied morphotypes of patellar unbalances, and he proved that although there is a 46% coupling genu valgus, this might also exist in the genu varus. Furthermore, in these patients there is a higher average anteversion (21^0) than in controls (14^0), and external tibia torsion is also higher (41^0) than in controls (34^0), with a femorotibial index of strong values, where tibial torsion is clearly higher in femoral torsion. There was also a higher average TA-GT distance (16.2 mm) than in the control group (12.6 mm).

In his review on effects of torsional abnormalities of the lower limb on the knee, **Grammont** [47] explains that all knees have their flexion axis inwards, thus starting from the basis that all condyles and femoral trochleas look inwards and all tibia tuberosities and feet look outwards.

Furthermore, strong external anatomic tibia torsions associated to femoral anteversions favour a more loaded knee in external dynamic tibia torsion and thus worsens the valgus situation in the braking phase. Talking about anterior tibial tuberosity, due to the fact that external tibia torsion is made in the first four centimetres of the tibia, this is involved as it is moved laterally. In his research on femoropatellar and femorotibial pressures according to the position of the **T.T.A**. he shows that in a normal knee femoropatellar pressure is proportional to the degree of flexion, although the isolated section of the patellar aileron does not present a modification of the requirements. On the other hand, he refers to the rotational characteristics of some internal gonarthrosis **(External Tibia Rotation On The Femur),** when showing a non-uniformly central sclerosis in the internal tibial plateau, despite what happens with genu varus gonarthrosis.

- In his research on the foot, in relation to the rotational alterations of the lower extremities, **Moyen** [(53)] refers to the foot axis as the axis that goes from the centre of the calcaneum to the center of the third toe. He also points out that in exaggerated external tibia torsions, the tendency of the foot is to offset the strong tibia torsion with an inward turns, and through a strong detorsion of the rear-foot and adduction of the front-foot, because the talus has a tendency to go inwards.

The functional morphology is completed in the following way:

- Femorotibial indices of soft torsions **(less than 20^0),** soft external tibia torsion, tendency to the genu varus and flat or normal feet.
- Soft femorotibial indices **(less than 20^0),** strong external tibia torsion, normal or varus knee, and normal or hollow feet.
- Strong femorotibial indices with a strong tibia torsion and soft anteversion, with a tendency to a normal or varus knee, and normal or hollow feet.
- Strong femorotibial indices with a strong tibia torsion and medium anteversion, tendency to observe a normal knee and flat feet.

- **The Cleveland Clinic Foundation**, **Cleveland, Ohio, U.S.A** [(60)]**.** Medial transfer of the tibial tuberosity has been commonly used for treatment of recurrent dislocation of the patella and patellofemoral malalignment. In this study, six fresh human cadaver Knees were used.

Static intra joint loads were recorded **Using Fuji Prescale Pressure-Sensitive Film** for contact pressure and contact area determination in a closed kinetic chain knee testing protocol. Peak pressures, average contact pressures, and contact areas of the patellofemoral and tibiofemoral joints were calculated on native intact knee specimens and after tibial tuberosity transfer. All native intact knee specimens had a normal Q angle. Medialization of the tibial tuberosity significantly increased the patellofemoral contact pressure. Medial displacement of the tibial tuberosity also significantly increased the average contact pressure of the medial tibiofemoral compartment and changed the balance of tibiofemoral joint loading. The results of this study suggested, that caution should be used when transferring a patellar tendon in the face of a preexisting normal Q angle as this will result in abnormally high peak pressure within the tibiofemoral joint. Overmedialization of the tibial tuberosity should be avoided in the varus knee, the knee after medial meniscectomy, and the knee with preexisting degenerative arthritis of the medial compartment.

Mochizuki and Schurman 1979 [(61)] , studied the complications involving the patella following total knee arthroplasty in eighty-six knees in which thirty-four unconstrained and fifty-two offset hinge prostheses had been implanted. The abnormalities that we studied included: patellar dislocation, five knees; subluxation, eighteen knees; localized wear, three knees; and generalized wear, four knees. In twenty-three patients these complications were associated with patellar malalignment, and occurred predominantly when the offset hinge model of prosthesis was used. The complications were attributed partly to mechanical factors inherent in the prosthetic design and partly to anatomical abnormalities. Failure of the surgeon to compensate adequately for both of those factors at the time of operation was a factor in most of the complications.

When talking about derotative tibia osteotomy in an adult, **Segal** [(56)] states that, since tibia torsion alterations take place in the zone between plateaus and the condyle of tibia tuberosity, the perfect place for the osteotomy is the tibial metaphisis. As for the type of osteotomy, the ones that correct both deformities at the same time are the flat-sloping one and the spherical one, although they both have an inconvenience, which is the impossibility to estimate exactly the correction degrees when the two deformities are combined. If a simple derotative osteotomy were performed, one would have to take into account that it has a slight valgus effect. As associated interventions, we find the sectioning of the external patellar aileron, and the fibula osteotomy, when they must be corrected more than 25-30 degrees, the dangers being an oppression at the level of the anterior tibial artery, a paralysis of the external popliteal sciatic or a hard adaptation to the extremity in rotations higher than 30^0.

Regarding the results in derotative osteotomies in adults, **Lerat** [49] states that they are not easy and free of risks, because the morphotype or the rotation degrees are not accurately controlled before the intervention. In such intervention the resulting complications were the paralysis of the external popliteal sciatic nerve, vascular problems **(Artery Compression With Serious Compartment Syndromes And Thrombophlebitis)**, quadriceps paralysis, fibula pseudarthrosis, limitation in bending the knee, posterior internal fomoropatellar syndromes and insufficient osteosynthesis, which originated none, controlled changes.

Referring to the correction of torsional abnormalities in adults, **Lerat** [50] states that they should hardly ever be performed, and that except from patellar instabilities, they are only to be performed when there is a gait abnormality or when they prevent someone from practicing a sport. When valuing the possibility for performing an osteotomy in cases with a high femorotibial index caused by a strong external tibia torsion **(where it would be more logical to perform it),** it is also important to check if the tibia torsion is compensated by the foot, and therefore extracting some degrees to the correction, in order to prevent the foot from doing an internal rotation. Once we are sure that the correction of the foot is possible by means of an osteotomy; it will be only performed from the superior femorotibial indices at 35^0, together with a soft submaleollar detorsion with a hip-foot index of 25^0-30^0.

Real derotative osteotomy is actually very rare. It will be usually associated to a correction on other planes where it was justified. This association makes it difficult for us to see the exact role that every abnormality plays in the origin of arthrosis, although they both probably influence in the creation of rotating arthrosis.

As a summary on torsional abnormalities, **Lerat** [51] concludes that there is no normality in a child if one doesn't take into account the age and the turning circle on a minimum of three years. He says that the femur and tibia morphology are linked to hereditary factors, that the results on femoral derotations are difficult to judge because we don't have enough experience, although they are usually positive on a medium-term. He adds that the definition of EEII morphotype, through torsion femorotibial index, is absolutely necessary to classify and value it, and that one must take into account the set-off created by the submaleollar angle and the global hip-foot index. He also said that the derotation osteotomies are rarely recommended in adults, that a fibula osteotomy may or may not be performed depending upon the possibility to correct the varus-valgus, that the results on these interventions recommend prudence that any patient who will be operated must have previously had a CT, and that there is not enough knowledge in this subject to set any faithful criteria.

In 1985, when talking about the **Elmslie-Trillat Technique,** and after reviewing a series of 100 knees operated with this technique, **Pache** [54] explain that these patients showed an anteversion in the normal femoral neck, a slightly exaggerated femoral torsion, an external tibia torsion and a genu varus, which would usually appear together with a high patella, increasing the pressure in the internal compartment compression, and decreasing the external rotation control mainly in the 30 first knees flexion degrees. They found out that in patents with an internal femoral torsion higher than 30 Degrees, the intervention had negative results. They concluded that the intervention was recommended in patellar habitual dislocations and in painful syndromes of the knee anterior compartment in lower extremities with normal axis. It is not recommended in genu varus, serious external tibia torsion, and in external ligamentous laxitude.

In 1985, Takai [57] measured, by **CT,** the lower extremities rotating alignment in 43 patients with gonarthrosis. He classified them in three groups according to what compartment was affected by gonarthrosis **(Femoropatellar, Internal Femorotibial And External Femorotibial).** He proved that femoral torsion in internal femoropatellar arthrosis was much bigger than internal femoropatellar arthrosis that the leg external torsion in femotopatellar arthrosis increased along with the femoral torsion, causing a compensatory increase of the leg external torsion in the gonarthrosis. He also proved that there is a relationship between the femoral anterversion and the external tibia torsion in the group suffering from femoropatellar arthrosis, the external tibia torsion being 5 degrees less in the internal femorotibial arthrosis than in the control group. He stated that femoral anteversion is not compensated enough by the external tibia torsion, that external tibia torsion and the leg external torsion in the group suffering from internal femorotibial arthrosis had a relationship with the femoral anteversion. He finally concluded by proving that among gonarthrosis aetiological factors the femorotibial angle and femoral torsion should be included.

In 1994, Yagi [59] analysed tibia torsion through CT on 85 patients with internal femorotibial arthrosis and 24 normal knees as control. He studied the angle of the femoral anteversion from both groups, where he did not see any significant differences between the two, the knee joint rotation angle, where there was no significant differences either, and tibia torsion, where the average rate of external tibia torsion in the first group was 11.3 degrees, a value significantly inferior to the one achieved in the control group (23.5 Degrees). He also saw that in 59.6% of the cases, torsion occurred in the tibia proximal metaphisis (In The First 4 cm.). This would explain that not all deformities **(Axial and Torsional)** can be corrected within the same chirurgic time, at a tibia proximal metaphisis level.

In 1986, when talking about exaggerated isolated anterversion of the femoral neck, **Taussig** [(58)] stated that this is the reason why a child's gait has the tendency to go inward. He also proved how important it was to check if compensatory external tibia torsion would appear after six years, with no femoral detorsion. In such case, the supporting foot is placed in the correct axis, but the knee is still on an internal rotation. Anteversion spontaneous correction may not take place in the femur. It can take place six years later through an external tibia torsion, causing the correction of the anteversion. We would then experience isolated external tibia torsion.

In 1988, Podovani and cols [(55)] talk about distinguishing between isolated and idiopathic tibia torsions, in the way they are associated to other diseases. They considered **Somerville Syndrome (1957)** as a different one, where increased external tibia torsion is due to an excessive femoral anteversion. They observed that isolated increased external tibia torsions take place in the proximal tibia quarter, approximately at the age of 10**,** which comes together with a patellar convergent strabismus, when the child puts his feet together. They also observed that there is an increase of the Osgood Slatter effect, an increase of patellar instability in the femoropatellar joint, and an increase of mono and three-compartment arthrosis. They reviewed the treatment with tibial medium subtuberositary osteotomy, with a section in the fibula. They stated that this type of osteotomy is recommended when there is a patellar instability, external tibia torsion higher than 40 degrees, or an internal rotation of 0 degrees.

They recommended the intervention when the torsional deformity is structured and before the apparition of degenerative arthrosis symptoms.

- **In 1992** [46]**, Duparc** continued the research on torsional abnormalities by measuring, through CT, 47 arthrosis knees where the internal compartment was affected. He classified them into three groups, based on **Lerat's research** [44,48]**,** according to the torsional morphotype described as the extremity torsion accumulated index. He then compared all the groups with each other. The results showed that there is a femoral torsion medium value of –16 degrees, with an important degree of dispersion. The tibia torsion is constantly external and has an average rate of 27.7 degrees, the medium femorotibial rotation reached 3 degrees, hip internal rotation reached an average rate of 21.8 degrees and the external rotation was 32 degrees**.** The accumulated torsional index was of an average rate of +11.7 degrees, but it also had an important dispersion **(From –7 to +32 Degrees).** This would show dispersion on the results, even when there was such symmetry among the lower extremities on the same patient. After getting these results, he separated them into **Three Groups :-**

- ***Group of medium torsion accumulated index*** (Considered to be the normal one), with an average rate of +14 degrees. Medium values of femoral torsion and tibia torsion are associated with this group. In the case of arthrosis, the most important factor in this group would be a varus in the frontal plane, according to the mechanical model described by **Maquet** [52]**.**

- ***Group of soft torsion accumulated index* (** Lower than 10 degrees**)**, with an average rate of 1.9 degrees. A strong anteversion and soft external tibia torsion are associated with this group. If the step angle is open, and the hip external rotation increased, the knee gravitational centre moves forward and outwards, improving the global varus axis.

- ***Group of strong torsion accumulated index* (**Higher than 20 degrees**)**, with an average rate of 30.1 degrees. A soft anteversion, a strong external tibia torsion, a knee internal rotation, and a decrease of the hip internal rotation is associated with this group. This is the only group where femorotibial rotation is negative or internal, causing a cartilage shearing when distributing the pressure over tibial plateaus.

They concluded by stating that the torsional accumulated index **(TAI)** allows us to get the joint compensatory angle necessary to get the exact step angle. There are three levels of adaptation: the hip, where external rotation might contribute to open the soft TAI step angle; the knee, where the internal rotation might contribute to decrease the strong TAI step angle; and the submaleollar detorsion.

- To this day, although there has been numerous clinical researches on femoral anteversion, external tibia torsion and Gonarthrosis, since there is an important morphological variety, and it is difficult to do a follow-up on the patients from their childhood to their adulthood, there is no conclusive research.

- It is For This Reason Why, following this scientific movement, we prepared this experimental research.

- Also I would like to say the extensometry is a good method used to measure deformities or abnormal torsional and too is a good method that can be used to continuously measure those tensions to which contact areas in the cadaver patellofemoral articulation are subject to.

Actually, I would like to say we need some simulation models, which could be able to find a procedure for **Normal Muscular Force.**

- The research of patellofemoral stress is a testimony to the exiting progress that has taken place in this field over the last few decades**?** While at the same time it provides a sobering perspective of the complexities of the various mechanisms responsible for the proper functioning of patellofemoral joint and present major challenges that need to be addressed in future research. However they had a lot of time in these methods while there were different methods more accurate and effective.

LOWER EXTREMITIES TORSIONAL DEVELOPMENT.

LOWER EXTREMITIES TORSIONAL DEVELOPMENT.

Always Depending Upon The Lower Extremities Alignment changes that take place during the fetal period, the hip joint in a just-born baby presents a femoral neck anteversion with an average value of 45^0, and a valgus effect of 150^0. The knee presents an inferior varus at 15^0 and the tibia presents a coronal position, which goes from 20^0 of internal rotation to 3^0 of external tibia torsion.

The foot presents an internal rotation with a fore-foot adductor, and it has a submaleollar detorsion angle of around 14^0.

The ulterior development of the lower extremity will cause a progressive reduction of the anteversion and the femoral neck valgus effects, which will reach their final values around 12-14 years of age, valued between $10\text{-}15^0$ and $120\text{-}130^0$ respectively.

In The Hip, the initial varus effect will usually disappear between 6 and 24 months. The physiological valgus phase would then start, being the valgus maximum values around the age have four, and evolving to a normoalignment, which in normal conditions will take place around the ages of 7 to 13.

Internal tibia torsion, if there is any, will experience a detorsion process on the opposite side than the one taking place in the femoral neck, that is on an external sense. This detorsion process takes place especially in the superior tibia epiphisis supratuberositary zone. If there is still internal tibia torsion after the age of 3-4, it will be considered pathologic[62,63,64,65].

The tibia torsion final evolution will end at the age of 12-14. Its normal average rate will be considered around 20-25^{0}.

The foot behaviour on internal rotation and the adduct of the front-foot will disappear progressively during the first few months of life, whereas the sloping angle of the astragal will present a progressive decrease of its value. The submaleollar detorsion angle will decrease from its initial value to around 14^{0} until it reaches an average of 3^{0} in an adult.

No matter the constitutional and/or racial values that shape the effect of elements **(**Articulated Capsule, Muscular Action, Biped Standing, etc**),** in the evolution of different axis, other causes such as the individual's weight, corporal attitudes and the practice of certain sports will also have an influence in the attainment of the final alignment of the extremity.

The frontal plane alignment is perfectly defined both in magnitude and in influence to the deviations, in varus or valgus, in the degenerative pathology or for the overload of the knee articulation.

Tibia Torsion Measurement Methods [66] : There are several methods to measure it, based on the extremity anatomical axis or the angle formed by the femur diaphisis and the tibia axes, with an average value of 7 degrees, or based on the value regarding the extremity mechanical axis, which is represented by the line that links the centre of the femoral head with the centre of the knee and the ankle with the centre of the knee. We should always bear in mind that in physiologic conditions the mechanical axis forms an angle with the 3^{0} vertical. It is also important to trace on the tibia the mechanical tibia angle between the mechanical axes and the line tangent to the tibial plateaus, which in normal conditions must be of 90 degrees.

The deviation of this angle will determine the constitutional tibia varus and valgus. Due to the internal tibia plateau wear or decay, in cases of prolonged genu varus, sometimes it is difficult to find the mechanical tibia angle, since the tangents do not coincide with both tibia plateaus. For this reason, it is recommended to use a proximal epiphyseal axis, defined as the line going between the two tibial spines and the conjunction centre.

- **In The Lateral Plane,** the measurement must be done on a static biped standing position, by calculating the axis angle of the tibia and femur diaphasis, after having checked the patient’s maximum extension of his knees. His normal maximum value cannot exceed **–5 degrees.**

The possibility of experiencing a knee hyperextension or genu recurvatum is an anatomic abnormality, usually associated with a hyperlaxitude, which usually comes with a high patella.

In order to value a high patella, one can use different measurement indices: **The Insall-Salvati Index,** which is one of the most used indices, although it also presents some possibility to error in relation to the contraction state or the relaxation of the quadriceps. It is obtained by calculating the resulting quotient when dividing the patellar tendon longitude by the patellar maximum diameter, which in normal conditions will be between 1.02 and 1.07.

The knee extension defect is usually associated with the degenerative knee pathology or to posttraumatic sequels, although in a teenager it can be associated to an important shortening of ischiotibial musculature.

Any value exceeding 5 degrees will be considered an important femoropatellar joint surcharge.

- **In The Coronal Plane,** the measurement of different alignments, which constitute the lower extremity torsional morphotype, is much more difficult than in other planes previously described.

- **Although Netter’s Manoeuvre** on a child’s hip can prove the magnitude of femoral anteversion, with an error margin of +/- 10%, the application in obese individuals or individuals with degenerative dysfunctions in the hip are not reliable.

Netter's Manoeuvre is carried out by placing the individual on a lying prone position on the examination table with his knee bended at 90 degrees. While the specialist makes the patient's hip rotate internally; he places his hand on the trochanter zone to check in what moment of the rotation a maximum lateralisation takes place. In other words, he checks the prominence of the greater trochanter.

The angle formed by the leg at that precise moment in relation with the examination table plane will be the femoral neck anteversion value.

- **In The Tibia**, the patient's examination, under a sedative state and with his legs hanging on the border of the examination table, allows us to value, in a quite precise way, the axis formed by the bimaleollar line and the knee frontal axis. The end result will constitute an approximate value of the tibia torsion. It is quite difficult to calculate the exact angular values of the lower extremity.

When performing a radiological examination, it is very possible to get a wrong measurement, in relation to the extremity position, by making projections on a plane of a three-dimensional structure. The radiological technique has to be very accurate as for the extremity position during the shot and the direct measurement over a simple x-ray. It is only valid in the knee anteroposterior and lateral axes.

For a simple coronal value radiological examination, an instrumented measurement must be done, using a rigorous radiological technique.

- **The DUNN or DUNLAP's** positioning device in the hip is used to perform an anterioposterior and axial hip projection. The projection values obtained by measuring the Cervicodiaphysiary angle in both planes will be placed in a conversion table, which will provide us with the valgus and femoral neck anterversion real values.

As for the leg, if we obtain a radiography of the lower extremity, having the patient on a sitting position with the knee bended and the foot on the radiograph screen, we will be able to get the tibia torsion direct value, if we have previously used some metal signallers to mark the extremity, in the way shown by **Fernández Sabater.** Both techniques are correctly performed and have little margin of error. They are difficult to perform worldwide because they are difficult to execute.

Through The **Computed Tomography (CT),** and with the possibility to perform various incisions all along the lower extremity, with no additional instrumentation, it is easier to clearly understand the lower extremity real form in the coronal plane [67].

The torsional scanner, although it always has some measurement risks, allows us to do some incisions at an acetabulum level **(** Acetabulum Anteversion **),** femoral neck and femoral condyles **(** Femoral Anteversion **),** tibial supratuberositary tableau and maleollar zone **(** Tibia Torsion **),** and maleollar zone and foot **(** Submaleollar Detorsion **),** independently from other knee measurements, with relation to its extensor apparatus coronal position.

When we get some data from the femoral neck anteversion and the tibia torsion, we will be able to get the femorotibial index, by subtracting both external tibia torsion values to the anteversion of femoral neck which, with an approximate average value of 20, will be very useful to classify torsional groups.

Torsional Morphotype Classification: The possibility of interrelating torsional abnormalities with a degenerative pathology, or a pathology caused by an overload in the lower extremities, demands a previous classification of individuals, in order to make an adequate randomisation of the different series [68].

Always having in mind the difficulty and also the risks of simplifying a schematic classification in a subject where there are so many variables, we propose and have actually used for years the following group **Classification** [69]**:**

Group I - Normal Anteversion and Tibia Torsion.

Group II - Anteversion At **15-30^0** and Tibia Torsion At **35-50^0**.

Group III- Normal Anteversion and Tibia Torsion Bigger Than **35^0** .

Group IV- Anteversion At **15-30^0** and Tibia Torsion Bigger Than **50^0**.

Group V- Normal Anteversion **or < 10^0** and Tibia Torsion Smaller Than **25^0**.

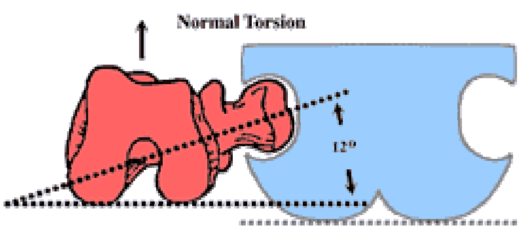
TORSIONS IN THE LOWER EXTREMITY.

TORSIONS IN THE LOWER EXTREMITY.

Torsions of the osseous structure of the lower extremity affect not only the angle of gait but also the function of the foot. The principle torsions of clinical interest are femoral torsion and malleolar torsion. The clinical picture of femoral torsion is complicated by positional **(Soft Tissue)** relationships of the hip. This treatise will describe the normal torsional relationship of the hip first, followed by the positional relationships of the femur to the pelvis, then the abnormal torsional relationships of the femur, and finally the torsion of the tibia. The effects on foot function and gait will be described at the end of the treatise (70).

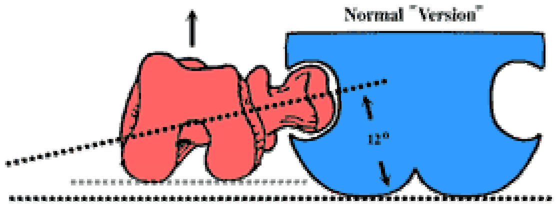
NORMAL TORSION OF THE FEMUR:

In the Normal Adult, the Head and Neck of the Femur are angulated by **12 degrees** relative to the femoral condyles as noted in the illustration below.



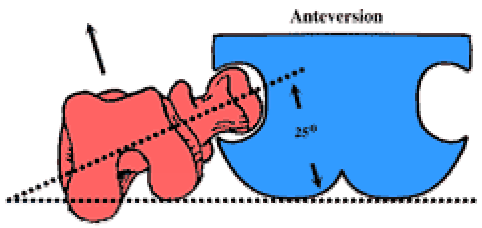
POSITIONAL RELATIONSHIP OF HIP ("VERSION" ANGLES):

In the Normal Adult the Head and Neck of the Femur is angulated approximately12degrees relative to the frontal plane of the body. In other words, the angle of the head and neck of the femur is measure relative to the posterior pelvis? Note that the leg faces straight forward. The gluteal fold is drawn for purposes of orientation only and is obviously not anatomically accurate. This represents a normal femur correctly **"Positioned" into the Acetabulum**. Note that the angle that the head and neck of the femur makes with the femoral condyles are identical to the angle that the head and neck make with the frontal plane of the body.



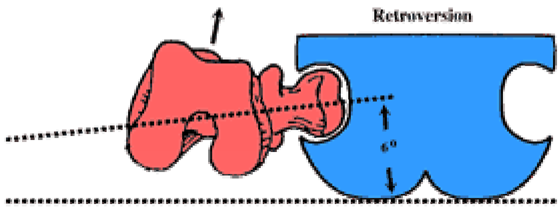
ANTEVERSION:

Is an increase in the angle of the Head and Neck of the Femur relative to the frontal plane of **?** the body. This represents a normal femur abnormally positioned in the acetabulum. The net effect of this positional relationship is an externally rotated leg.



RETROVERSION:

Is a decrease in the angle of the Head and Neck of the Femur relative to the frontal plane of **?** the body. This represents a normal femur that is abnormally positioned relative to the acetabulum. The net effect of this positional relationship is an internally rotated leg.

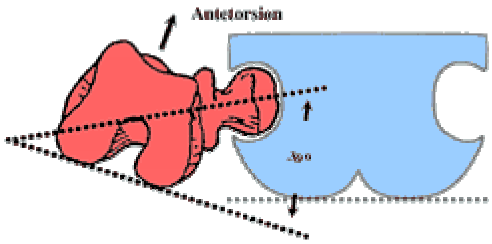


In the three preceding illustrations the angular relationship between the head and neck of the femur and the femoral condyles **(Torsion)** are normal. These three illustrations describe the positions of a normal femur relative to the frontal plane of the pelvis.

In the following description of femoral torsional abnormalities, it is important to understand that the angle that the head and neck of the femur make with the frontal plane of the body is **12 degrees**. In other words the position of the head and neck relative to the pelvis is normal but the torsion within the bone is abnormal.

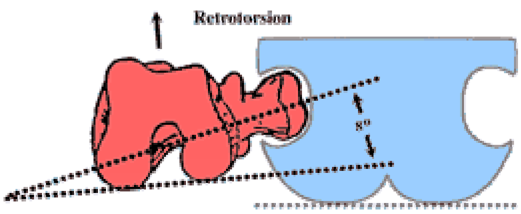
ANTETORSION:

Is an increase in the angle of the Head and Neck of the Femur relative to the femoral**?** condyles as noted below. An angle of **30 degrees** is shown. Note that the angle that the head and neck of the femur make with the frontal plane of the body is normal and therefore Antetorsion results in an internally deviated thigh.

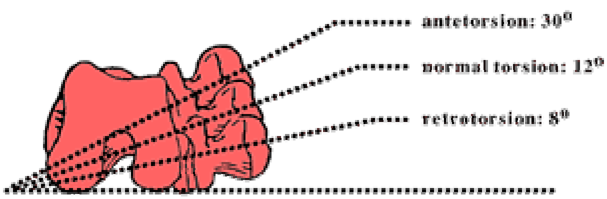


RETROTORSION:

Is a decrease in the angle of the Head and Neck of the Femur relative to the femoral condyles? In the illustration the angle is approximately **8 degrees**. Note that the angle that the head and neck of the femur make with the frontal plane of the body is normal and therefore retrotorsion results in an externally deviated thigh.



For purposes of clarity, the following illustrates the superimposition of normal torsion, retrotorsion, and antetorsion.

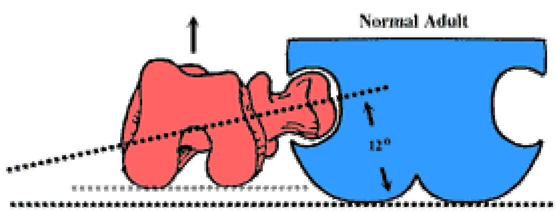


Remember: when speaking of the ***TORSION*** angles, the head and neck of the femur are measured relative to the condyles of the femur. When speaking of the ***VERSION*** angles, the head and neck are measured relative to the frontal plane of the body.

To keep the terminology and concepts without confusion, I suggest the following crutch. If Antetorsion causes and internal rotation of the limb then Retrotorsion will cause an external rotation of the limb. If Antetorson causes an internal deviation and Anteversion will cause the opposite **i.e., External Rotation.**

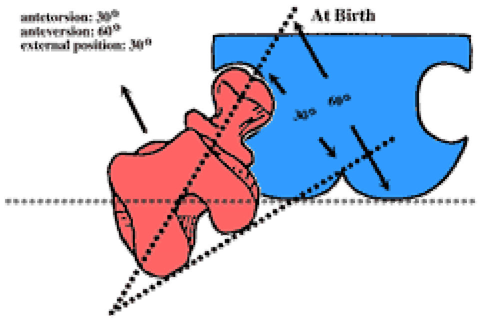
In the Normal Adult, the "***Torsion*"** Angle equals the "***Version***" Angle.

"Torsion"="Version"=12 Degrees.



At birth, the Torsion within the femur and the position of the femur relative to the frontal plane of the body are markedly different from adult values. Examination of the newborn should demonstrate an externally rotated limb by approximately **30 degrees.**

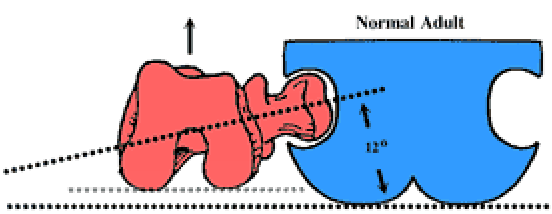
- **Antetorsion = 30 Degrees**
- **Anteversion = 60 Degrees**



The limb is externally rotated because the increase in anteversion is 30 degrees greater than the increase in antetorsion.

From Birth to Adulthood Anteversion decreases from 60 degrees to 12 degrees for a difference of 48 degrees.

Therefore the net effect of this decrease is a positional change of 48 degrees resulting in a less externally deviated limb. At the same time, Antetorsion reduces from 30 degrees to 12 degrees for a difference of 18 degrees. The net effect of this decrease in antetorsion is a structural change resulting is less internal deviation of the limb. These changes usually occur in the first six years of life but may be delayed until adolescence.



Statistically, 95% of abnormal torsion of the femur reduces by adolescence. Between age 6 and adolescence, the presence of an in-toe gait secondary to an internal torsion may indicate a torsional abnormality that may proceed into adulthood or a delay in development. While the clinician may have to wait for adolescence to verify spontaneous reduction, a good clue may be found in the families of the child's parents. The presence of an in-toe gait within the child's adult family is highly suggestive of a true torsional abnormality **(and the limb will not derotate with time)** while the absence of an adult with an in-toe gait within the child's family indicates delayed development and probable spontaneous resolution.

At birth there is no tibial **(** Malleolar **)** torsion but soon develops with weight bearing. Normal adult value for malleolar torsion is 18 to 23 degrees.

A decrease in this value leads to an adducted gait while and increase in this value leads to an Abducted gait.

The position of the foot in the transverse plane **(** Abducted or Adducted **)** is not readily altered by Gait Plates.