Outcome of High Tibial Osteotomy With Limited Internal Fixation in Unicompartmental Osteoarthrosis of knee

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INTRODUCTION

Medial unicompartmental osteoarthrosis of the knee is a degenerative disease with focal areas of damage to load bearing articular cartilage and accompanied by increasing varus deformity. Degenerative changes in articular cartilage of the joint with subsequent new bone formation at articular margins in osteoarthrosis leads to significant problems with mobility and is most common cause of disability in elderly people.

As there is no accurate treatment for osteoarthrosis, the aim of treatment is to reduce pain postponing the progression of degeneration and improve the joint function.

In the active patient with a life expectancy of twenty years or more with unicompartmental osteoarthrosis, high tibial osteotomy is a generally accepted treatment that can result in excellent pain relief and functional improvement.

High tibial osteotomy distributes the stress of weight bearing across the knee more evenly. It relieves excessive pressure. Most patients of symptomatic osteoarthrosis of knee are associated with varus malalignment that is causative or contributory factor to painful arthrosis. It is rational to correct the malalignment to transfer the functional load to the unaffected or less affected compartment of the knee to relieve symptoms.
This study, reports the outcome of high tibial osteotomy in the medial compartment osteoarthrosis of the knee. This study is being done in Balaji Institute of Surgery, Research and Rehabilitation for the Disabled, Trust Hospital, Tirupati.
AIMS OF THE STUDY

1. To evaluate the efficacy of high tibial osteotomy in terms of
   a. Relief of pain
   b. Range of motion and stability of the joint.

2. To determine the efficacy of minimal instrumentation enabling early full weight bear mobilization on second post operative day.

3. To study the effect of early mobilization on correction of the varus angle.
ANATOMY

The knee is a diarthrodial, hinge joint with an intricate mechanical architecture. Compared with the function of the ball-and-socket joint of the hip, knee movement is more complex, with greater definition by bone and ligament anatomy.

Flexion and extension of the knee create a simultaneous internal and external axial rotation of the tibiofemoral joint. When the knee flexes, the tibia rotates internally on the femur, and when the knee extends, the tibia rotates externally. In full extension, the knee locks into a very stable position for the stance phase of walking. This external rotation with extension is produced by both the diverging curvature of the femoral condyles and the winding of the cruciate ligaments around each other.

Bones and articulations

Patellofemoral articulation

A sesmoid bone, the patella has three facets that articulate with the distal femur. When the knee is in full extension, the patella articulates with the suprapatellar pouch; in 10° to 20° flexion, the patella articulates with the hyaline cartilage of the most proximal aspect of the femoral trochlea,
the groove between the femoral condyles in which the patella tracks when the knee is extended and flexed. In midflexion range, the articulation is at the medial and lateral facets, and in hyper flexion, at the peripheral portions of the medial and lateral facets as well as the odd facet.

The patella not only protects the femoral condyles against a direct blow, it increases the rotational force of the quadriceps mechanism. As the force across the patellofemoral joint increases with knee flexion, the patella is pressed against the distal femur.

To offset this stress on the patella, the area of contact between the patella and the femur increases during flexion, creating a fairly uniform distribution of stress as the knee flexes from 0° to 90°. During stair climbing, the forces on the patellofemoral joint can increase up to 3.5 times body weight.
Tibiofemoral articulation

The distal femur has two condyles of different sizes and curvatures. The v-shaped femoral trochlea between them articulates with the patella. The cruciate ligaments are located in the intercondylar notch. The epicondyles, small protuberances on the femoral condyles, are the sites of origin of the collateral ligaments of the knee.

In contrast to the convex femoral condyles, the articulating surface of the proximal tibia is concave medially and convex or flat laterally. The anterior cruciate ligament inserts into the anterior part of the tibial eminence (or tibial spine); the insertion of the posterior cruciate ligament is into the posterior part of the tibial plateau.

The tibia articulates with the fibula separately from the knee joint. The fibula serves as the insertion site of the lateral collateral ligament and biceps femoris tendon.

Compartments

Functionally, the knee joint can be divided into three compartments: patellofemoral, medial tibiofemoral, and lateral tibiofemoral. These compartments, defined anatomically by the articulation of the bones, are contained within the same joint capsule and thus are in continuity. The compartments of the knee are made up of three interconnected joint spaces. The compartmentalization describes the articulations between opposing
cartilage surfaces - two tibiofemoral articulations and one patellofemoral articulation.

The patellofemoral compartment, formed by the patella and the femoral trochlea, is located on the anterior aspect of the knee and is easily localized by moving the patella over the femoral trochlea. The medial tibiofemoral compartment comprises the medial femoral condyle (plateau), the medial meniscus, and the concave medial tibial condyle. This compartment is located on the medial aspect of the knee, and the medial joint line between the femur and tibia can be palpated when the knee is either flexed or extended. The lateral tibiofemoral compartment includes the lateral femoral condyle, the lateral meniscus, and the flat lateral tibial plateau. Located lateral to the midline of the limb, it encompasses the lateral half of the knee joint. The fibula, although not a part of the lateral tibiofemoral compartment, is easily palpated distal to the joint line.

**Femoro-tibial surfaces:**

Femoral condyles are described as “cam-shaped” in lateral profile. Their cross-section is generally oval, being described as part of a helix. However, the posterior part, the part that meets the tibia in deep flexion is circular. Medial condyle has a larger radius of curvature than the lateral. Medial compartment is concave and stabilised on weight bearing. It also extends distal to the lateral on anteroposterior view. Lateral condyle may
be smaller, but projects further anteriorly to act as a buttress against lateral patellar dislocation. In contrast to the medial condyle, the anterior part of the lateral condyle is rather flat and is in contact with the anterior horn and the anterior part of the tibial articular surface in full extension. Lateral compartment is less stable compared to the medial one.

Tibial plateau has a 30° lateral inclination and 90° of posterior slope. Medial tibial plateau is posteriorly flat where it is in contact with flat posterior horn of the menisci and the posterior femoral facet. Anteriorly it slopes upwards and forwards. Here, the anterior part meets the anterior circular facet of the femur in extension. Lateral tibial plateau is centrally flat but curves downwards in front and behind to provide area for the menisci. Contact area of medial plateau is 50% larger than the lateral one and sustains higher forces than the lateral. Tibio-femoral contact is made more congruous by the presence of the menisci. Between the two articular surfaces is the intercondylar eminence. It is like a raised inverted cone. The eminence is the pivot around which the femur rotates. It is straight medially and convex laterally; suggesting that as the condyles move around the eminence, medial condyle translates in a straight line, while the lateral condyle has a somewhat curved excursion.
Menisci

The menisci are semi lunar cartilages with very important functions in the knee. The medial meniscus is three-fifths of a ring and is well attached at its periphery and at both anterior and posterior horns. In cross section, the medial meniscus is wedge shaped, and only the outer third of its periphery is well vascularized. This anatomic detail is of great clinical significance because that portion of the meniscus has the potential to heal after injury.

The lateral meniscus also has only peripheral vascularity; however, there is a peripheral avascular zone in the area of the popliteus tendon hiatus. The shape of the meniscus has significant functional importance. The superior surface of the lateral meniscus is concave and conforms to the surface of the femur; on the inferior aspect, it is flat matching the tibial surface. The lateral meniscus is more mobile than the medial meniscus; this may make it less vulnerable to tearing.

The menisci function in both force transmission and knee joint stability. The convex femoral condyle articulates with the flatter tibial plateau. Without the menisci, the contact area between the femur and the tibia is very distinct and small. Intact menisci provide the femur and tibia with a larger contact area, thereby providing a larger surface area of support for each unit of force transmitted through the knee joint. A functional meniscus decreases stress concentration. This dampening, or shock distribution, protects the hyaline cartilage surfaces of the knee.
The menisci also function as secondary stabilizers by preventing abnormal motion between the tibia and femur, thus stabilizing the knee joint. Abnormal movement is a particular problem in a knee with a stretched or ruptured anterior cruciate ligament; removal of menisci increases overall anterior movement of the tibia in relation to the femur in the presence of anterior cruciate ligament deficiency. Thus, the menisci both protect the hyaline cartilage by dampening force and contribute to joint stability.

**Ligaments**

The anatomy of the ligaments and joint capsule of the knee is fairly straightforward. The ligaments of the knee are either cruciate or collateral structures.

**Cruciate ligaments**

The anterior and posterior cruciate ligaments are cordlike structures coursing through the middle of the knee in the intercondylar notch the
anterior cruciate ligament originates from the poster medial portion of the lateral femoral condyle and inserts into the anterior aspect of the tibial spine. The posterior cruciate ligament originates from the anterolateral aspect of the medial femoral condyle and, crossing behind the anterior cruciate ligament, inserts into the posterior surface of the tibial spine, inferior to the joint line. The anterior cruciate ligament prevents anterior movement of the tibia on the femur. The primary function of the posterior cruciate ligament is to prevent straight posterior displacement of the tibia on the femur. Both cruciate ligaments function secondarily as internal collateral ligaments, preventing varus and valgus rotation of the knee.

**Collateral ligaments**

The joint capsule is divided into two hemispheres (medial and lateral), which are further split into thirds. Each third is named for the location of its insertion into the tibia (anterior, middle and posterior). The capsule spans and surrounds the joint from the femur to the tibia. The middle medial part of the joint capsule is usually described as the deep medial collateral ligament, the posterior medial third is the posterior oblique ligament, and the posterior lateral third of the lateral knee is called the arcate ligament.
The medial collateral ligament comprises both superficial and deep portions. The superficial part (also called the tibial collateral ligament) takes its origin from the medial femoral epicondyle and inserts into the tibia about 4 cm below the tibiofemoral joint line. The superficial tibial collateral ligament provides about 80% of the resistance to valgus force. The deep medial collateral ligament, the middle third of the knee joint capsule, secures the medial meniscus to both the tibia and femur and plays a lesser role in resisting valgus forces.

The lateral (fibular) collateral ligament is a discrete, cord like structure originating from the lateral femoral epicondyle and inserting into the fibular head. The lateral collateral ligament provides about 70% of the overall resistance to varus stresses on the knee.

**Muscles and tendons**

The muscles of the knee joint can be described as either extensors or flexors. The main extensor of the knee is the quadriceps femoris muscle; flexion is provided by the posterior thigh muscles, the hamstrings.

**Iliotibial tract**

The iliotibial tract, the posterior third of the iliotibial band, inserts proximally into the lateral epicondyle of the femur and distally into the lateral tibial tubercle (Gerdy’s tubercle). It thus forms an additional
ligament that is contiguous anteriorly with the vastus lateralis and posteriorly with the biceps. The iliotibial band moves forward in extension and backward in flexion but is tense in both positions.

**Quadriceps femoris muscle**

Extension is executed primarily by the quadriceps femoris muscle, which is made up of the rectus femoris muscle, vastus intermedius, vastus medialis, and vastus lateralis. These four muscles converge at the quadriceps femoris tendon, which inserts into the patella; the quadriceps femoris tendon continues distally to join the patella to the tibia, where it becomes the patellar ligament. For optimal knee function, the quadriceps group (especially the vastus medialis) must be strong. The extensor mechanism is balanced to allow tracking of the patella in the femoral trochlea, or groove. When this delicate balance is disrupted the patella does not track properly in the femoral trochlea, and knee symptoms of instability and pain occur.

A line drawn from the anterior superior iliac spine through the patella intersects with a line drawn vertically from the tibial tuberosity through the midpoint of the patella. The angle formed is called the quadriceps (q) angle. Valgus deformity of the knee, external rotation of the tibia, and tibial tuberosity in a more lateral position of the knee all increase the q angle. The larger the q angle, the greater is the resultant vector...
tending to displace the patella laterally. Extensor mechanism alignment is regulated by four factors: (1) q angle, (2) Medial restraints (joint capsule and oblique portion of the vastus medialis), (3) Lateral restraints (joint capsule and oblique portion of the vastus lateralis), and (4) Bony architecture (femoral trochlea and patella).

**Hamstrings**

Four muscles - semitendinosus, semimembranosus, and the two heads of the biceps femoris - flex the knee; collectively, they are called the hamstrings the pes anserinus is the common tendinous insertion of the Sartorius, gracilis, and semitendinosus muscles.

**Popliteus and gastrocnemius muscles**

Originating on the posterior portion of the tibia, the popliteus muscle wraps around the posterolateral aspect of the tibia to insert into the lateral femoral epicondyle. It provides a rotational force to the tibia on the femur as well as resistance against posterior movement of the tibia on the femur. The medial and lateral heads of the gastrocnemius muscle originate from the posterior aspect of the femur and also flex the knee.

**Neurovascular structures**

The nerves and blood vessels surrounding the knee are intricate and vulnerable to injury. The popliteal artery, firmly attached at the adductor
hiatus, dives into the leg under the soleus muscle where the artery is also securely fixed. Any injury to the knee, especially a dislocation or fracture of the femur or tibia, can damage the artery, either by direct laceration or puncture or by stretching of the vessel away from the points of firm attachment.

The tibial and peroneal nerves traverse the posterior aspect of the knee and may also be stretched by fractures or dislocations around the knee. The peroneal nerve is injured more often than the tibial nerve.

The middle geniculate artery provides the intraarticular cruciate ligaments with a rich blood supply. Sensory innervation to both cruciate ligaments accompanies the vascular supply.

**Normal biomechanics of the knee joint**

The knee is classified as a diarthrodial or freely mobile joint of the ginglymus or hinge type. Kinematic studies have shown that complex series of movements about variable axes and in three separate planes occur during the course of normal gait cycle. Flexion and extension do not occur about a fixed transverse axis of rotation but about a constantly changing center of rotation, polycentric rotation, describing a j shaped curve about the formal condyles. Flexion and extension of the knee occur by both rolling motion and gliding motion between the femoral and tibial condyles,
in the sagittal plane. Abduction and adduction occurs in the coronal plane and internal and external rotation occurs in the transverse plane.

The knee joint is stabilized by the dynamic action of muscles crossing the joint, by the ligaments and their structural arrangements, shape of the articular surfaces and other soft tissue about the knee.

**Tibiofemoral alignment**

A line drawn along the femoral shaft is a useful reference for measuring overall tibiofemoral alignment. A line drawn parallel to the surface of the femoral condyles shows that a distal femur angles $6^\circ$ to $8^\circ$ valgus relative to the femoral shaft; thus, the normal femoral shaft is not parallel to the tibial shaft. Rather, the tibia has a slight valgus orientation in relation to the femur. The exact degree of valgus varies among individuals. Genu varum, an abnormality of tibiofemoral alignment in which the distal tibia is angulated closer to the midline, creates the appearance of bowleg. In Genu valgum the distal tibia is farther away from the midline than normal, giving the appearance of knock-knee.
Tibiofemoral alignment is extremely important in balancing the force vector between the medial and lateral tibiofemoral compartments during weight bearing. In a knee with normal anatomic alignment, weight bearing is equally distributed between the two tibiofemoral compartments. However, a varus or valgus malalignment distributes weight unequally to the medial or lateral compartment. Increased weight bearing in one compartment can lead to permanent cartilage degeneration and early osteoarthritis. The degeneration of the cartilage further worsens the malalignment as the normal joint surface is worn away. With advancing osteoarthritis and increasing malalignment, the bone is deformed and osteophytes (bone spurs) develop.
Tibiofemoral alignment is also an important consideration in total knee joint replacement. Any malalignment must be corrected because a residual imbalance can cause early loosening of the prosthetic components.

**Menisci**

Medial meniscus provides greater restraint to anterior translation. Lateral meniscus is more mobile and the popliteus tendon guides its movement. Medial meniscus is more constrained and more prone to injury. They also help in shock absorption. Menisci can transmit up to 50% of compressive load in extension and 90% in flexion. Medial meniscectomy can decrease contact area by 70%.

**The collateral ligaments:**

Provide side-side stability. Medial collateral ligament is assisted by contraction of pes anserinus. Lateral collateral ligament is assisted by iliotibial tract, tensed by tensor fasciae latae. They are taut in extension and
lax in flexion. Superficial part is the more important contributor to stability. But if the deep part is cut keeping the superficial part intact, then there is very little laxity. Postero-medial capsule gets tight with increasing extension of the knee and provides some stability. Medial collateral ligament becomes important to stability with increased flexion. Lateral collateral ligament resists half of varus load in full extension and is the primary restraint to varus load in range if motion of flexion. Lateral collateral ligament is tight in extension and get increasingly lax at more than 30\(^{0}\) of flexion. With increasing flexion, biceps femoris provides continuous tension to lateral collateral ligament and helps to maintain its role as a stabiliser against varus load.

**The cruciates:**

Anterior cruciate ligament: although a single ligament, it is arranged into distinct bands. It has antero-medial and postero-lateral bands, named from their tibial origins. Antero-medial band is taut in flexion; the postero-lateral band is taut in extension. The bands change in length through knee movement. Both anatomically and functionally, the ligament is a collection of distinct bands and is never truly isometric. It is flat in extension, but twists 90\(^{0}\) on itself on increasing flexion. The ligament becomes more horizontal with flexion and acts as a primary restraint to anterior tibial translation. It also acts as a secondary restraint to internal rotation,
varus/valgus strain and hyperextension. Apart from anterior translation of tibia, anterior cruciate ligament deficiency also results in loss of roll-glide mechanism at the joint.

posterior cruciate ligament: it is also arranged in two bands- antero-lateral and postero-medial. No part of posterior cruciate ligament is truly isometric during range of motion. It is a primary restraint to post translation of the tibia on the femur and secondary restraint to varus/valgus and external rotation. It causes couples external rotation of tibia during posterior translation.  Anterior cruciate ligament and posterior cruciate ligament are commonly described as being analogous to a crossed 4 bar linkage system. It accounts for the changing roll-glide ratio with knee movement.
Roll-glide: roll-glide is the fundamental movement of the articular surfaces. Example of roll is a car tyre rolling on road, glide is a tyre slipping. Because of the complementary concave and convex shape of the articular surfaces, roll and glide occurs simultaneously, in opposite and same direction. It helps prevent subluxation and impingement of the opposing articular surfaces. Rolling initiates’ flexion, gliding occurs with final flexion reverses in knee flexion from full extension to 20 degrees of flexion.
Popliteus complex consists of a dynamic component, which is the popliteus muscle and a static complex, which are the popliteal ligamentous complex. It originated from posteromedial part of tibia and is directed obliquely outwards to lateral femoral condyle. It is unique in being the only structure positioned obliquely across the postero-lateral corner of the knee and is well suited to prevent tibial external rotation with increasing knee flexion. Its fibers are tensed by tibial external rotation. Sectioning of popliteus results in marked increase of tibial external rotation in 90º flexion.

Popliteus is active in screw-home mechanism in terminal knee extension it initiates knee flexion by unscrewing the locked knee it also retracts the lateral meniscus popliteofibular ligament is an important restraint to tibial external rotation at all range of flexion.
Knee range of motion can be divided into three distinct stages. Between 0-20° is the range of “screw home movement”. 20°-120° is the active functional range of movement. Between 120°-160° is the range of arc of passive flexion. These three different arcs of movement have differing kinematics properties. Knee flexes about 20° during stance phase, increasing to maximum 60° during swing phase for foot clearance. Flexion up to 120° is used for stair climbing and getting off chairs. In this active range longitudinal rotation of tibia can occur independent of flexion and vice-versa. Flexion beyond 120° is passive. The knee gets subluxated; femoral condyles lose contact with tibial surface and are in contact with posterior horn of the menisci.

Recent MRI evidence would suggest that the medial femoro-tibial articular surface is somewhat congruent to allow any effective sliding and as such the medial condyle can only rotate like the ball in a socket and produce flexion and longitudinal rotation. On the other hand, as the lateral surface is comparatively flat, it allows the lateral condyle to roll and slide (Martelli and Pinskerova, 2002).

It is now felt that the medial condyle flexes and rotates longitudinally, whereas the lateral condyle undergoes both roll and glide. The medial tibio-femoral contact area transfers from anterior to posterior through increasing flexion.
The joint reaction force shifts from medial to lateral throughout the gait cycle. Medial plateau sustains the force in stance phase when the force is the highest.

**Joint reaction force**

Femoral axis runs infero-medially. So, the applied force $f$ on tibia has a vertical component $v$ and a horizontal component. The horizontal component is resisted by the medial soft tissue constraints. If there was no medial soft tissue balance, then the femur would tilt medially (broken blue femur).
BIOMECHANICS OF THE KNEE JOINT IN OSTEOARTHRITIS

Medial compartment knee biomechanics

During normal daily activities, a load of two to four times body weight crosses the knee joint. In the normal knee, approximately two-thirds of this load passes through the medial compartment.

The degree of varus (bowing) present in a knee joint is a combination of the geometric alignment of the femur and tibial (congenital), and the degree of narrowing in the medial compartment (due to loss of cartilage and/or bone), and/or widening of the other joint space compartments (due to ligament laxity or injury to other soft tissue structures). These alterations in the joint alignment may result from injury, surgical removal of the medial meniscus and/or degenerative changes, and, if the knee is predisposed, will accelerate the development of arthritis of the medial knee joint. Greater the degree of varus alignment, greater is the load across medial compartment and the potential for development of degenerative changes. The presence of Medial compartment arthritis will further alter the knee alignment and redistribute the weight-bearing load to the affected compartment. This may accelerate the degenerative process, and cause pain.
Meniscus

With the non conforming surface and increased motion of the knee, wear of the cartilage surface become a problem, and here menisci function to decrease the load. The menisci, with the medial larger than the lateral, have only a slight role in the stability of the knee joint and their major role appears to be weight bearing\textsuperscript{44}. While the stress support by the meniscus is low, the contact area is high; therefore, it is estimated that half of the total force across the knee is born by the meniscus.

A complete meniscectomy would double the load across a single condyle. Distribution of the force is also narrowed (increasing stress) and increased wear of the cartilage can occur.

Sub chondral bone

The calcified cartilage sits on a thin subchondral plate of bone that rests on an area of spongy or cellular bone. The deformation of the subchondral bone is responsible for maximal joint fit under high loads. A low frequency of micro fractures of the cancellous subchondral bone occurs physiologically. Over straining may result in micro fractures, which heals with an increase in the volume of fracture material and a stiffening of the subchondral bone. This leads to extra load on the articular cartilage.
Hyaline cartilage

Opposing surfaces of hyaline cartilage of the knee joint are virtually friction free cartilage is smooth, soft and viscoelastic. Viscoelastic materials are those that display creep and stress relaxation. Creep is the deformation over time in response to a constant load. Stress relaxation occurs when an enforced deformation is placed on a viscoelastic material; initially, high stress results, which in time, decreases, these properties allow cartilage to attenuate joint peak forces and aid in the lubrication of the diarthrodial joint. Lubrication in the joints is in the form of a thin film and a boundary layer type performed by the glycoprotein lubricin found adherent to the articular surfaces. The thin film lubrication implies the trapping of a fluid film between the articular surfaces. When the surfaces move relative to each other, the formation and maintenance of this film is called "hydrodynamic lubrication". Deformable and permeable surfaces such as cartilage exhibits elastohydrodynamic lubrication. The deformation, with load and motion, of the cartilage surfaces causes fluid to flow out of the cartilage ahead of the contact area and also entraps the fluid between the surfaces. Fluid is absorbed in the cartilage surface behind the area of contact
ETIOPATHOGENESIS

Etiology:

The etiological factors in osteoarthritis are geography, racial groups, age, and gender, socioeconomic groups, occupation, obesity, metabolic, mechanical factors. Age is the most consistently associated factor with osteoarthritis the reasons being loss of mechanical resistance of ageing cartilage, due to a defect in stabilizing components of the matrix. Mechanical stress such as single impact stress, gross anatomical damage, subtle mechanical derangement, joint hyper mobility and repeated impacts are associated with osteoarthritis

Pathogenesis

\[
\text{Physical force} \quad \Downarrow \\
\text{Cartilage disruption} \quad \Downarrow \\
\text{Chondrocytes breakdown} \quad \Downarrow \\
\text{Enzymatic secretion} \quad \Downarrow \\
\text{Destruction}
\]
Overload
\[\downarrow\]
Subchondral fracture
\[\downarrow\]
Repair of fracture
\[\downarrow\]
Increase stiffness
\[\downarrow\]
Decrease shock absorbing

**Cartilage degeneration cartilage repair**

- Increased stress on cartilage
  - Cartilage erosion
  - Micro fracture subchondral bone stiffening
- Chondrocyte injury
  - Release of degradative enzymes
  - Matrix degradation
  - Chondrocyte stimulation
- Chondrocyte proliferation
  - Increased proteoglycan and collagen synthesis

- Loss of cartilage elasticity
Pre clinical stage

- Change in cartilage collagen framework
- Change in cartilage proteoglycans synthesis
- Enzymatic degradation of cartilage
- Crystal deposition of cartilage

**Collagen changes**

- Disturbance in cartilage bone interface
- Change in subchondral bone resilience
- Defect in synovial fluid

![Diagram of collagen changes](image)
Intermediate staging

- Fibrillation
- Horizontal splitting at interface between uncalcified and calcified zone shear damage
- Cartilage thinning from grinding due to abrasive wear

Late stage

- Calcified tissue exposed on joint surface
- Micro trauma at subarticular surface leads to synovial seeping leading to cyst formation
- Destruction of bony tissue, loss of height and trabecular collapse
- Outgrowth of new bone can extend beyond the original perimeter of articular surface giving lipping.
- New bone covered by fibrous and chondroid tissue

Synovial and capsular changes

- Acute synovitis due to debris released from joint/cartilage degeneration
- Chemical products, bone, hydroxyapatite crystals
Cysts

Lendells\textsuperscript{28} states that a cyst arises in the following manner: fracture of the terminal bone lamella, occurs due to overloading and as the joint moves, the synovial fluid under pressure is forced into the cancellous bone whose trabeculae becomes relatively weak. Their breakdown produces a cystic cavity. Later the stroma through which the cyst communicates with the articular cavity gets blocked by connective tissue bone or the fibrin plug. This stoppage terminates the process and the cyst spreads no further.

Trias\textsuperscript{40} states that the formation of cyst phenomena in healthy individual joints is by overloading.

Ondrouch\textsuperscript{35} objects Landell’s theory of cyst formation. He states that in every healthy joint there exist physiological defects of the terminal lamella that do not lead to the formation of cysts. How a simultaneous breakage of the terminal lamellae at opposite points on either side of a joint can occur so often, he found it difficult to explain one, the formation of some pump like one-way valvular system to magnify and direct the pressure in the direction was postulated, second, how the pressure which caused the trabeculae to breakdown would not damage the soft fibrin of the plug or impede the formation of connective tissue or bone. Ondrouch states that photo-elasticity investigations disclose on overburdening of the bone beneath the surface of the joint, which in turn resembles the shape of cysts.
Johnson (1959) described that in the formation of subchondral cysts, there is initially an edema in the subchondral marrow followed by formation of a mucinous fatty marrow and dilatation of surrounding sinusoids. There is mucoid secretion within the centre of this area and the expansion of the cyst cavities by osteoclastic resorption of bony trabeculae. Surrounding this there is some osteoblastic response and a sclerotic wall is found (mercer).

**Osteophytes**

Harrison Trueta and Schajowicz reports that following the degeneration and reduction in the depth of the noncalcified part of the cartilage, the calcified zone increases in thickness. Calcification moves surface wards into the radial zone of non calcified cartilage. Now the subchondral blood vessels enter the calcified Cartilage and progress parallel to the joint surface, preceded usually by calcification. A layer of fibro cartilage in varying degrees of degeneration covers the vascular marrow and the newly formed bone: these tissues lay down at the expense of the degenerative cartilage forms the osteophytes.

The earliest osteophytes are formed at the junction of articular cartilage and synovial membrane. The osteophyte formation is limited to any area of low joint stress and can be better termed as "marginal" structures. Harrison et al, therefore did not consider osteophytes the
resultants of various mechanical stimuli which occurs at the junction of the articular cartilage and synovial membrane (Bennett and Bauer 1937) or in any way secondary to articular cartilage degeneration occurring more centrally (fisher 1922 and Bennett et al 1942) 13.

Johnson described osteoarthrosis as occurring at local sites of excessive cartilage abuse, which undergoes proliferation in some areas to produce overgrowth on the surface and shedding of cartilage in other areas to give 'eburnation" of the underlying bone. The exposed bone ends of the articular surface are subjected to considerable friction, in consequence the bone trabeculae in the immediate neighborhood are thickened and the marrow space obliterated. The change involves only a thin layer abutting on the joint and when the surface of this layer gradually becomes more and more smooth and polished as a result of continual rubbing, the process is known as “eburnation" sclerosis at the subchondral region is partly due to osteophytes viewed "end on" and partly to the presence of increased bone per unit volume of cancellous tissue in the involved joint and due to callus formation uniting the micro fracture. The fibrous tissue of the capsule becomes dense and as its point of attachment to the articular margin, may be transformed into fibro or hyaline cartilage. In some cases bony nodules appear under the surface of the synovial membrane and project into the joint cavity. These nodules may be sessile or pedunculated, in the latter
event they may break loose to form" joint mice" and may lead to lock of the joint (mercer).

Aging is often associated with osteoarthrosis and is due to loss of self replicating capacity of the chondrocytes, or in terms of physicochemical changes in the matrix taking place independently of cell functions. Osteonecrosis as a feature of osteoarthrosis is increasingly being recognized. The association of Osteonecrosis with micro fractures may give evidence for the necrosis being a secondary phenomenon: in others fractures are not evident and other vascular insult with arterial occlusion may be the reason. This is important because of the concept that osteoarthrosis is not primarily a disorder of cartilage but the consequence of repetitive micro fractures sustained by bone during heavy loading. Obese people are often associated with osteoarthrosis and Radin in a study reports that 80% of his patients with osteoarthrosis were obese. The role played by malalignment and meniscus in osteoarthrosis are mentioned in the biomechanics of the knee joint.
## Radiographic – pathologic correlation

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Radiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartilage fibrillation and erosion</td>
<td>Localized decrease in joint space</td>
</tr>
<tr>
<td>Increase cellularity/ hypervascularity</td>
<td>Bony eburnation</td>
</tr>
<tr>
<td>Synovial seeping/ bony contusion</td>
<td>Subchondral cysts</td>
</tr>
<tr>
<td>Revascularization of cartilage</td>
<td>Osteophytes</td>
</tr>
<tr>
<td>And capsular traction</td>
<td></td>
</tr>
<tr>
<td>Compression of weakened and deformed cartilage</td>
<td>Bony collapse</td>
</tr>
<tr>
<td>Fragmentation of osteochondral fragments Disruption</td>
<td>Intraarticular loose bodies</td>
</tr>
<tr>
<td>and distortion of capsular and ligamentous structures</td>
<td>Deformity and malalignment</td>
</tr>
</tbody>
</table>
Biochemical factors in osteoarthrosis

The articular cartilage is hyper hydrated tissue with water content being 60% to 80% of the total wet weight. The remaining 20% to 30% of the wet weight of the tissue is mainly due to two macromolecular materials: collagen which forms 60% of the dry weight and proteoglycans, which represents most of the remaining weight. The water content is highest at birth, with slight decrease in adult tissues and a further diminution with advanced age. An increase in total water content is noted with immobilization, with denervation and with joint motion without weight bearing.15

Proteoglycans are macromolecules that consist of a linear protein core to which are linked long chain polysaccharide moieties called Glycosaminoglycans. The Glycosaminoglycans molecules consists of long chain, these are chondroitin 4 sulfate, chondroitin 6 sulfate and keratin sulfate. The chondroitin sulfates are the most prevalent Glycosaminoglycans in cartilage

Biochemical changes in articular cartilage in osteoarthrosis
The alteration found is as follows16

1. A change in morphology, chemistry and rate of synthesis of collagen without much alteration in total concentration
2. An increase in total water content and water binding capacity.
3. An increase in the number of cells and rate of cell proliferation, which is parallel to the severity of the disease up to a point of 'failure'.
4. A decrease in the quantity of proteoglycans, which parallels the severity of the disease.
5. An increase in the concentration of lysosomal enzymes in direct proportionality to the severity of the process.

**History, development and types of osteotomies**

Wardle reported that tibial osteotomy distal to the tubercle for degenerative arthritis was practiced in Liverpool since the time of Sir Robert Jones. Osteotomy through the upper end of the tibia was originally used to correct valgus and varus deformities of the knee caused by rickets and poliomyelitis. In 1958, Jackson first reported the results of upper tibial osteotomy in patients with osteoarthritis of the knee. Six supracondylar osteotomies and eight upper tibial osteotomies were done. There was greater restriction of movements after supracondylar osteotomy, hence tibial osteotomy was preferred. Jackson and Waugh reported the results of a dome type of osteotomy done just below the tibial tubercle in 1961. They immobilized the knee in a plaster cast.

In 1962, Venemans reported the results of 40 tibial osteotomies done immediately below or distal to the tibial tuberosity in 34 patients and immobilized by skeletal pins of the Roger Anderson type. At eight weeks
pins were removed and walking plaster was applied. The majority gave improvement.

Dawson\textsuperscript{9} in 1965 did the osteotomy 1.5 centimeters from the articular surface. He advocated osteotomy of the fibula if there is varus deformity. Gunn\textsuperscript{12} in 1966 reported high tibial osteotomy but it was done at the level of the tibial tubercle or lower.

Jackson and waugh\textsuperscript{21} later modified their previous technique by using four pins with compression for 6 weeks, but the osteotomy was still below the tibial tubercle. Jackson and waugh\textsuperscript{23} reported a curved osteotomy, convex upwards, at the level of tibial tuberosity and the fibula was divided initially through a separate incision. Jackson, Waugh and green\textsuperscript{22} performed the osteotomy above the tubercle and fixed the fragments with staples.

Coventry \textsuperscript{4,5} advised tibial osteotomy to be done after flexing the knee to, 45° degrees to allow popliteal and peroneal structures to be relaxed. He excised the head of the fibula had osteotomy with stepped staples. Plaster cylinder was used and early weight bearing allowed. He noted one peroneal nerve palsy from pressure.

In 1967, Wiley described high curved tibial osteotomy after clearance of osteophytes or synovectomy of the knee. The osteotomy was fixed internally either with a long single screw or a special nail plate. A
plaster cylinder was used for two weeks but weight bearing was allowed after eight weeks.

Judet described a modified method of oblique osteotomy done proximal to the tibial tuberosity from the lateral side up to medial cortical bone of the medial side and fixed with staples\textsuperscript{30}. In 1973 Levy et al\textsuperscript{3} reported an inverted 'v' osteotomy of the tibia with the apex of the 'v' being proximal to the tibial tuberosity under the patellar ligament. The advantages claimed are that it is simple, safe with no necessity to identify the peroneal nerve or prolong the operating time and early weight bearing is allowed.

Maquet\textsuperscript{33} reported barrel vault osteotomy on forty one patients, done proximal to the tibial tuberosity and aimed at over correcting the deformity and at displacing forward the tibial tuberosity. Charnley's compression clamps were used. Immediate post operative mobilization was started. The advantages claimed are that the osteotomy heals much faster and permits simultaneous anterior displacement of the patellar tendon while correcting the angular deformity and also prevents abnormal bulge below the knee.

Slocum\textsuperscript{38} reported a lateral closing wedge type of high tibial osteotomy where through a transverse skin incision; the fibular head is partially or completely curetted out preserving a thin shell of bone. The tibia is osteotomised leaving a thin lip of bone attached to the back of the
proximal segment. The osteotomy is closed permitting the posterior lip of bone above, to override the bone distal to the osteotomy. He claims that this type of osteotomy is more stable.

Sundaram et al.\textsuperscript{39} reported dome osteotomy of the tibia done through a midline vertical incision with the dome just above the tibial tuberosity. Two wires or Steinmann pins are passed parallel to each on either side of osteotomy site and these marker wires subtend the desired angle after osteotomy is completed and the fragment rotated. Post operative mobilization of the knee was allowed. The author concluded that accurate correction of deformity does not appear to be essential for relief of pain nor does the best correction give the best results for reasons unexplained.

In 1983 Ogata\textsuperscript{34} described an interlocking wedge osteotomy of the proximal tibia. Hence, the anterior and posterior cortices are left attached to the distal and proximal fragments respectively when the bone wedge is removed. Medial rotation of the distal fragment is done so that the tibial tubercle advances anteriorly and the posterior cortex of the proximal fragment overrides the distal fragment. The author suggested that the contact area and stability at the osteotomy site are increased by an interlocking effect of the cortices and the stress under the patella is reduced by anterior advancement of the tibial tubercle. This requires a smaller
amount of bone resection and soft tissue dissection and can be done without resecting the fibular head or damaging the tibial tubercle.

In 1981, Vainionpaas reported high tibial osteotomies using an L shaped blade plate. The blade of an L shaped blade plate was driven into the proximal fragment so that it penetrated the opposite cortex and the plate was fixed under compression to the distal segment of the tibia with screws.

Koshino and Mori et al. reported the use of an L shaped blade plate for fixation of the fragments. This plate was initially developed in 1975, as a fragment fixation device. There are two kinds of Koshino blade plate. One blade is V shaped and the other is an inverted U shaped. Among the advantages claimed, this type of internal fixation does not disturb any motion of daily activities, does not obstruct during walking or on bending the knee joint. There is no necessity for a heavy cast and there are no visible external fixators. The blade fixation widened the indications for high tibial osteotomy, especially to the elderly with osteoporosis. But the disadvantages are that the surgical technique is more complicated, and the realignment of the fragments after fixation is a little more difficult during the post operative course if realignment is necessary.

Maquet, in 1963 recommended anterior advancement or elevation of the insertion of the patellar tendon on to the tibial tuberosity to reduce the
articular pressures in the patello femoral joint. Maquet elevates a tongue of bone anteriorly, with its distal attachment intact, the bone comprising of tibial tuberosity and the attachment of the patellar tendon. A block of iliac bone is inserted at its most proximal part. The pressure of the tongue of tibial bone will hold this block in place but Murray recommends a single stainless steel screw to be inserted with a lag effect. Maquet in 1976 reported good or an excellent result in 56 of 57 patients. Later Kaufer, Bandi and Ferguson et al. confirmed that significant reduction of the patellofemoral loading forces could be achieved by this procedure. By elevating the patellar tendon, the angle of the quadriceps pull and the moment arm of the patellar tendon are increased, thus decreasing the contact stress at the patello femoral articulation.

Maquet reported two patients treated by proximal tibial osteotomy for correction of angular deformity and also anterior displacement of the patellar tendon for patello femoral arthritis. One had excellent result the other had a poor result. Bourguignon (1981) reported a combined procedure of high tibial osteotomy and elevation of the tibial tubercle. According to him, the advantages of combining the Coventry and Maquet procedures in one operation are that only a single incision would be required, no iliac bone graft donor site would be needed, and sagittal
alignment of the tibial shaft and the tibial plateau would be presented, thus providing better contact between the osteotomised surfaces \(^{17}\).

In 1973, Coventry\(^{5}\) stated that valgus deformity of more than 12 to 15 degrees or if the plane of the knee joint deviates from the horizontal by more than 10 degrees, tibial osteotomy will not realign the weight bearing surfaces satisfactorily. Even though the overall alignment of the limb is correct, there will still be overloading of the lateral femoral and lateral tibial condyles. Here osteotomy through the supracondylar region of the femur was advised bearing in mind that stiff knee can result, as Jackson pointed out.

Dror Paley new concepts in high tibial osteotomy to genu varum in medial compartment osteoarthritis is a malalignment due to a) tibial b) femoral or c) lateral ligamentous laxity or three of them and also procurvatum deformities can contribute for malalignment Paley’s malalignment test measurement of Lateral distal femoral angled and Medial proximal tibial angle, comparison between them will help to recognize the malalignment \(85-90^0\)is normal range.
Importance of standing and full weight bearing radiographs

Bauer et al.\(^3\) emphasized that the radiograph of the knee should be taken with the patient in a standing position for measurement of varus or valgus deformities. The extent of the disease process in each compartment should be assessed before deciding to perform a high tibial osteotomy. It is generally accepted that thinning of the articular cartilage is revealed radiographically by narrowing of the joint space. (Leach, Gregg and Siber 1970). In films taken when the patient is not taking weight on the limb, accurate assessment of joint space narrowing is not possible, this lead Ahlback (1968) to advocate the routine use of radiographs taken with the patient standing. On weight bearing, the joint space of the more involved compartment narrows. In the less affected compartment, it is often unchanged or it may increase in width as weight is transferred to the more
affected side (Thomas et al 1975). The principal of stress radiography described by Coventry is the radiological joint space represents the thickness of the intervening articular cartilage, only when the joint surfaces are forcibly opposed. If a radiograph taken with the knee stressed, retains a width of 5 mm or more in the compressed compartment, then the articular cartilage in that compartment is normal.¹⁰
MATERIALS AND METHODS

In this retrospective as well as prospective study thirty six patients with unicompartmental osteoarthrosis of the knee presenting to Balaji institute of surgery, research and rehabilitation for the disabled hospital from year 2002 to 2008 were treated with high tibial osteotomy.

**Material**

The study material includes data collection, clinical examination and investigations of thirty six patients who underwent high tibial osteotomy.

**Age and sex distribution**

Out of thirty six patients, twenty four patients were women and twelve patients were men with a ratio of 2:1.

**Table 1: Sex distribution**

<table>
<thead>
<tr>
<th>Sex</th>
<th>No of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>24</td>
<td>66.67</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>33.33</td>
</tr>
<tr>
<td>total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

**Figure 1: distribution**

- Female: 33%
- Male: 67%

MATERIALS AND METHODS
Age Distribution:

The mean age at the time of surgery was 54.44 years with a range of 33 years to 73 years.

Table No: 2 Age Distribution

<table>
<thead>
<tr>
<th>S.No</th>
<th>Age in years</th>
<th>No of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31-40</td>
<td>2</td>
<td>5.56</td>
</tr>
<tr>
<td>2</td>
<td>41-50</td>
<td>14</td>
<td>38.89</td>
</tr>
<tr>
<td>3</td>
<td>51-60</td>
<td>11</td>
<td>30.56</td>
</tr>
<tr>
<td>4</td>
<td>61-70</td>
<td>6</td>
<td>16.67</td>
</tr>
<tr>
<td>5</td>
<td>71-80</td>
<td>3</td>
<td>8.33</td>
</tr>
<tr>
<td>6</td>
<td>80+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 2: Age Distribution
Affected side

Right side unicompartmental osteoarthrosis is seen in seventeen patients (41.67%) and nineteen patients (58.33%) had left side involvement.

**Table 3: Affected Side**

<table>
<thead>
<tr>
<th>Side</th>
<th>No of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>17</td>
<td>41.67</td>
</tr>
<tr>
<td>Left</td>
<td>19</td>
<td>58.33</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

**Inclusion criteria**

Patients with medial compartmental osteoarthrosis.

Patients with Prides criteria (radiological) type I and II

Patients with minimum 3 months follow up.
Exclusion criteria
Patients with pre existing disease or trauma to the knee.
Patients with polyarticular involvement.
Grossly unstable knee.

Preoperative planning
Patient’s problem was evaluated using
2. Radiological criteria

CLINICAL FUNCTIONAL CRITERIA
The parameters which were assessed in clinical and functional criteria are
History of pain, nature of pain, percentage of pain relief using visual
analogue scale, joint line tenderness, retropatellar tenderness, instability,
range of motion and walking distance.

Pain:
Pain is assessed based on nature as none, rest pain, loading pain, both rest
and loading pain.
Percentage of pain was assessed based on visual analog scale.
The scale consists of markings from 0 to 10. 0 indicates no pain, 4
indicates uncomfortable pain, 6 and above is severe or annoying pain
based on this numerical value percentage is calculated.
Stability:

We assessed stability based on insall’s criteria of thrust which was observed in coronal plane on weight bearing and if any medial or lateral thrust present then it is considered as instability. Varus and valgus stress tests were also conducted on patients to assess the stability.

Range of motion:

The range of motion is measured using a goniometer. The arc of motion was in range of 0 to 120°. Preoperative range of motion was measured for all cases and compared with post operative range of motion.

Walking distance:

Walking distance was calculated in terms of blocks (50 meters was considered as one block) and patients were asked orally how many blocks they could walk prior to the surgery and post operatively, any improvement in walking distance is documented.

Coventry’s rating system

Functionally all the patients were assessed by Coventry’s rating system, grading of pain, nature of pain, retro patellar pain, stability of knee joint, range of movement, walking distance pre operatively and post operatively.

Good:-

All or most of the pain relieved.
90° or more flexion of the knee.
Returned to full work status or at least to the status that prevailed before the onset of knee disability.
Fair:-
Had bothersome pain
less than 90° of knee flexion, mild instability requiring the use of a cane.
Able to return to work with less pain than before the operation.

Poor:-
Pain unrelieved or recurred.
Severe stiffness of the knee, gross instability.

Subjective results:
Each patient was asked orally whether they are satisfied with the procedure are not and documented.

Knee score
Insall’s modified knee score
This scoring system combines a relatively objective knee score that is based on the clinical parameters and a functional score based on how the patient perceives that the knee functions with specific activities. The maximum knee score is 100 points and functional score 100 points. To calculate the two scores the answers to the questions and the findings on the examination are given a value based on the results. To obtain the knee score and the functional score the result of each question is totaled.

<table>
<thead>
<tr>
<th>Pain</th>
<th>50 (maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>35</td>
</tr>
<tr>
<td>Mild or occasional</td>
<td>30</td>
</tr>
<tr>
<td>Moderate</td>
<td>15</td>
</tr>
<tr>
<td>Severe</td>
<td>0</td>
</tr>
<tr>
<td>Stairs</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>15</td>
</tr>
</tbody>
</table>
### Range of motion

<table>
<thead>
<tr>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild or occasional</td>
<td>10</td>
</tr>
<tr>
<td>Moderate</td>
<td>5</td>
</tr>
<tr>
<td>Severe</td>
<td>0</td>
</tr>
</tbody>
</table>

\[8^\circ = 1\text{ point}\]

### Stability

**25 (maximum)**

<table>
<thead>
<tr>
<th>Direction</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial/lateral</td>
<td></td>
</tr>
<tr>
<td>0-5 mm</td>
<td>15</td>
</tr>
<tr>
<td>5-10 mm</td>
<td>10</td>
</tr>
<tr>
<td>&gt;10 mm</td>
<td>5</td>
</tr>
<tr>
<td>Anteroposterior</td>
<td></td>
</tr>
<tr>
<td>0-5 mm</td>
<td>10</td>
</tr>
<tr>
<td>5-10 mm</td>
<td>8</td>
</tr>
<tr>
<td>&gt;10 mm</td>
<td>5</td>
</tr>
</tbody>
</table>

### Deductions

#### Extension lag

<table>
<thead>
<tr>
<th>Degree Range</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>&lt;4 degrees</td>
<td>-2</td>
</tr>
<tr>
<td>5-10 degrees</td>
<td>-5</td>
</tr>
<tr>
<td>&gt;11 degrees</td>
<td>-10</td>
</tr>
</tbody>
</table>

#### Flexion contracture

<table>
<thead>
<tr>
<th>Degree Range</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5 degrees</td>
<td>0</td>
</tr>
</tbody>
</table>
MATERIALS AND METHODS

6-10 degrees - 3
11-20 degrees - 5
>20 degrees -10

Malalignment

5-10 degrees 0

(5° = -2 points)

Radiological criteria:

Weight bearing anteroposterior, lateral radiographs and orthoscandograms were taken and assessment was done using
1) Pridie’s classification.
2) Tibio femoral angle correction.
3) Varus angle regression.

According to modified Pridie’s classification, all these patients were graded into three groups.

Pridie’s classification

Radiological grading

Grade I:

- Good cartilage space.
- Squaring of margins of femoral condyles and/or tibial plateau.
- Sharpening of the outlines of tibial spines.
- Minimal or no osteophyte formation.

Grade II:

MATERIALS AND METHODS
• Diminished cartilage space.
• Subchondral sclerosis.
• Severe osteophyte formation.

Grade III:
• Marked obliteration of cartilage space.
• Collapse of femoral condyle or tibial plateau.
• Subluxation of the joint.
• Loose bodies.

At least two of these criteria should be present to group any patient into one of these grades

**Tibio Femoral Angle:**

1) Mechanical tibio femoral angle
2) Anatomical tibio femoral angle

**Mechanical axis:** A line drawn from the centre of the femoral head to the centre of the ankle typically passes immediately medial to the centre of the neck.

**Anatomical axis:** The anatomical axis of the bone is the mid diaphyseal line of that bone.

**Mechanical tibio femoral angle:** It is formed by the intersection of mechanical axis of the femur and mechanical axis of tibia. It is $1.3 \pm 2^0$ varus

**Anatomical Tibio Femoral Angle:** It is formed by the intersection of anatomical axis of femur and anatomical axis of tibia. This is usually approximately six degrees valgus.

The tibio femoral angle by definition denotes the anatomical tibio femoral angle.
Tibio femoral and varus angle regression were assessed with radio graphs and orthoscanograms.

**Pain:**

**Nature of pain:** out of thirty six patients, twenty seven patients had pain in rest as well as loading. Nine patients had pain on loading.

**Table 4: Nature of Pain**

<table>
<thead>
<tr>
<th>Nature of the pain</th>
<th>Pre op number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Rest</td>
<td>0</td>
</tr>
<tr>
<td>Loading</td>
<td>9</td>
</tr>
<tr>
<td>Rest+loading</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
</tr>
</tbody>
</table>
Instability:
None of thirty six patients had instability.

Range of motion:
The range of motion measured with goniometer is assessed in ranges. Nine patients were having range of motion between 90-99 degrees, ten patients were having range of motion between 100-109 degrees, twelve patients are having range of motion between 110-119 degrees and three patients were having range of 120 degrees or more.
Table 5: Range Of Motion

<table>
<thead>
<tr>
<th>Range of motion</th>
<th>Pre op number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-99</td>
<td>9</td>
</tr>
<tr>
<td>100-109</td>
<td>10</td>
</tr>
<tr>
<td>110-119</td>
<td>12</td>
</tr>
<tr>
<td>120 and above</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 5: Range Of Motion

WALKING DISTANCE:

Walking distance was calculated in terms of blocks. 50 meters was considered as one block and patients were asked orally how many blocks they could walk prior to the surgery and post operatively if there is any improvement in walking distance is documented.
Table 6: Walking Distance

<table>
<thead>
<tr>
<th>Walking distance</th>
<th>Pre op range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlimited</td>
<td>6</td>
</tr>
<tr>
<td>4 to 6 blocks</td>
<td>23</td>
</tr>
<tr>
<td>1 to 3 blocks</td>
<td>7</td>
</tr>
<tr>
<td>Indoors only</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 6: Walking Distance

**Tibiofemoral angle:**
Twenty patients were having varus angle between 0-4° and eleven patients were having varus angle between 5-9° and five patients in range of 10-15°.
Table 7: Range of Tibio Femoral Varus Angle

<table>
<thead>
<tr>
<th>Range of varus angle</th>
<th>No of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4°</td>
<td>20</td>
</tr>
<tr>
<td>5-9°</td>
<td>11</td>
</tr>
<tr>
<td>10° or more</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 7: Range of Tibio Femoral Varus Angle

Radiological Grading of osteoarthritis:
Twenty four (66.67%) patients had grade I twelve (33.54%) patients had grade II according to pridie’s classification.
Table 8: Grading Of Patients According To Pridie’s Classification

<table>
<thead>
<tr>
<th>Grade</th>
<th>No of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>24</td>
<td>66.67</td>
</tr>
<tr>
<td>II</td>
<td>12</td>
<td>33.54</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 8: Grading Of Patients According To Pridie’s Classification

Operative procedure

Under spinal anesthesia, patient in supine position, the limb was prepared and draped from foot to thigh and a tourniquet was used. The procedure is carried out under image intensifier control. The affected limb was placed at an angle of 90° this carries the popliteal vessels and the peroneal nerve posteriorly and relaxes the iliotibial band 3 bony points viz;
the head of fibula and the tibial tubercle and gerdy’s tubercle are marked. A oblique incision between these three bony landmarks starting from tibial shin to mid lateral aspect of the knee joint and ended just proximal to the lateral femoral condyle.

The anterior tibial muscles are dissected stripped from the tibia up to the proximal 1/3 of tibial taking care not to injure the anterior tibial vessels which pass along the anterior compartment.

Tibio fibular syndesmosis identified and release done. Parallel to joint line and 1.5 cm distally is drilled and cancellous screw with washer is passed parallel to the joint line and a cortical screw passed distally in the same line. The osteotomy was carried out under direct vision using a wide osteotome using power saw.

The upper limit of the wedge was first marked out along a plane two centimeters below and parallel to the articular surface. The appropriate wedge was marked out below the previously established line. Wedge is
removed leaving a thin posteromedial lip of bone on the proximal tibial fragment following closure of the osteotomy after removal of wedge of bone.

The posterior lip overrides the proximal end of the distal fragment and thus gives added support and stability to osteotomy. By this method the distal fragment is displaced anteriorly thereby obtaining the maquet effect.

The osteotomy is approximated with lateral circlage in figure of eight. Keeping in valgus the corrected knee is checked under image intensifier.
Post operative protocol

Post operatively intravenous antibiotics given for three days followed by oral antibiotics for another week. Wound inspection is done on second post operative day and drain is removed. Suture removal is done on eleventh
post operative day. An anteroposterior, lateral radiographs and an orthoscanograms were taken alignment was assessed.

**Physiotherapy:**

Active and passive knee mobilization was done on first post operative day. Quadriceps and hamstring exercises were taught and allowed to practice under supervision.

**Mobilization:**

Full weight bear mobilization was started on second post operative day after teaching active quadriceps exercises.

**Post operative Tibiofemoral angulation:**

Postoperative tibiofemoral angle is calculated using radiographs and orthoscanograms.

Patients followed up for every six weeks and clinical examinations, radiographs were taken in antero posterior, lateral in standing position and the joint space, any regression in the varus angle and the tibio femoral alignment is looked after.

**Pre operative orthoscanogram**
Post operative orthoscanogram
Clinical Examples

Case 1 - 35 Years Male
Case 2 - 52 Years Female

MATERIALS AND METHODS
MATERIALS AND METHODS
RESULTS

In the evaluation of the clinical functional results according to Coventry’s criteria, radiological results according to Pridie’s classification were assessed and documented along with complications.

The present study was conducted on patients who had undergone high tibial osteotomy for unicompartamental osteoarthrosis between 2002 to 2009 we have done thirty six surgeries in between this period.

Clinical and functional results:

Pain, postoperative tibio femoral angle, range of motion, walking distance, complications were monitored in all the patients who had undergone surgery.

Pain:

The nature of pain, grade of pain and percentage of pain relief were assessed.

Nature of pain:

Preoperatively out of thirty six patients, twenty seven patients had pain in rest as well as loading. Nine patients had pain on loading. Postoperatively thirty two patients had no pain, one had rest pain, two patients had loading pain and one had rest and loading pain.
Table 9: Nature of Pain

<table>
<thead>
<tr>
<th>Grade</th>
<th>Pre-OP</th>
<th>Post-OP</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Rest</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Loading</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Rest+Loading</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>36</td>
</tr>
</tbody>
</table>

Figure 9: Nature of Pain Post Operative
Osteoarthritis Pain Grade:
Post-operatively the mechanical pain assessed showed no pain in thirty-two patients, mild pain in three patients and severe pain in three patients.

Table 10: Grade of Pain

<table>
<thead>
<tr>
<th>S.No</th>
<th>No of patients</th>
<th>Pre-op</th>
<th>Post-op</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Mild</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
<td>36</td>
</tr>
</tbody>
</table>

FIGURE 10 GRADE OF PAIN

Percentage of pain relief:
Percentage of pain relief is measured using visual analog scale and percentage of pain calculated accordingly. Twenty seven (75%) patients had pain relief between 90-100%. Four (11.11%) patients had pain relief
between 71-80% and 81-90% respectively. One patient (2.78%) had pain relief between 21-30%.

**Table 11: percentage of pain relief:**

<table>
<thead>
<tr>
<th>Range in %</th>
<th>No of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11-20%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>21-30%</td>
<td>1</td>
<td>2.78%</td>
</tr>
<tr>
<td>31-40%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>41-50%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>51-60%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>61-70%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>71-80%</td>
<td>4</td>
<td>11.11%</td>
</tr>
<tr>
<td>81-90%</td>
<td>4</td>
<td>11.11%</td>
</tr>
<tr>
<td>90-100%</td>
<td>27</td>
<td>75.00%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Figure 11: percentage of pain relief**
Stability:

Stability is measured using installs criteria of thrust movement in coronal plane. Thirty five (97.22%) patients had no instability post operatively and only one patient had lateral instability which was 2.78%

<table>
<thead>
<tr>
<th>Instability</th>
<th>No of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>1</td>
<td>2.78</td>
</tr>
<tr>
<td>Absent</td>
<td>35</td>
<td>97.22</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 12: In Stability
Range of motion:
The arc of motion was in range of 0 to 120°. All most all knees had greater than 90° of flexion. The range of motion assessed with goniometer showed significant improvement post operatively. Seventeen patients had range of motion of 110° to 119°. Fifteen patients had range of motion of 120°.

Table 13: Range Of Motion Pre Operative and Post Operative

<table>
<thead>
<tr>
<th>Range of motion</th>
<th>Pre op</th>
<th>Post op</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-99</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>100-109</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>110-119</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>120 and above</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

Figure 13: Range Of Motion Post Operative
Average Range of motion:
The average pre operative range was $105.5^0$ and post operative average was $110.8^0$

Table 14: Average Range of Motion

<table>
<thead>
<tr>
<th>Preoperative avg in degree</th>
<th>Post operative avg in degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>105.5</td>
<td>110.8</td>
</tr>
</tbody>
</table>

Figure 14: Average Range of Motion
Walking distance:

Almost all patients had improved walking distance when compared to preoperative period. Walking distance improved significantly. The number of patients walking unlimited blocks increased from six to thirteen (36.12%). The number of patients walking 4-6 blocks were sixteen (46.44%). Seven patients (19.44%) were having walking distance 1-3 blocks remained the same after the surgery.

**Table 15: walking distance**

<table>
<thead>
<tr>
<th>Walking distance</th>
<th>Pre op</th>
<th>Post op</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlimited</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>4 to 6 blocks</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>1 to 3 blocks</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Indoors only</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 15: Walking Distance**
Table 16: Walking Distance Percentage

<table>
<thead>
<tr>
<th>Walking distance</th>
<th>Pre op%</th>
<th>Post op%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlimited</td>
<td>16.8</td>
<td>36.12</td>
</tr>
<tr>
<td>4-6 blocks</td>
<td>63.88</td>
<td>44.44</td>
</tr>
<tr>
<td>1-3</td>
<td>19.44</td>
<td>19.44</td>
</tr>
<tr>
<td>Indoors only</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 16: Walking Distance Pre Operative Percentage

Figure 16: (b) walking distance post op percentage
Walking aids:

Four patients used cane for walking pre operatively and post operatively two patients used the cane. One patient who had non union used walker support.

Table 21: No of patients using cane

<table>
<thead>
<tr>
<th>No of patients using cane</th>
<th>Pre op</th>
<th>Post op</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 21: No of Patients Using

![No of patients using cane](image-url)
Knee score:

Post operative knee score was assessed using insall’s modified knee score

The pre operative objective score was assessed using Insall’s modified score. Twenty seven patients had preoperative objective score of thirty three and nine patients had a score of fifty three.

Table 22: objective pre operative score

<table>
<thead>
<tr>
<th>No of patients</th>
<th>Objective pre op score</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>9</td>
<td>53</td>
</tr>
</tbody>
</table>

Figure 22: objective pre operative score
Functional preoperative score

Twenty three patients had pre operative functional score of forty eight, seven patients had score of thirty eight and six had functional score of seventy eight.

Table 23: Functional Pre Operative Score

<table>
<thead>
<tr>
<th>No of patients</th>
<th>Functional pre op score</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>7</td>
<td>38</td>
</tr>
<tr>
<td>6</td>
<td>78</td>
</tr>
</tbody>
</table>

Figure 23: Functional Pre Operative Score
**Post operative objective knee score**

Post operatively thirty patients had objective post operative score of ninety. Two patients had a score of sixty three and two patients had a score of forty nine.

**Table 24: objective post operative score**

<table>
<thead>
<tr>
<th>No of patients</th>
<th>Objective post op score</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>79</td>
</tr>
<tr>
<td>2</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
</tr>
</tbody>
</table>

**Figure 24: objective post operative score**
Post operative functional score

Post operatively, thirty two patients had knee score of ninety, one patient had knee score of sixty and two patients had a functional score of fifty. One patient had a score of thirty

Table 25: Functional Post Operative Score

<table>
<thead>
<tr>
<th>No of patients</th>
<th>Functional post op score</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>90</td>
</tr>
<tr>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>

Figure 25: Functional Post Operative Score
Post operative Tibio femoral angle:

Postoperative tibio femoral angle which was aimed for over correction was assessed. Twenty four patients had tibio femoral angle of $5-9^0$ (66.67%), ten patients had between $10-15^0$ (27.78%) and two patients had between $0-4^0$ (5.56%)

Table 17: Post operative tibio femoral angle

<table>
<thead>
<tr>
<th>No of patients</th>
<th>Pre op tibio femoral angle in degrees</th>
<th>No of patients</th>
<th>Post op tibio femoral angle in degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0-4°</td>
<td>2</td>
<td>0 -4°</td>
</tr>
<tr>
<td>11</td>
<td>5-9°</td>
<td>24</td>
<td>5-9°</td>
</tr>
<tr>
<td>5</td>
<td>10-15°</td>
<td>10</td>
<td>10-15°</td>
</tr>
</tbody>
</table>

Figure 17: Post operative tibio femoral angle
Table 18: Percentage of post operative tibio femoral angle

<table>
<thead>
<tr>
<th>Post operative tibio femoral angle</th>
<th>Present study %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4º</td>
<td>5.56</td>
</tr>
<tr>
<td>5-9º</td>
<td>66.66</td>
</tr>
<tr>
<td>10-15º</td>
<td>27.78</td>
</tr>
</tbody>
</table>

Figure 18: Post operative tibio femoral angle percentage
Varus Angle regression:

Out of thirty six patients, eleven (30.56%) patients showed regression and twenty five (69.44%) patients had no regression of angle in the final follow up.

Table 19: varus Angle regression

<table>
<thead>
<tr>
<th>Varus angle</th>
<th>No of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>11</td>
<td>30.56</td>
</tr>
<tr>
<td>No regression</td>
<td>25</td>
<td>69.44</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 19 (A): Varus Angle Regression

Figure 19 (B): Varus Angle Regression Percentage
Radiographs and joint space:

The patients were clinically evaluated and standing full weight bearing radiographs were obtained for every three months or more after surgery. Post operatively, Widening of joint space was observed in thirty one cases. Subchondral sclerosis was observed post operatively. There was slight decrease in subchondral sclerosis in ten knee joints at follow up.
Complications

One patient (2.78%) was affected with superficial infection that was treated with antibiotics. One case (2.78%) had nonunion for which plate osteosynthesis with bone graft was done. One case (2.78%) had extensor lag of ten degrees and mild instability.

Table 26: Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>No of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>1</td>
<td>2.78</td>
</tr>
<tr>
<td>Non-union</td>
<td>1</td>
<td>2.78</td>
</tr>
<tr>
<td>Ext-lag</td>
<td>1</td>
<td>2.78</td>
</tr>
<tr>
<td>None</td>
<td>33</td>
<td>91.67</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 26: Complications
Infection

One patient out of 36 patients had superficial skin infection which was treated with intravenous antibiotics for 3 days followed by oral antibiotics for one week.

Figure 26 (a): Infection

Non union

One patient had non union at the osteotomy site for which open reduction and internal fixation was done with plate osteosynthesis with bone grafting.

Figure 26 (b): Non union

Extensor lag

One patient had an extensor lag of $10^0$ post operative with mild instability.

Figure 26 (c): Extensor lag
OBJECTIVE AND SUBJECTIVE RESULTS

Objective Results

The results were evaluated using the rating system by Coventry. Thirty three (91.67%) knees are rated good, one (2.78%) knee was rated fair and two (5.56%) knees were rated poor. In one knee with fair result, there was pain on loading. In the two knees with poor results, one case had mild instability and an extensor lag of 10°; one patient had bothersome pain in rest and non union on radiographs.

Table 27: Objective Results

<table>
<thead>
<tr>
<th>S.No</th>
<th>Results</th>
<th>No of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Good</td>
<td>33</td>
<td>91.67</td>
</tr>
<tr>
<td>2</td>
<td>Fair</td>
<td>1</td>
<td>2.78</td>
</tr>
<tr>
<td>3</td>
<td>Poor</td>
<td>2</td>
<td>5.56</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 27: Objective Results
SUBJECTIVE RESULTS

Thirty four (94.44%) patients were satisfied with the surgery and two patients (5.56%) were not satisfied.

Table 28: Subjective Results

<table>
<thead>
<tr>
<th>Results</th>
<th>No of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfied</td>
<td>34</td>
<td>94.44</td>
</tr>
<tr>
<td>Not satisfied</td>
<td>2</td>
<td>5.56</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100</td>
</tr>
</tbody>
</table>

FIGURE 28: SUBJECTIVE RESULTS
ANALYSIS

In the treatment of osteoarthrosis, the goals are to reduce the pain, shift the mechanical axis and improve the function.

High tibial osteotomy is an excellent modality in treating unicompartmental osteoarthrosis.

Our study includes thirty six patients treated as in patients at Balaji institute of surgery, research and rehabilitation for the disabled.

Our study is compared with Coventry’s and Insall’s study respectively.

Osteoarthrosis of the knee, affecting thirty six patients, after attempting conservative management and having persistent symptoms were taken up for the high tibial osteotomy.

In our series male and female patients were included with ages ranging from thirty three years to seventy three years were with the mean age being 54.44years.

**Sex distribution:**

In our study twenty four patients were female and twelve patients were male, where as in Coventry study forty eight patients were male and twenty five were female, in Insall’s study twenty four patients were male and fifty nine patients were female.
More number of female patients was noted in our study and Insall study when compared to Coventry’s study.

Insall recommended that high tibial valgus osteotomy is reserved for the patients younger than sixty years of age. Coventry suggested that the age of the patient is irreverent for surgery and the average age of patients in the series is forty nine years. In our study we feel that osteotomy should not be denied to patients based on the age if the other criteria like unicompartimental involvement, stable joint with no fixed deformities are present.

The mean age of patients’ in our study is 54.44 years. The mean ages of Insall’s and Coventry studies were sixty years and sixty three years respectively.

**Mean follow up period:**

The average mean follow up period in our study was 14.38 months and the mean follow up of Coventry and Insall’s are 103.2 months and 51.6 months successively.

**Number of osteotomies:**

In our study thirty six osteotomies were done and in Insall and Coventry studies, eighty three and seventy three osteotomies were done. All osteotomies were done proximal to tibial tubercle
Osteotomy and instrumentation

All thirty six patients had undergone lateral closed wedge osteotomy with tibio fibular syndesmotic release where as Insall and Coventry has done lateral closed wedge osteotomy with fibular head excision.

In our study we used cancellous screw with washer and a cortical screw, SS wire in the form of figure of eight. Coventry used staples for closure of osteotomy. Insall haven’t used any instrumentation.

Kazunori Yasuda etal\textsuperscript{49} used closed wedge osteotomy and fixation with charnley external fixation device.

Aaron. A Hofmann etal \textsuperscript{49} used transverse tibial jig for osteotomy and one buttress plate used for fixation.

Krackow\textsuperscript{50} used using paediatric blade staple for internal fixation.

Lemaire reported rigid fixation with angled blade plate.

Xavier Fletcher etal used Blount staple and an AO half tube plate with three screws.

Billings et al had done calibrated osteotomy transverse osteotomy jig and used one buttress plate.

When compared to the above studies we have used minimal instrumentation
Pain:

The mechanical pain was assessed as none, mild, moderate and severe. In our study the number of patients without pain postoperatively is thirty two (94.44%), and patients with mild pain were three (5.56%) and severe pain was one (2.78%) patient respectively. Insall reported 97% with no pain and 3% had mild pain. In Coventry study 67% patients had mild pain, 24% had moderate pain and 7% had severe pain during follow up. There was more pain relief in our study when compared to the above two studies.

Pain either disappeared or was relieved to a large extent after surgery. Arnoldi felt that the relief of pain was due to lowering of the intraosseous venous pressure. Patients with degenerate osteoarthritis knee have impaired venous drainage from the juxta chondral cancellous bone across the cortex. Intravenous phlebography showed that pain disappears when the high medullary pressure is released by osteotomy. Helal 14 explained that the absence of resting pain was due to decongestion.

Coventry agreed with this hypothesis that osteotomy may lower the intraosseous hypertension in the short term. The mechanical realignment of the joint with the transfer of load from the involved compartment to the opposite normal compartment is explained as the reason for relief of pain. Here we agree with Insall 18 and Vainionpaa etal 43 that the effect of the
pain relief is due to mechanical factors contributing to realignment with osteotomy.

**Range of motion:**

In our study there was 5 degrees improvement in mean range of motion on average. None of the patients lost any further flexion in final follow up where as in Insall study the range of motion was decreased in six patients. In Coventry’s study the range of motion decreased by a mean of 5 degrees and there was 5 degrees of mean flexion and 5 degrees of mean extension lost in the final follow up.

From the above data there was improvement in range of motion in our study when compared to the above studies may be due to early mobilization when compared to the above studies which were immobilized in plaster cast.

**Day of mobilization:**

Patients were mobilized on second post operative day with full weight bear mobilization after teaching active quadriceps exercises in our study, where as in Insall study partial weight bearing was advised from third day with crutches and in Coventry study partial weight bearing was done after one week.
Lawrence, a\textsuperscript{32} in a study compared patients who were on cylinder cast for 6 weeks with those patients who were started on early motion in a cast brace and noted fifteen patients who were on cast for 6 weeks lost a mean of 10 degrees flexion when compared to nineteen patients who were treated by early motion in cast brace had not lost my flexion.

**Maquet effect:**

In our study retro patellar pain was associated with severe degenerative changes in patello femoral joint. In our study eight patients had retropatellar pain pre operatively. After the osteotomy the symptoms totally disappeared in six patients. In one patient there was mild pain and in one knee it remained the same. We believe the relief of retropatellar pain was due to the Maquet effect. In 1981, Insall\textsuperscript{18} reported in his study, when high tibial osteotomy combined with tibial tubercle elevation done in eighteen patients only one had poor result. After tibial osteotomy was performed along with Maquet effect, only two knees had persisting retro patellar tenderness with poor results because the Maquet effect was not appreciable.

From the above two studies, we conclude that retropatellar pain can be decreased remarkably by Maquet effect.
Walking distance:

In our study almost all patients had improved walking distance when compared to preoperative period. Preoperatively 19.44% patients were able to walk 1 to 3 blocks and patients walking 4 to 6 blocks were 63.88% and those walking unlimited were 16.88% whereas after surgery patients walking 4 to 6 blocks was increased to 44.4% and patients walking unlimited was 36.2%.

In Coventry study patients walking from 1 to 3 blocks were 44%, 4 to 6 blocks were 34% unlimited were 16% post operatively those walking 1 to 3 blocks reduced to 19.4% and those walking 4 to 6 blocks rose to 44.4%, those walking unlimited rose to 36.12%.

80.6% of the patients had improved walking distance and 16.62% patients had same walking distance as earlier and 2.78% patients had reduced walking distance whereas in Coventry study, 54% had better walking distance post operatively and 37% patients had same walking distance as before the surgery and 9% patients had reduced walking distance after the surgery.

The improvement of walking distance in our patients is due to stable fixation and early mobilization.
**Stability:**

We have one case of instability reported in our study. We noticed that pain and instability were closely related and all the unstable knees had moderate loss of joint space there was no ligamentous laxity.

We believe that by using Ao-Asif method of fixation with cancellous screws and circlage tie laterally helped in achieving the stability.

Coventry\(^4\) reported three cases of gross instability out of seventy six knees after using his techniques of lateral collateral ligament reconstruction.

Sixteen patients had mild instability in Insall’s study and ten patients had moderate instability during final follow up.

From the above data, our study showed better post operative stability when compared to the two studies the reason being the stable fixation with screws and circlage wire laterally using tension band principle.

**Tibio femoral angle:**

Post operatively tibio femoral angle was measured with radiographs and orthoscanograms. In our study the post operative tibio femoral angles were assessed in percentage. 66.6% patients had tibio femoral valgus angles of 5 to 9 degrees. 27.78% patients had between 10 to 15 degrees of
valgus. In Insall study 43.96% patients were in the ranges of 5 to 9 degrees. And 45.06% patients were in the range of 10 to 15 degrees.

In Coventry study 98% of knees were in valgus angulation at final follow up.

From the above data, in our study we have achieved 94.43% of desired or over correction of tibio femoral angle whereas in Insall’s study it was 98.46%.

The rationale of proximal tibial osteotomy is to change the varus deformity to valgus angulation at the knee and thereby decreasing the load on the medial plateau. The question is how much valgus angulation is correct amount. Coventry\textsuperscript{5} recommended 5 degrees over correction beyond the normal angle of 5 to 8 degrees of genu valgum, or a final tibio femoral valgus angle of 10 to 13 degrees.

Paley\textsuperscript{9} et al eventually concluded that 2 to 4 degrees of mechanical valgus over correction achieved the best results where as neutral alignment, under correction or significant over correction led to inferior results.

Bauer recommended correction up to a tibiofemoral valgus angle of 3 to 16 degrees. We found that the over correction should be at least 2-4 degrees of valgus but cannot specify an upper limit with certainty. This finding suggests that there is individual variation. We had, at final follow-
up, an average tibio femoral valgus angulation of 6.6 degrees. Keeping the results in view, we noted good results if an average tibiofemoral valgus angulation measured 8.5 degrees, two knees rated poor in our series had valgus angulation less than 2 degrees. Insall\textsuperscript{18} reported that the best results were obtained in knees which had tibio femoral angle between 10 to 14 degrees post operatively. They felt that post operative valgus angle between 5 degrees and 14 degrees to be acceptable.

Paley\textsuperscript{9} feels 2 to 4 degrees over correction in other words \((5^0+2^0=7^0\) or \(4^0=9^0\)) 7 to 9 degrees of valgus angulation is ideal.

**Regression of varus angle:**

During the follow up period twenty five cases showed no regression in varus. Eleven cases showed varus in which seven cases showed more than one degree regression.

After valgus high tibial osteotomy, four knee joints had regressed to 2 to 4 degrees varus alignment.

In Coventry study after five week fall seventy percent of knees showed regression at a rate of one degree.
Inference of varus regression:

1. Varus regression of the tibio femoral angle can occur in some knee joints in course of time
2. Tibio femoral alignment at follow up need not be the same as it was after the osteotomy
3. The results of the osteotomy correlated well with appropriate correction of tibio femoral angulation
4. It is better to over correct the valgus angulation rather than under correct the angulation though it may be cosmetically unpleasant.
5. The knees which were inadequately corrected initially had early recurrence of mechanical pain.
6. Varus regression was noted not only in under corrected knees but also in over corrected knee joints

Complications:

In our study one case had superficial skin infection, one case had extensor lag and one case had non union constituting 8.33% complication date. Whereas in Insall study the complication rate was 4.22%

There was only one non union in our series. The bony union was rapid because the osteotomy was through cancellous metaphyseal region of the tibia. We agree with Dehne et al and brown and urban that most patients had little or no pain on early weight bearing. Coventry\textsuperscript{5} in his
series of eighty six knees noted no delayed or non union when the osteotomy was proximal to the tibial tuberosity but noted some delay in union when it was distal to the tibial tuberosity in a few cases.

Coventry\textsuperscript{5} advocates that fibular head be resected after dissecting out the conjoined tendon and later fixing it to the fibular neck, under physiological tension. In eighty six knees, he reports no case of peroneal palsy or compartment syndrome. There was one case of avulsion of the attached lateral fibular ligament.

We had less number of complications because we used less instrumentation and fibular osteotomy was not done unlike both studies.

Kettle kemp etal concluded that anterior tibial artery might be injured during osteotomy\textsuperscript{26} avulsion of the lateral collateral ligament after osteotomy can occurs. Intra-articular extension of the fixation devices can occur.

Weakness of dorsiflexion of the foot has been described by Jackson and Waugh (1984) as "the most puzzling and potentially dangerous symptom after tibial osteotomy". It is a well documented complication which, early reports referred to as a common peroneal nerve palsy\textsuperscript{4}. Walsh termed it as peroneal weakness of non-committally, weakness of dorsiflexion\textsuperscript{23}. The most popular theories are that it results from an anterior tibial compartment syndrome\textsuperscript{23} or damage to the peroneal nerve\textsuperscript{4}. This
occurs in about 10% of tibial osteotomies. Peroneal nerve palsy is a complication which can be prevented by the knee flexion during the procedure so that the neurovascular bundle falls posteriorly and is not near the osteotomy site.
CONCLUSIONS

- High tibial osteotomy is a useful surgical procedure in Unicompartmental osteoarthrosis of the knee joint.

- AO technique of tension band principle with 2 screws and circlage wire is stable method of internal fixation.

- Excellent relief of pain is observed after high tibial osteotomy

- The relief of mechanical pain is significant in knees where the post operative correction of tibiofemoral angle ranges from $7^0$ to $9^0$.

- It is very effective in unicompartmental osteoarthrosis of the knee, with or without involvement of the patellofemoral compartment. The relief of pain in Patellofemoral articulation is due to creating Maquet effect.

- In course of time varus regression of the tibiofemoral angle with recurrence of the deformity can occur after high tibial osteotomy.

- The knees which are inadequately corrected initially will have an early recurrence of mechanical pain.

- The range of movement of the knee, the walking ability of the patient and the distance that patient can walk, improved after high tibial osteotomy.
• When high tibial osteotomy is indicated, age of the patient is irrelevant. High tibial osteotomy gives good results in all age groups.
• Early weight bearing mobilization can be started as early as second post operative day.


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