

**“A PROSPECTIVE STUDY OF PATELLAR FRACTURES
TREATED BY MODIFIED TENSION BAND WIRING”**

By

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**Dissertation submitted to
SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION
& RESEARCH, TAMAKA, KOLAR, KARNATAKA**

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MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the guidance of

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MAY 2013

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LIST OF ABBREVIATIONS USED

AO	Arbeitsgemeinschaft fur Osteosynthese fragen
ORIF	Open Reduction and Internal fixation
ROM	Range Of Motion
K-WIRES	Kirschner Wires
POP	Plaster Of Paris
CPM	Continuous Passive Motion
RTA	Road Traffic Accident
18 G	18 Gauge

ABSTRACT

TITLE

A PROSPECTIVE STUDY OF PATELLAR FRACTURES TREATED BY MODIFIED TENSION BAND WIRING

OBJECTIVES OF THE STUDY

1. The advantages of modified tension band wiring fixation in patellar fractures.
2. The complications associated with this method of fixation.
3. To assess the role of early mobilization with this technique.

METHODS

This prospective study was done in Department of Orthopaedics at R.L. Jalappa Hospital and Medical Research Center, attached to Sri Devaraj Urs Medical College, Kolar during the period from December 2010 to June 2012. This study consists of 30 cases of displaced transverse patella fracture treated by modified tension band wiring.

RESULTS

In our series the range of age was between 19-70 years, the mean age was 42 years and the incidence was high in the age group of 31-40 years. 24 fractures were in men and 6 fractures were in females. 22 fractures were as a result of indirect mechanism and 8 cases were due to direct trauma to the patella as in Road traffic accident. 17 patients had fracture on the right side and 13 patients had fracture on the left side. Based on WEST'S Criteria our results were graded as excellent in 26 cases (86.6%), good in 3 cases (10%) and poor in 1 case (3.3%).

CONCLUSION

Our study shows that modified tension band wiring is a definitive procedure in management of displaced transverse patellar fracture with least complications. This surgery of modified tension band wiring helps for early mobilization post-operatively which plays an important role in final outcome.

KEYWORDS: PATELLA; FRACTURES; TREATMENT; WIRING

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INTRODUCTION

Patella is the largest sesamoid bone in the body situated in the quadriceps tendon. The main function of patella is to improve the efficiency of quadriceps muscle by improving the mechanical leverage of the quadriceps muscle.

Patellar fractures are common and it constitutes about 1% of all skeletal injuries resulting from either direct or indirect trauma. The subcutaneous location of the patella makes it vulnerable to direct trauma as in dashboard injuries or a fall on the flexed knee. Whereas violent contraction of the quadriceps results in indirect fractures of patella. These fractures are usually transverse and are associated with tears of medial or lateral retinacular expansions. Any improper and inadequate treatment would inevitably lead to a disability which would be most perceptibly felt in a country like India, where squatting is important activity in daily life.

Controversy exists regarding treatment of patellar fracture since the earliest times. One school of thought, led by Brooke (1936) and supported by Watson Jones (1945) favoured patellectomy. And another school of thought lead by Haxton (1945) believed in complete, accurate and anatomical reduction of patella fracture. Thomson (1942) advocated excision of smaller fragment and reattachment of the larger fragment to the ligamentum patellae.

In this study a series of 30 cases of fracture patellae have been studied where the results obtained after treating with Modified Tension Band Wiring.

AIMS AND OBJECTIVES

AIMS OF THE STUDY

To evaluate the clinical outcome of Transverse fractures of patella treated with modified tension band wiring.

OBJECTIVES

The objectives of the study are to study:

1. The advantages of modified tension band wiring fixation in patellar fracture.
2. The complications associated with this method of fixation.
3. To assess the role of early mobilization with this technique.

HISTORY AND REVIEW OF LITERATURE

MALGAEGNE in 1850 was the first surgeon to fix the patellar fractures percutaneously using a bone clamp that held each fragment by sharp hooks. SIR HECTOR CAMERON and LISTER in 1877 were first to treat patellar fractures by open reduction and wiring through drill holes in the patella. DENNIS in 1886 reported 49 cases of patellar fractures operated by open reduction and metal sutures and showed excellent results. STIMSON in 1898 reported that open reduction was the ideal treatment as it reduced the period of rehabilitation and gave an improved result. WILLIS in 1907 treated patellar fractures with total patellectomy and reported excellent results. HEINECK in 1909 condemned total patellectomy for simple transverse fractures and recommended patellectomy only for severely comminuted fractures. PHEMISTER in 1915 used silk to suture the patellar fragments. GALLIE in 1924 used Achilles tendon to suture the patellar fragments.¹

THOMSON in 1935 treated patellar fractures by surgical excision of small fragments and capsule repair. He suggested avoiding total patellectomy, because of the impairment of leverage of quadriceps during extension of knee.²

BROOKES and HEYGROOVES in 1937 suggested that the patella inhibits the action of quadriceps tendon and they thought that the strength of the knee was improved with patellectomy.^{3,4}

FRIBERG in 1941 did study on patellectomy and reported diminished extensor power following total patellectomy.

HAXTON in 1945 on the basis of his experiments proved that patella improves the efficiency of the knee joint and demonstrated that the power of extension increases as the knee joint extends.⁵

SCOTT in 1949 did a clinical study of total patellectomy and reported increased incidence of pain and discomfort during movement of the knee.⁶

O DONOGHUE in 1952 suggested that total patellectomy diminished the extensor power of the knee and resulted in various post patellectomy symptoms.⁷

WEST in 1962 reported limitation of flexion following patellectomy.

JANI in 1966 reported increased incidence of secondary osteoarthritis following patellectomy.

MULLER in 1970 introduced anterior application of two stainless steel wires inserted through longitudinally drilled holes.⁸

KAUFER in 1971 compared intact and patellectomized cadaver knees and found that 15% to 30% more quadriceps force was required to fully extend patellectomized knees compared with intact knees.⁹

ANDERSON in 1971 suggested circumferential wire loop for treating patellar fractures, he also recommended inserting metal wires through longitudinally drilled holes.

WEBER in 1980 along with his colleagues studied the efficacy of fixation of patella on 25 cadaver knees by using the following techniques - circumferential wiring, tension band wiring,¹⁰ Magnusson wiring and modified tension band wiring. The knees were mounted in a machine capable of measuring the quadriceps force, flexion angle and fracture separation simultaneously. Separation of fracture fragments were very much less with Magnusson wiring and modified tension band wiring than with circumferential wiring or standard tension band wiring. They recommended anchoring the fixation wiring directly in bone rather than threading it through the soft tissue around the patella if early motion is to be initiated.

DUDANI B and SANCHETI in 1981 did a study on patellar fractures treated by tension band wiring and reported 11 excellent results out of 15 cases treated by modified tension band wiring.¹¹

LIANG in 1987 treated about 27 cases by open reduction and external compressive skeletal fixation using superior and inferior pins placed transversely, adjacent to the proximal and distal poles, and connected externally to compressive clamps and reported excellent results in 24 cases.¹²

MARYA and colleagues in 1987 compared knee function after patellectomy and osteosynthesis with a tension band wiring for similar type of patellar fractures.¹³ Good results were reported in only 50% cases where patellectomy was done and excellent results were achieved in 80% treated with osteosynthesis and tension band wiring.¹³

BRAUN-W in 1993 suggested that all types of patellar fractures should not be fixed. He concluded that in certain types of patellar fractures with displacement less than 3 mm conservative treatment is the best option, and overtreatment with internal fixation should be avoided.¹⁴

A.K. Us and KINIK in 1996 had come out with a self-locking modified tension band technique to prevent proximal migration of the k - wires, where the proximal ends of the k-wires are bent by 360 degrees to form a loop and the 18 gauge Stainless Steel wire is passed through this loop. Thus preventing proximal migration of the k-wires which is the most common complication.¹⁵

FORTIS AP et al in 2001 conducted an experimental investigation of the tension band in fractures of patella to investigate strain patterns developed in anterior and posterior patellar surfaces during knee motion when intact as well as after an osteotomy and internal fixation, eight fresh cadaveric knees were used in this study. They concluded the classical tension band technique is effective in fixation of fractured patella but can be improved by an additional circular wire.¹⁶

SRINIVAS K and his colleagues in 2004 did a study consisting of a prospective and retrospective analysis of results of various methods of surgical treatment of 32 fractures of patella, modified tension band wiring Vs. partial patellectomy Vs. total patellectomy and they concluded that the osteosynthesis with modified tension band wiring gives the best results as the normal anatomy is being restored.¹⁷

BARAN and his colleagues in 2008 did a study on anatomical and biomechanical evaluation of the tension band technique in patellar fractures in 30 patients and concluded that the tension band is main stability factor in patellar fracture treatment, by transferring the tension force directly on to the bone.¹⁸

SHRESTHA B et al in 2009 did a prospective study on functional outcome of modified tension band wiring in transverse fracture patella in 36 patients and concluded that, following the rehabilitation protocol post operatively after modified tension band wiring , the better function can be achieved early.¹⁹

LEFAIVARE KA et al in 2010 did a study on 31 patients with patellar fractures treated with modified tension band wire technique and reported that hardware removal is required less frequently with modified tension band technique than with the traditional AO/ASIF tension band wiring technique .²⁰

ANATOMY OF KNEE

The knee-joint was earlier described as a Ginglymus or hinge-but is really of a much more complicated character. It must be regarded as consisting of three articulations in one: two condyloid joints, one between each condyle of the femur and the corresponding meniscus and condyle of the tibia; and a third between the patella and the femur, partly arthrodial, but not completely so, since the articular surfaces are not mutually adapted to each other, so that the movement is not a simple gliding one.²¹

Knee is the largest joint in the body and it is the most frequently injured joint in our body because of its anatomical structure, exposure to external forces and functional demands placed on it.

Larson and James²² classified structures about the knee into 3 broad categories:

1. Osseous structures
2. Extra articular structures
3. Intra articular structures

1. OSSEOUS STRUCTURES

The Osseous structures of the knee consist of three components they are:

- ❖ The patella
- ❖ The distal femoral condyles
- ❖ The proximal tibial plateaus or condyles.

2. EXTRA ARTICULAR STRUCTURES

The important extra articular structures, supporting and influencing the functions of knee joint are:

- ❖ Capsule
- ❖ Synovium
- ❖ Collateral ligaments
- ❖ Musculotendinous units which are – Quadriceps mechanism, Gastrocnemius, Medial and lateral hamstring groups, Popliteus and Iliotibial band.

Capsule

Capsule is a sleeve of fibrous tissue which envelopes the joint, anteriorly it extends from patella to patellar tendon, proximally attached to femur around the articular margins of the condyles and intercondylar notch posteriorly. On the lateral condyle the attachment includes pit for the popliteus tendon. Distally it is attached to the tibia around the articular margin except where the tendon of popliteus crosses the joint. The capsule is supplemented and strengthened by accessory ligaments and by tendons or expansion from them and by deep fascia, the ligamentum patella replaces it in the front. At the back, it is strengthened by the oblique posterior ligament. The medial ligament overlies the joint on the medial side and the lateral ligament on the lateral side. In the interval that separates those two ligaments from the ligamentum patella, the capsule is subcutaneous and it strengthened by the fascia lata and expansions from the lateral and medial vasti which fuse with it.

Synovium

The synovial membrane lines the inner surface of the fibrous capsule but it ceases at the periphery of articular cartilages, medial and lateral menisci. Above it is continuous with supra-patellar bursa which is synovial pouch intervening between quadriceps femoris muscle and anterior surface of lower part of shaft of femur, above the patellar articular surface the apex of bursa is kept in position by attachment of articularis genu muscle and it separates the ligamentum patellar from the infra patellar pad of fat and lines the deep surface of the quadriceps tendon.

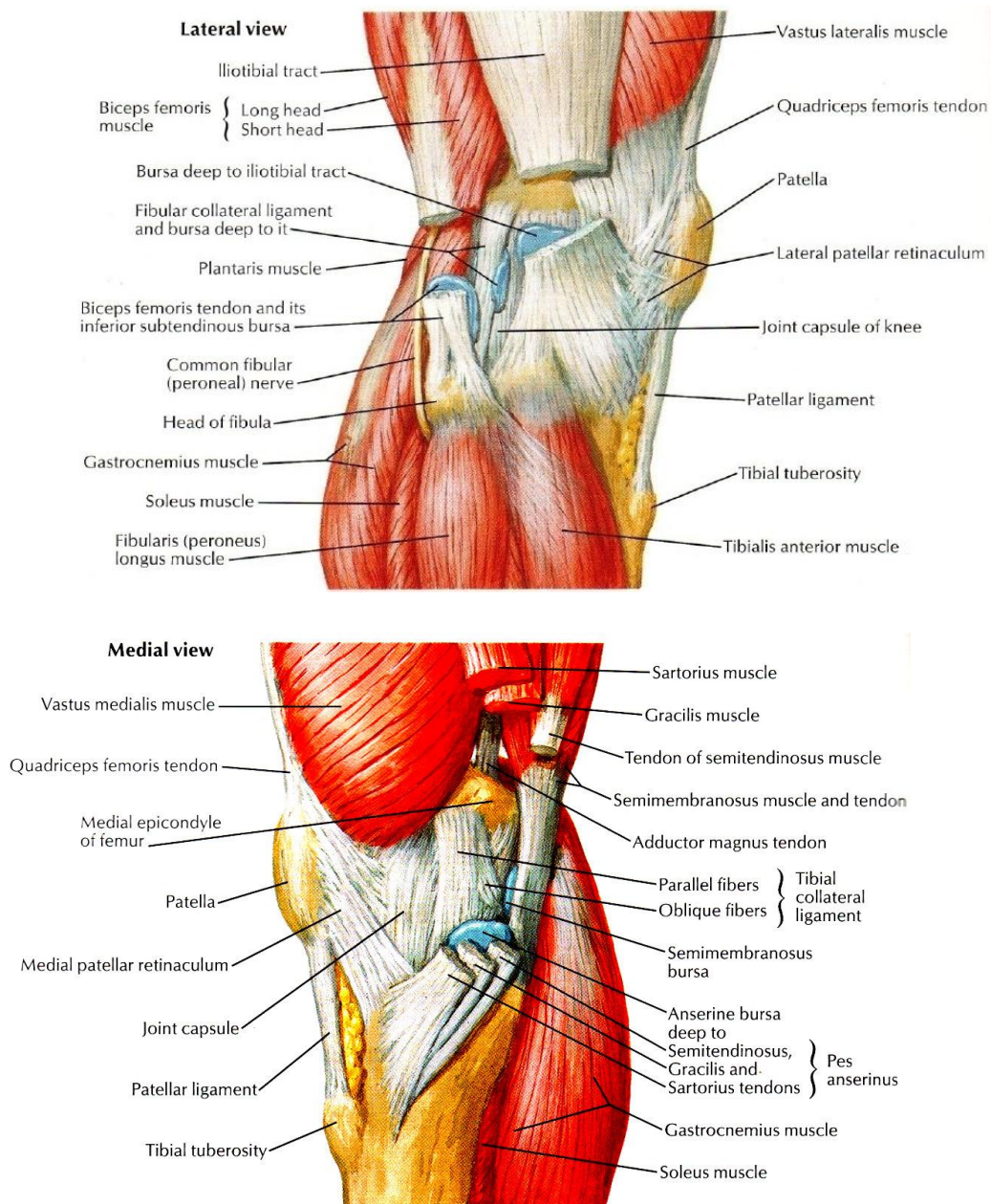
The medial ligament consists of two parts the superficial and the deep. The superficial part is a strong flat triangular band arising from a point immediately below the adductor tubercle and is inserted into the medial surface of the shaft of tibia distal to its tubercle. The deep part is attached to the articular margins of the femur and tibia on their medial aspect and is continuous with capsule in front and behind.

The lateral ligament is a round band which arises from lateral epicondyle of the femur immediately proximal to the groove for the tendon of popliteus and is attached distally to upper surface of head of the fibula.

3. INTRA ARTICULAR STRUCTURES

The principle intra articular structures of importance are

1. Medial and lateral menisci /semilunar cartilages.
2. Anterior and posterior cruciates.

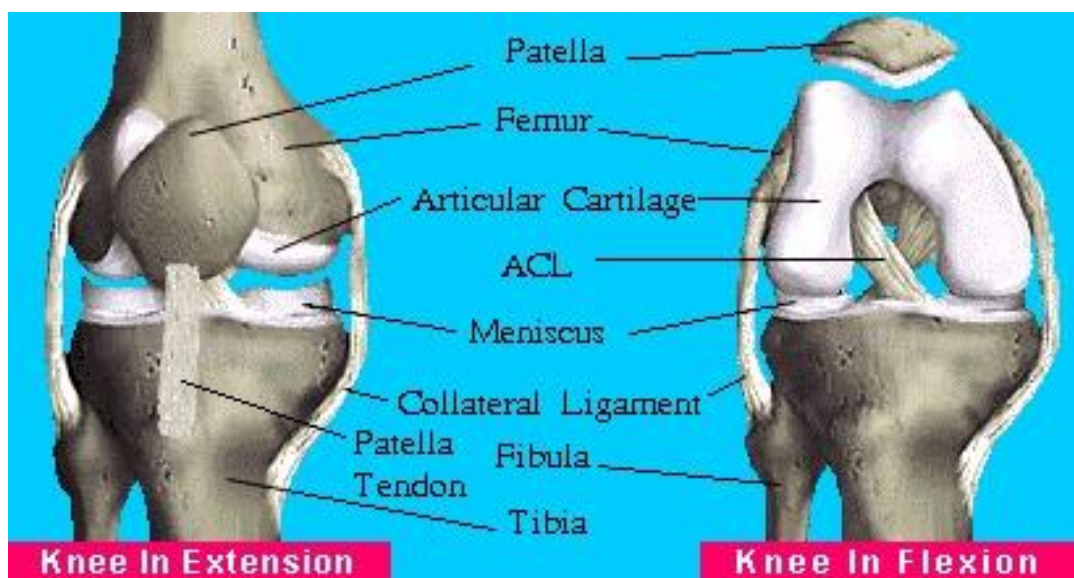


The menisci are two crescentic plates of fibrocartilage, which are placed on condylar surface of the tibia. Each has two horns which are attached to the intercondylar area on the proximal surface of the tibia and the menisci are anteriorly connected by a fibrous band called the transverse ligament, by means of which each is partly controlled by other during knee movements. The main functions of menisci are:

1. Distribution of joint fluid
2. Shock absorption

3. Deepening of the joint and
4. Load or weight bearing function.

The cruciate ligaments are so named because they cross each other, like limbs of the letter 'X' and the anterior cruciate ligament springs from the anterior part of the tibial plateau in front of the tibial spine and extends upwards and backwards to a smooth impression on the lateral condyle of the femur, well back in the inter condylar notch. The posterior cruciate ligament is attached to posterior part of the tibial inter condylar area and passes upwards forwards and a little medially and is attached to the anterior portion of the internal surface of the medial condyle of the femur. It receives one or two strong slips from the posterior horn of the lateral semilunar meniscus.



The functions of cruciates are, it stabilizes the joint and axes around which rotatory motion, both normal and abnormal occurs and they resist the backward and forward motion of tibia on femur.

PATELLOFEMORAL JOINT

Patellofemoral joint is saddle type of synovial joint; it is formed by anterior articular surface of both femoral condyles with posterior articular surface of patella. The anterior articular surfaces of femur are saddle shaped that is concave from side to side but convex from above downward, the articular surface of patella is divided by a vertical ridge creating a small medial and a larger lateral articular surface. With knee in extension the patella rides above the superior articular margin of the femoral groove.

In extension the distal portion of the lateral patellar facet articulates with the lateral femoral condyle but the medial patellar facet barely articulates with the medial femoral condyle until complete flexion is approached at 45° of flexion. In complete flexion the proximal portions of both facets are in contact with the femur and during extension the patella moves 7 to 8 cms in relation to the femoral condyles. (The femoro-patellar joint communicates with each condylar joint through a semilunar space between the femoral condyle and free lateral margins of infra patellar fold).

ANATOMY OF PATELLA

It is a flat, triangular bone situated on the front of the knee-joint. It is usually regarded as a sesamoid bone, developed in the tendon of the Quadriceps femurs.

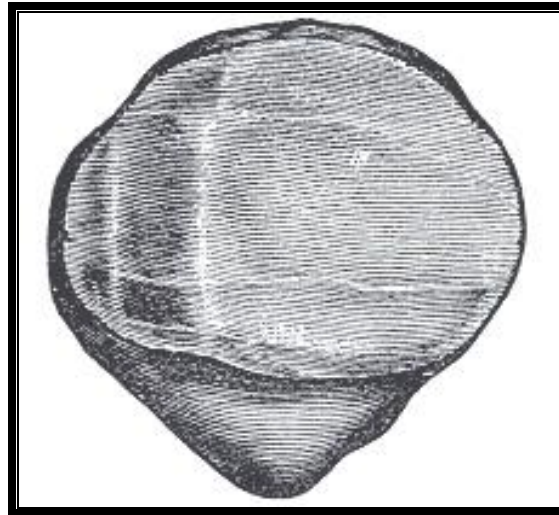
It has an anterior and a posterior surface, three borders and an apex.²¹

SURFACES

The Anterior surface is convex, perforated by small apertures for the passage of the nutrient vessels, and marked by numerous rough, longitudinal striae. This surface is covered by an expansion from the tendon of the quadriceps femoris, which is continuous below with the superficial fibers of the ligamentum patellae. It is separated from the integument (skin) by a bursa (pre-patellar bursa).

The posterior surface presents proximally a smooth, oval, articular area which is divided into seven facets, upper, middle, and lower horizontal pairs, and a medial perpendicular facet. When the knee is forcibly flexed, the medial perpendicular facet is in contact with the semilunar surface on the lateral part of the medial condyle; this semilunar surface is a prolongation backward of the medial part of the patellar surface. As the leg is carried from the flexed to the extended position, first the highest pair, then the middle pair, and lastly the lowest pair of horizontal facets is successively brought into contact with the patellar surface of the femur. In the extended position, when the Quadriceps femoris is relaxed, the patella lies loosely on the front of the lower end of

the femur. Below the articular surface is a rough, convex, non-articular area, the lower half of which gives attachment to the ligamentum patellae and, proximal to this area, between the roughened apex and the articular surface is covered by an infrapatellar pad of fat. This adipose tissue separates the upper half from the head of tibia.



BORDERS

Patella has got three borders- superior, lateral and medial borders. The superior border or the base is the thick, and slopes down and forward, except near its posterior margin. It gives attachment to that portion of the Quadriceps femoris which is derived from the Rectus femoris and Vastus intermedius.

The medial and lateral borders are thinner and converge below. And to them are attached portion of quadriceps femoris which are derived from the Vastus lateralis and medialis termed medial and lateral patellar retinacula. The lateral retinaculum receives accessions from the iliotibial tract.

APEX

The apex is pointed and gives attachment to the ligamentum patellae.

STRUCTURE

The patella consists of a nearly uniform dense cancellous (trabecular) tissue, covered by a thin compact lamina. The cancelli (trabeculae) beneath the anterior surface are arranged parallel with it. In the rest of the bone they radiate from the articular surface toward the other parts of the bone.

OSSIFICATION:

The patella develops from one center of bone formation or ossification center which usually appears by third year. In some cases a second center of bone formation is present. This second center usually fuses with the main mass by puberty. If these two centers of bone formation do not fuse, a situation arises where there is an accessory bone from the second center which is attached to the patella by fibrous or cartilage tissue. This is often seen in the superior-lateral corner of the patella and usually the condition is bilateral and termed as bipartiate patella. The diagnosis for which is made incidentally when x-rays were taken for knee injury. It may be mistakenly diagnosed as a patellar fracture. A comparison x-ray of the other side will rule out the condition.

BLOOD SUPPLY

Blood supply of the patella has been classified into two groups.²³

1. Extra osseous arterial pattern.
2. Intra osseous arterial pattern.

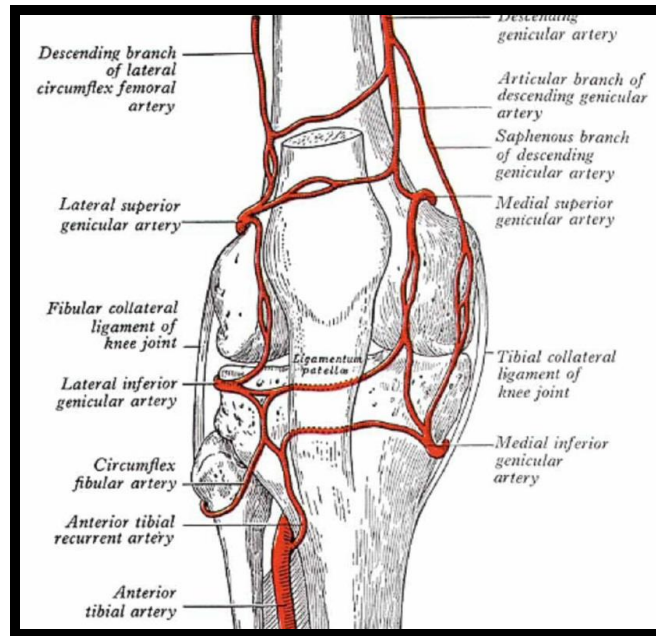
1. Extra osseous arterial pattern :

The patella is surrounded by a vascular anastomotic ring lying in the thin layer of loose connective tissue which covers the dense fibrous rectus expansion.

The main vessels that contribute to this anastomotic circle are the supreme genicular, the medial superior genicular, medial inferior genicular, lateral superior genicular, lateral inferior genicular arteries and the anterior tibial recurrent artery.

The lateral superior genicular and the medial superior genicular arteries run towards each other along the upper border of the patella just in front of the attachment of the quadriceps tendon, anastomosing there with branches of the supreme genicular artery. The lateral inferior and medial inferior genicular arteries before reaching the margins of the ligamentum patellae divide into three branches. The ascending parapatellar artery, the oblique prepatellar artery and the transverse infrapatellar artery.

The ascending parapatellar branches run upwards along the lateral margins of the patella to anastomose with the descending parapatellar branches of the superior genicular arteries. The oblique prepatellar branches converge centripetally towards the anterior surface of the patella, together with other rami from the vascular anastomotic circle. The transverse infrapatellar branches anastomose behind the ligamentum patella, giving off polar vessels which enter the bone behind the origin of the patellar ligament. From this complex network of arteries in front of the patella the nutrient vessels enter its anterior surface obliquely.



2. The Intraosseous arterial pattern :

The intraosseous arteries can be grouped into 2 main systems.²³ The first system is represented by the mid patellar vessels which enter the vascular foramina situated on the middle third of the anterior surface. These foramina open at the bottom of longitudinal fissures and vary in number from ten to twelve. The vessels enter the patella obliquely from below upwards and ramify inside the cancellous bone right up to the chondro-osseous junction a few recurrent branches run back to supply the anterior cortex and the cortex at the superior border of the patella. A peculiar finding has been the lack of vascular penetration around the margins of the bone, that is, the areas which give rise to tendinous and ligamentous structures.

The second system of arteries arises from the polar vessels which come from the infrapatellar anastomosis behind the patellar ligament. This anastomosis is formed by the transverse infrapatellar branches of the inferior genicular arteries.

The polar vessels pierce the deep surface of the patella between the attachment of the ligamentum patellae and the articular surface. They run upwards supplying the lowest third of the patella and communicate within the bone with branches of the mid patellar vessels.

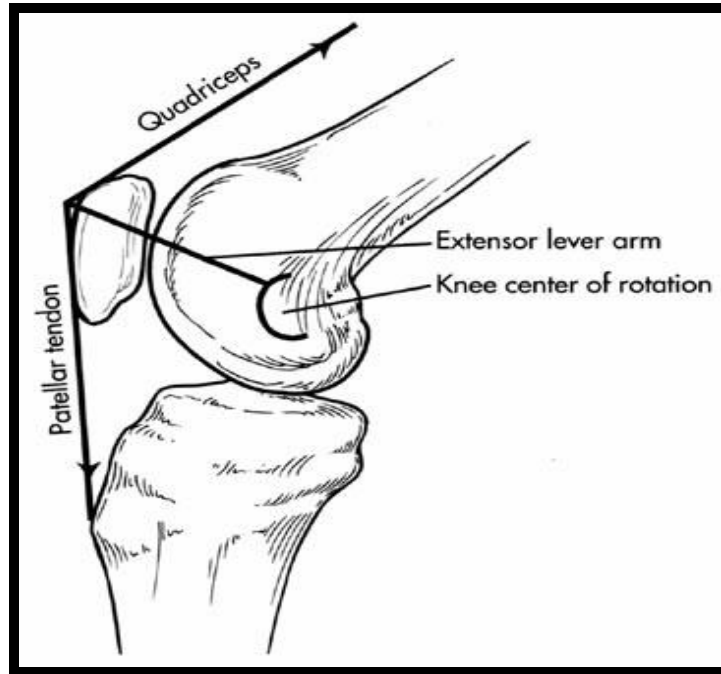
FUNCTIONS OF PATELLA

1. Patella **protects the femur** from trauma produced by quadriceps tendon as shown by Bruce and Walmsley.⁵
2. Patella functions as a **rocking lever** whose fulcrum shifts distally as the knee joint moves from flexion to extension as per Licky.⁶
3. Patella holds the extensor tendon forward, away from the center of the knee joint and **increases the leverage** of its action. (Bowen, Grant and Thomson.⁵)
4. The primary action of patella is to act as a **bone block** to prevent hyperextension of the knee.
5. Patella is responsible for most of the increase in **extensor efficiency** which accompanies knee extension.
6. The patella **distributes** upon a large and tolerably even surface, during kneeling, the pressure, which would otherwise fall upon the prominent ridges of the femoral condyles.
7. Patella gives **cosmetic** look to the knee.

BIOMECHANICS OF PATELLO- FEMORAL JOINT

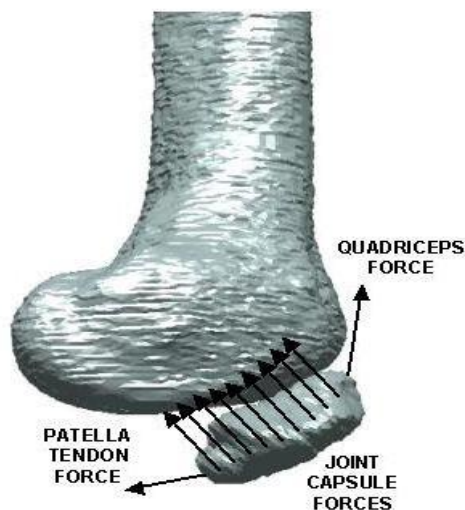
The patella is one link in the mechanism comprising the quadriceps muscle, the quadriceps tendon, the patella and the patellar ligament. The mechanism serves two important biomechanical functions. First, as it is the principle site of insertion of the quadriceps muscle, it transmits the tensile forces generated by the quadriceps to the patellar ligament.

Second, the patella effectively increases the lever arm of the knee extension mechanism from the axis of knee flexion extension. This increases the knee extensor moment generated by contraction of the quadriceps.²⁴



Kaufer clearly documented this mechanical enhancing function of the patella⁹ using cadaveric knee. He balanced a simulated quadriceps force with a restraining force at the distal aspect of the tibia at 0° to 120° of knee flexion. By calculating the moment about the knee axis (the knee moment equals the tibial force multiplied by the tibial moment arm), he was able to determine the effective quadriceps moment arm (the quadriceps moment arm equals the knee movement divided by the quadriceps force). He found that the patella serves to increase the magnitude of the quadriceps moment arm and that the contribution made by the patella increases with progressive extension of the knee, being almost 30% at full extension. And his findings have been confirmed by others and they support the contention that total patellectomy should be avoided in the treatment of patellar disorders.

The patella is subjected to complex loading with knee in extension. It transmits almost all the force of the quadriceps contraction and thus is loaded primarily in tension. However with knee in flexion, its posterior surface comes in contact with the distal aspect of the femur and is subjected to a compressive force. Which is generally called the patello-femoral joint reactive force, loading on this surface creates a three point bending configuration in the patella.



This bending load results in tension at the anterior surface of the patella, which is additive to that naturally generated by distraction from contraction of the quadriceps. The relative contribution of these modes of loading of the patella depends primarily on the position of the knee joint. As the knee moves into greater flexion, the bending forces become increasingly important. The magnitude of tensile forces in the anterior surface of the patella reaches a maximum near 45° of knee flexion.

Load across the patella have not been precisely measured but they probably are on the order of 3000 Newton's of tensile load and may rise to 6000 Newton's in young trained men.²⁴ Considering the magnitude of

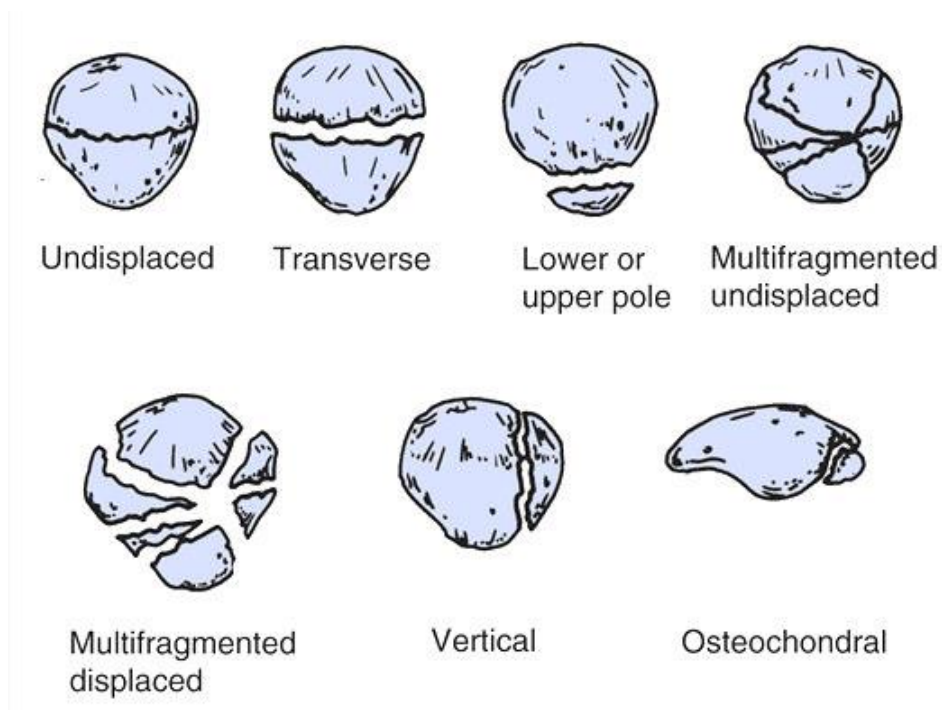
tension, three-point bending stress and compressive forces that occurs on the posterior surface of the patella in a loaded flexed knee, the recognized prevalence of patellar fracture is not surprising. Studies done by Goldstein and his team on strain on the anterior surface of the patella demonstrated that normal activities, such as stair-climbing, can generate magnitudes of surface strain that are dangerous and can result in fracture (1000 to 2000 micro strains).

These large strains in the patella play a major role in the initiation of fractures and have an equally important effect on the efficacy of various methods of treatment of fractures. The posterior articular surface of the patella is predominantly convex. The anterior articular surface of the femur is convex as well. Thus the point of contact for the patella-femoral joint through much of the range of motion of the knee is a transversely linear band. Mathews²⁴ determined experimentally the contact area for the patella-femoral joint for a range of knee flexion angles and patello-femoral loads and these studies showed small contact areas of approximately two to four square centimeters throughout most of the arc of flexion and extension. For virtually all activities and angles, the patello-femoral contact stresses exceed those sustained by the tibio-femoral joint and by other major weight bearing joints. These high contact stresses magnify the importance of maintenance of articular congruity in the treatment of patellar fractures in order to facilitate and maximize stress distribution.

CLASSIFICATION OF PATELLAR FRACTURES

Fracture of patella has been classified morphologically into.^{22, 24}

1. Transverse fractures
2. Comminuted fractures
3. Stellate fractures
4. Proximal or distal pole fractures
5. Longitudinal or marginal fractures
6. Osteochondral fractures
7. Sleeve fractures
8. Oblique fractures



Fractures occurring in a medial and lateral direction are transverse. These are usually in central and distal third of patella. Vertical fractures are in the superior inferior direction and they are rare. Fractures of the edge of the patella do not extend across the patella and are not associated with disruption of the extensor mechanism are called marginal fractures.

Displaced fractures are those with articular incongruity (step off) of more than 2 mm or separation of the fragments of more than 3mm.²⁴ Fractures with multiple fragments are called comminuted fractures. Some comminuted fractures can be characterized as stellate fractures; some transverse fractures also demonstrate comminution of one or both poles. Osteochondral fractures are primarily two types, one which is a single fragment that includes articular cartilage, subchondral bone and supporting trabecular bone which may be displaced or undisplaced. The other type of osteochondral fractures, also called Sleeve fractures which is a fractures of inferior pole of the patella with a considerable amount of articular cartilage.

MECHANISM OF INJURY

Fractures of patella occur from two major mechanism of injures:

1. Direct and
2. Indirect trauma.

The patella may be fractured by a direct blow, during a fall onto the knee or when it hits the dashboard as in an automobile accident, because of small amount of pre-patellar soft tissue and the direct contact with distal aspect of the femur posteriorly, nearly all of the force of a direct blow is delivered to the patella such direct trauma frequently causes considerable comminution but often there will be displacement of the fracture fragments with certainty, the articular cartilage of the contact area is damaged by this mechanism of injury.

Indirect trauma that causes fractures can be due to jumping or more frequently due to unexpectedly rapid flexion of knee against a fully contracted quadriceps. The natural anatomy and biomechanics of the knee

create tension, three point bending and compressive strains in the patella that exceed values sufficient to cause a fracture. Fractures resulting from indirect injury tend to be less comminuted than those from direct trauma, but they are displaced and are often transverse.²⁴ The articular cartilage is damaged with direct trauma. Most patellar fractures occur as a result of a combination of direct and indirect trauma, rarely when one hits a dash board with relaxed quadriceps.²⁴ Thompson clearly demonstrated that direct blows to patella of magnitude less than those sufficient to cause patellar fractures predictably damage the contacting articular cartilage of the patella and femur and that early biochemical and histological changes after such blows are consistent with the initiation of post traumatic arthritis.

The osteochondral fractures is caused by direct blow or more commonly a patellar dislocation may cause an immediate fracture around the point of contact²⁴ and the sleeve fractures which is an avulsion fracture occurs due to sporting activity, which requires vigorous extension of the knee is an indirect injury.²⁵

MANAGEMENT OF PATELLAR FRACTURE

A history of a direct blow, a muscle contraction or unexpected rapid knee flexion while the quadriceps was contracted together with localized pain and the inability to strongly extend the knee, is nearly diagnostic. Weak voluntary extension, a palpable defect and localized contusion, tenderness and swelling helps to make more accurate diagnosis.

Transverse fractures usually are best seen on a lateral view, whereas vertical fractures, osteochondral fractures, and articular incongruity are best evaluated on axial views. A comparison view of the opposite knee sometimes is necessary to differentiate an acute fracture from a bipartite patella, which is a failure of fusion of the superolateral portion of the patella and usually is bilateral.

TREATMENT OF PATELLAR FRACTURES

There are two modes of treatment for patellar fractures.

1. Conservative mode of treatment and
2. Operative mode of treatment.

1. Conservative Treatment: Indications

Indications:¹⁴

1. Undisplaced vertical, transverse or comminuted fractures with 2mm or less of articular surface step-off or 3mm or less of displacement of the fragments.
2. No palpable defect.
3. Ability to actively extend the knee.

The extensor retinaculum is not totally disrupted in these sorts of fractures. As patellar fractures are generally associated with hemarthrosis, under aseptic conditions the knee joint is aspirated and an above knee posterior slab is applied with knee in extension. Once swelling has subsided a cylindrical cast from ankle to groin is applied. After 4-6 weeks, cast is removed and patient is encouraged to do quadriceps strengthening and knee bending exercises.

Bostrom considered 3 to 4 mm of fragment separation and 2 to 3 mm of articular incongruity to be acceptable for nonoperative treatment; if either separation or articular incongruity is greater, operative treatment is indicated. Using these criteria in 212 nonoperatively treated fractures, 84% had no pain and 91% had normal or only slightly decreased function. In his long-term follow-up study, fractures treated non-operatively had the best overall results.

2. Operative management:

Indications:

1. Fractures with more than 2-3 mm of separation or articular incongruity.
2. Fractures associated with retinacular tears, as evidenced by a palpable defect.
3. Open fractures.
4. Fractures with displacement of loose body in the joint.

All the patellar fractures were managed conservatively until 1877 which resulted in poor results due to prolonged immobilization, delayed union, nonunion, limitation of motion and decreased quadriceps muscle

strength.²⁶ In 1877 Cameron and Lister were the first to perform open reduction and internal fixation for patellar fractures. In first half of 19th century there were opinions from many surgeons across the world about the unimportance of patella and they had advocated patellectomy for all patellar fractures. This was later disproved by various experiments and studies which led to procedures which salvages the patella and thereby preserves the function of patella by open reduction and internal fixation.

If there is too much of comminution, but with a major fracture with substantial amount of normal articular cartilage, partial patellectomy is appropriate. And only if the patella is severely comminuted and when reconstruction is not possible, total patellectomy is advised.

Operative treatment: There are **three types** of operative treatment of patellar fractures.

They are

1. Restoration of normal anatomy of fractured fragments by using metallic implants. The goal is restoration of articular congruity and repair of the extensor mechanism with fixation secure enough to allow early motion.
2. Repair of quadriceps apparatus retaining only the large fragment.

Partial patellectomy.

3. Repair of quadriceps apparatus after excising patella. ***Total patellectomy.***

Common approach for Patellar Fractures.²²

A transverse curved incision approximately 12.5 cm long with the apex of the curve on the distal fragment will give enough exposure for reduction of the fracture and repair of the ruptured extensor expansion and synovium.

Alternatively, a longitudinal midline or lateral parapatellar incision can be used, especially if the fracture is comminuted or if future joint replacement is anticipated. If an area of skin is severely contused, attempt to avoid it or elect to excise a small area, since skin closure produces no significant difficulty. Reflect the skin and subcutaneous tissue proximally and distally to expose the entire anterior surface of the patella and the quadriceps and patellar tendons. If the fracture fragments are significantly separated, tears in the extensor expansion are presumed, and these must be carefully explored medially and laterally. Remove all small detached fragments of bone and inspect the interior of the joint and especially the patellofemoral groove for an osteochondral fracture. Thoroughly irrigate the interior of the joint to remove blood clots and small particles of bone. Anatomically reduce the fracture fragments using large towel clips or appropriate bone-holding forceps and fix the fragments internally. Inspect the articular surface after fixation to be sure that the reduction is anatomical. Carefully repair with interrupted sutures synovium, ruptured capsule, and extensor mechanism from their outer ends toward the midline of the joint.

Advantage of Transverse Incision:

The advantage of transverse incision is that, the retinacular tears on either side can be identified and sutured and it is found to be cosmetically superior.²⁴

Disadvantage of Transverse Incision:

The disadvantage is that, this incision can seldom be used for other procedures on the knee should these become necessary in the future.²⁴

1. RESTORATION OF NORMAL ANATOMY OF FRACTURED FRAGMENTS:

Restoration of normal anatomy of patella and maintaining its articular congruity can be achieved by using any of these techniques.

- Martin's circumferential wire loop fixation.
- Fixation with screws and pins.
- Interfragmentary wiring.
- Magnuson's technique.
- Tension band wiring.
- Pyford technique
- Modified tension band wiring.

Circumferential wire loop fixation:

Circumferential wire loop fixation was formerly the most popular technique. With the loop threaded through the soft tissues about the patella, rigid fixation is not achieved, so a delay of 3 to 4 weeks in starting knee motion is necessary if this technique is used. It has been replaced by more rigid fixation techniques to permit early motion of the joint, although it can be used in conjunction with other techniques for fixation of comminuted fractures.

Technique (Martin):

Begin threading a no. 18 G stainless steel wire at the superolateral border of the patella, passing it transversely immediately next to the superior pole of the patella through the quadriceps tendon.

Pass the wire through the tissue using a large Gallie needle, or thread it through a large Intracath needle inserted with the sharp point exiting at the site where the next suture is desired. Fit the no.18 wire into

the sharp end of the Intracath needle, and as the needle is withdrawn, pass the no. 18 wire along its path within the needle. This usually is easier than using the large Gallie needle because of the stiffness of no. 18 wire. Pass the medial end of the wire in a similar manner along the medial border of both fragments midway between the anterior and posterior surfaces. Next pass the medial end of the wire transversely through the patellar tendon from the medial to the lateral side around the distal border of the patella and then proximally along the lateral side of the patella to the superolateral border. The wire must be placed close to the patella, particularly above and below; if it is inserted through the tendons away from the fragments.

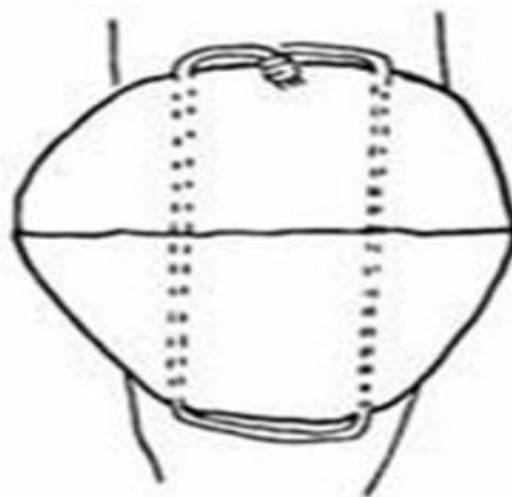
Fixation will be insecure because the wire will cut through the soft tissues when under tension and allow separation of the fragments. Furthermore, centering the wire midway between the anterior and posterior surfaces will keep the fracture line from opening anteriorly or posteriorly as the circumferential wire is tightened. Approximate the fragments and hold them in position with a towel clip or bone-holding forceps; then draw both ends of the wire until they are tight and twist them together. Confirm the position of the fragments, especially the relation of the articular surfaces, by roentgenograms of the knee in both the anteroposterior and lateral planes and by direct inspection and palpation before the capsular tears are repaired. Then cut off the redundant wire and depress the twisted ends into the quadriceps tendon. Repair the capsular tears and quadriceps expansion with interrupted absorbable suture.

A pre-twisted wire that is tightened by twists at two points opposite each other supplies more even pressure and fixation across the fracture

site. Placing the first twist in the wire before beginning its insertion allows for this extra site for tightening.

Wire loop fixation through both fragments (Magnuson):

With a small-caliber drill make two holes through the proximal fragment, beginning at the medial and lateral borders of the quadriceps tendon and directed obliquely downward to open on the fracture surface of the patella posterior to a point midway between its anterior and posterior surfaces. Drill two corresponding holes in the distal fragment, their apertures being opposite those of the proximal fragment. Thread a stainless steel no. 18 wire distally through the medial holes and then proximally through the lateral holes. After properly opposing the fragments, draw the ends of the wire taut and twist them together. Cut off the extra wire and embed the twisted ends in the soft tissue. Supplemental internal fixation using threaded pins or lag screws in addition to the wire loops occasionally is required. Lag screws that produce interfragmentary compression across fracture sites are especially useful.



Magnuson wire loop fixation

Tension band wiring for fixation:

The AO group has used and recommended a tension band wiring principle for fixation of fractures of the patella by proper placement of the wires. The distracting or shear forces tending to separate the fragments are converted into compressive forces across the fracture site, resulting in earlier union and allowing immediate motion and exercise of the knee. Generally two sets of wires are used one passed transversely through the insertion of the quadriceps tendon immediately adjacent to the bone of the superior pole, and then passing anteriorly over the superficial surface of the patella and in a similar way through the insertion of the patella tendon.

This wire is tightened until the fracture is slightly over corrected or opened on the articular surface. The second wire is passed through transverse holes drilled in the superior and inferior poles of the anterior patellar surface and tightened. The capsular tears are then repaired in the usual manner. The knee is immobilized in flexion, and early active flexion produces compressive forces to keep the edges of the articular surface of the patella compressed together. Early active flexion exercises are essential for the tension band principle to work. Schauwecker describes a similar technique but crosses the wire in a figure of '8' fashion over the anterior surface of the patella. Again supplemental lag screws or Kirschner wires may be used to increase fixation in comminuted fractures.

MODIFIED TENSION BAND WIRING:**Technique:**

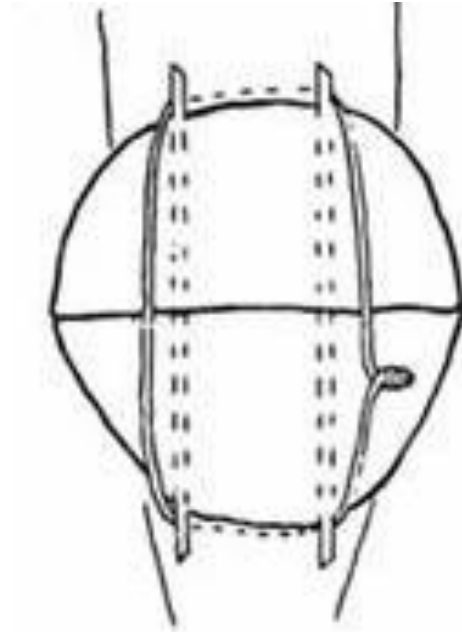
Patellar fracture approached in the usual fashion. Carefully clean the fracture surfaces of blood clot and small fragments. Explore the extent of the retinacular tears and inspect the trochlear groove of the femur for any articular damage. Thoroughly lavage the joint. If the major proximal and

distal fragments are large, reduce them accurately, with special attention to restoring a smooth articular surface. With the fracture reduced and held firmly with clamps, drill two 2-mm Kirschner wires from inferior to superior through each fragment. Place these wires about 5 mm deep to the anterior surface of the patella along lines dividing the patella into medial, central, and lateral thirds. Insert the wires as parallel as possible. In some cases, it is easier to insert the wires through the fracture site into the proximal fragment in a retrograde manner before reduction.

This is made easier by tilting the fracture anteriorly about 90 degrees. Then withdraw the wires until they are flush with the fracture site, accurately reduce the fracture and hold it with clamps, and drive the wires through the distal fragment.

Leave the ends of the wires long, protruding beyond the patella and quadriceps tendon attachments to the inferior and superior fragments. Now pass a strand of 18-gauge stainless steel wire transversely through the quadriceps tendon attachment, as close to the bone as possible, deep to the protruding Kirschner wires, then over the anterior surface of the reduced patella, then transversely through the patellar tendon attachment on the inferior fragment and deep to the protruding Kirschner wires, then back over the anterior patellar surface; tighten it at the upper end. Alternatively, place the wire in a figure-eight fashion. Check the reduction by palpating the undersurface of the patella with the knee extended. If necessary, make a small longitudinal incision in the retinaculum to allow insertion of the finger. Bend the upper ends of the two Kirschner wires acutely anteriorly and cut them short. Once they are cut, rotate the Kirschner wires 180 degrees and, with an impactor, embed the bent ends into the superior margin of the patella posterior to the wire loops. Cut the protruding ends of

the Kirschner wires short inferiorly. Repair the retinacular tears with multiple interrupted sutures.



Pyrford Technique:

The patella is accurately reduced and held with a circumferential cerclage wire passed in a purse-string fashion close to the bone. To complete the fixation a second wire was passed through the quadriceps tendon. Looping anteriorly across the patella and through the patellar tendon to act as a tension band; both wires were of 18 G stainless steel thus Pyrford Technique is a combination of cerclage and tension band principles.

Advantages of open reduction and internal fixation:

1. Restores normal integrity of bone
2. Cosmetically appearance is good
3. Symmetry of knee joint maintained
4. Restores the protective mechanism of the knee

5. Period of immobilization is reduced
6. Residual disability is minimal
7. Instability will be minimized

Disadvantages:

1. Difficult to restore smooth articular surface
2. Predisposes to early osteoarthritis
3. Avascular necrosis - due to interference with the blood supply more common in circumferential wire loop
4. Infection of the joint
5. Inadequate fixation leads to nonunion or fibrous union
6. Requires second surgical procedure to remove the implant.

2. PARTIAL PATELLECTOMY:

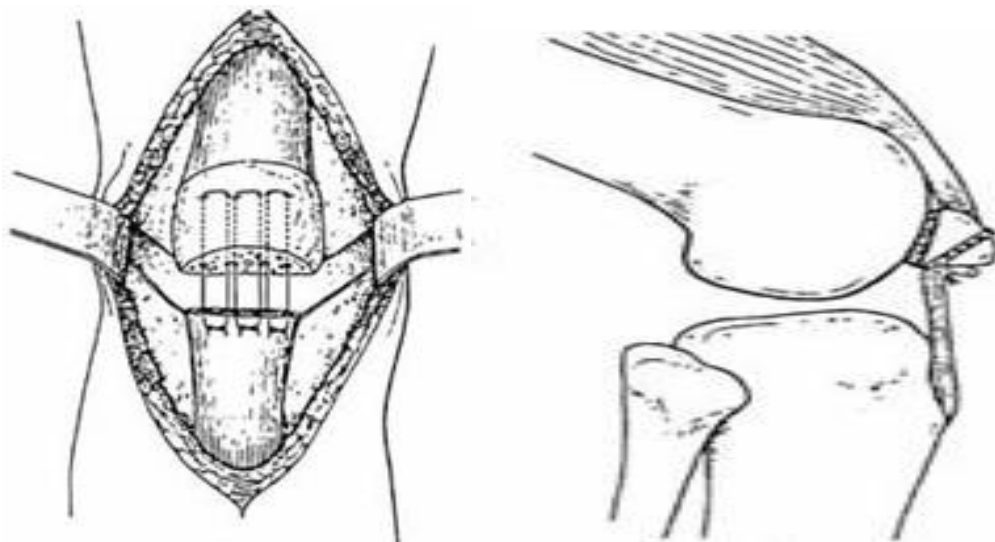
Indication:

In fractures of patella where there is comminution of distal fragment leaving a substantial and relatively normal proximal fragment. This fragment plays an important part of the extensor mechanism and which can be preserved.

Technique:

Expose the fracture through a transverse incision and clear the joint of loose fragments of bone and cartilage. If the proximal half or more of the patella is intact, preserving that part, the edges of capsule and tendon are trimmed. Excise the comminuted fragments leaving a small fragment of the distal and anterior part of patella buried deep within the tendon to facilitate anchorage. Trim the articular edge of the proximal fragment and smooth it with a rasp. Beginning on the fracture surface of the proximal fragment just anterior to the articular cartilage, drill two holes in a proximal direction pass

a No. 18 G stainless steel wire through the patellar tendon distal to the small fragment of bone and then insert its ends through the holes in the remaining part of the patella. Draw the wire tight so that the small fragment of bone in the patellar tendon is evaginated and lies in an axis at a right angle to its original position and opposes the fracture surface. The wire suture is placed correctly in a posterior position through the fracture surface; the patellar tendon will come in contact principally with the articular edge of the fragment and not its anterior edge. Thus the tilt of the fragment is prevented and its raw surface does not contact the femur, occasionally the proximal pole of the patella is comminuted, leaving a single distal fragment consisting of half or more of the bone. This fragment, provided it contains a smooth articular surface should, also be preserved by applying the principles given in the technique just described.



3. TOTAL PATELLECTOMY:

Indications:

- ❖ Comminuted fracture of patella, where reconstruction is not possible.
- ❖ Compound fracture patella.

- ❖ Old non-union or malunited fracture patellar causing secondary patello-femoral arthritis.

Technique:

Through a transverse Incision expose the patella and excise all the fragments, preserving as much of the patellar and quadriceps tendons as possible.

Clear the joint of bone chips and debris by thorough irrigation, place a No. 18 stainless steel wire or a strong non absorbable suture like proline, through the margins of the patellar and quadriceps tendons and through the medial and lateral capsular and extensor expansions in a purse-string manner. Tighten the wire with a wire tightener and evaginate the tendon ends completely outside the joint when the suture has been tightened until it makes a circle about 2cm in diameter, twist it securely, cut it off at the twist and embed its ends in the quadriceps tendon.

Although small, this rosette of tendon may give the appearance of a small patella.

Supplemental interrupted sutures are used to repair the capsular rupture and to further oppose the quadriceps and patellar tendon ends. The purse-string suture shortens the quadriceps mechanism and helps prevent extensor lag post-operatively.

The limb is immobilized in extension with posterior slab; the patient is encouraged to perform quadriceps-strengthening exercises and within few days should be lifting the leg off the bed. At 10-14 days the sutures are removed and a cylinder cast is applied with knee in extension.

Repair of the patellar tendon as in total patellectomy requires a minimum of four weeks immobilization after this period; progressive rehabilitation of knee is initiated with protective immobilization between exercise sessions. Passive stretching does not help to restore mobility and may harm repair. Several months of continuous effort are necessary to produce maximum range of motion and strength.

COMPLICATION AND THEIR MANAGEMENT

The complications of the treatment of patellar fracture²⁷ are classified into

1. Early complications

- a. Infection
- b. Loss of reduction

2. Late complications

- a. Delayed union
- b. Refracture
- c. Non-union
- d. Malunion
- e. Secondary arthritis of patella-femoral joint
- f. Avascular necrosis
- g. Loss of knee movement

Early complications:

a. Infection:

Infection may be the result of open fracture or may be secondary to operative repair of a patellar fracture and treatment is the same, in principle regardless of the origin of infection. The rate of infection for patella fractures is low in most clinical series. The rate of infection in

open injuries is 10.7% in the Mayo clinic series.²⁸ Although not common, postoperative wound infections should be recognized and treated according to standard protocols. This should include debridement of all nonviable soft tissue and evaluation of the stability of the fixation. Stable fixation may be retained with an aggressive surgical debridement and the use of intravenous antibiotics. A secondary goal is to prevent the exposure of the knee joint to the infection. Areas of osteomyelitic bone should undergo aggressive removal of all nonviable tissue. The patient should receive a 6-week course of culture-specific intravenous antibiotics. Once the bone infection is controlled, every attempt is made to salvage the remaining patella. This can be accomplished using modified wiring techniques. A total patellectomy is indicated for failure to control the infection or inability to salvage the remaining patella. Adequate soft tissue coverage is important in the treatment of infections and may require local rotational flaps at the knee.

b. Loss of reduction:

With the use of early aggressive range-of-motion exercises, redisplacement of the fracture fragments can occur due to inadequate fixation or inadequate postoperative immobilization. Although not common, Nummi noted a 7.4% incidence of late displacement of patella fractures managed with closed treatment. He found an 11% incidence of loss of reduction with internal fixation.

Hardware failure can occur and may require revision surgery in the healing phase of fracture management. Indications for reoperation are separation of fragments of more than 3 to 4 mm or the development of more than 3 mm of articular incongruity. If a closed reduction fails to

improve the position of the fragments as determined by the lateral radiograph, this may warrant a second surgical procedure.²⁹

Late complications:

a. Refracture:

Refracture of the patella occurs infrequently, usually where the fracture healed by fibrous union and later pulls apart from stress or through osteoporosis or demineralization in the few months following fracture. The partial patellectomy repair may also cause the remaining fragment to refracture in which case another surgical repair or excision will be required.

b. Non-union/ Delayed union:

Delayed union can be defined as failure of trabecular bone to bridge the fracture gaps on radiographs at 2 or more months after injury. Postoperative radiographs with greater than 2 mm fracture gap may lead to delayed unions. Prolonged immobilization may be considered in fracture gaps of less than 2 mm; however, repeat open reduction and internal fixation should be considered for larger gap displacement.

The surgeon should be prepared to use any number and combination of fixation techniques for the revision surgery. There is a low incidence (2.4% to 12.5%) of patella fracture non-union. Weber and Janecki found only three cases of non-union in their large series.¹⁰ Non-unions are most common in transverse fractures but can be seen in comminuted fractures without stable internal fixation. Most non-union can be treated with a period of decreased motion. Nummi found good clinical results in 14 of 17 nonunions.²⁹ Some elderly patients tolerate the non-union well with its associated muscle weakness and lengthening of

the extensor mechanism, however this is not tolerated in the younger patient. Reoperation should be considered in non-union with a large separation gap (>4 mm), especially in the younger patient. If extensive chondromalacia or osteoarthritis exists, a partial or total patellectomy may be warranted in certain patients.

c. Malunion:

Mal union of patellar fractures is detrimental, because of the articular surface incongruity, which causes grating, grinding and degenerative arthritis. There is no way of correcting malunion except by total patellectomy or resurfacing.

d. Avascular necrosis:

Avascular Necrosis occurs more commonly in circumferential wiring of patella usually the upper fragment will go for avascular necrosis. It is diagnosed by characteristic increased density on an X-ray taken after two months.

e. Loss of knee movement:

Functional range of motion can usually be achieved with stable internal fixation and early aggressive physical therapy. However, in some cases, loss of flexion may persist. Every attempt to restore this motion with intensive physical therapy should be tried for 6 to 8 weeks. Failure of conservative treatment is an indication for a controlled manipulation under anesthesia. Before such a procedure, the postoperative radiographs should be scrutinized carefully to ensure there is no mechanical blockage by the internal fixation. The manipulation should be performed carefully to prevent rupture of the soft tissue or refracture. Should manipulation fail to achieve a functional range of motion, an arthroscopic lysis of

adhesions can be considered. The use of an indwelling epidural anesthesia and continuous passive motion with intensive physical therapy may provide physical and physiologic benefits for the patient. A quadricepsplasty may be considered after 8 to 12 months if there is no improvement in the range of postoperative knee motion.

f. Secondary osteoarthritis:

In middle aged and elderly patients, fracture of patella may lead to osteoarthritis, which can be managed by excising the patella.

TENSION BAND PRINCIPLE

The tension band concept was introduced to orthopaedics by Pauwels in the 1930's and was applied to internal fixation of eccentrically loaded bone.⁸ In order to restore the load bearing capacity of an eccentrically loaded fractured bone and minimize the force borne by the fixation device, it is necessary to absorb the tensile forces, the result of the bending movement and convert them into compressive forces. This requires a tension band. A tension band is therefore a device, "which will exert a force equal in magnitude but opposite in direction to the bending force".

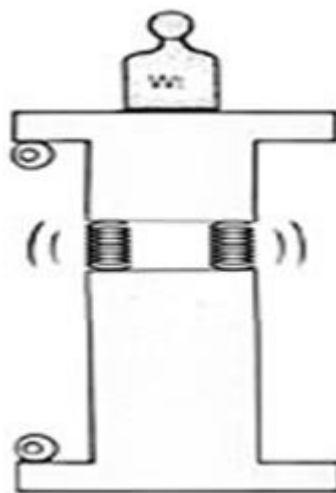
The tension band must be made of a material which resists tensile forces and which can be prestressed. The bone must be able to withstand compression. This means that the bone must not be comminuted either under or on the opposite side from the tension band. The prestressing of a wire in tension will result, as we have already learned in axial compression of bone. If such a bone is now subjected to eccentric loading as for example the femur, the prestressing of the tension band plate will resist the tensile forces and convert them into compressive forces. This will result in a simultaneous increase and uniform distribution of compressive forces across the fracture. The dynamic component of the compression rises when the bone is loaded and is subjected to bending. The pre-stress in the tension band ensures that the bone remains loaded in compression even when the dynamic component of the loading is removed. Thus the fluctuations in the load are in magnitude not in direction.

The pre-requisites for tension band fixation are:

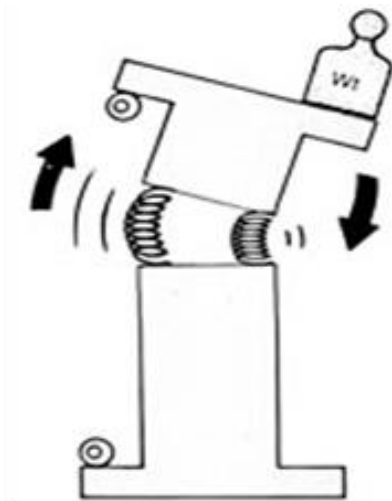
1. A plate/wire should be able to withstand the tensile forces.
2. Bone should be able to withstand compression.
3. An intact buttress of the opposite cortex.

Muller et al, described the principles of tension band wiring as below. Schematic drawing which illustrates the differences between load and stress and which demonstrates the principle of tension and fixation.

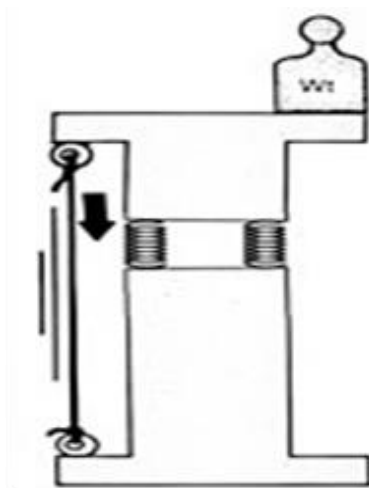
- a. If a column with a surface area of 10 cm^2 is loaded axially with 100 kp, it is subjected to pure axial compression $D=10 \text{ kp/cm}^2$.



- b. If the column is now subjected to eccentric loading, we have not only the axial compressive stresses but also additional bending stresses which give rise to further compressive stresses and tensile stresses. In our example, the resultant compressive stresses on the medial side $D=110 \text{ kp/cm}^2$ and on the lateral side the tensile stresses $Z=90 \text{ kp/cm}^2$.



c. These bending stresses can be neutralized by a chain (or a wire) prestressed to exert a force equal and opposite to the weight. The chain then represents a tension band (c). The resultant compression corresponds to the pressure which would result if a second weight were placed on the opposite side and equidistant from the center of the column (d). Although the load is increased (200 kp), the total stress is reduced to a fifth ($D=20 \text{ kp/cm}^2$), because the bending stresses have been completely neutralized.



If we wish to use the tension band principle to achieve dynamically an increase in interfragmental compression, we must place the prestressed

implant (wire or plate) wherever we have maximal tensile forces, i.e. furthest from the load axis.

Modified tension band wiring

Modified tension band wiring was first described by Muller⁸ which involves the use of two parallel 2mm Kirschner wires combined with an 18 gauge wire looped over the Kirschner wires and over the anterior aspect of the patella to act as a tension band. This anterior tension band neutralizes the large distraction force that occurs across the anterior surface with contraction of the quadriceps and also with flexion of the knee. As tension is resisted by this wire, compressive forces are generated at the posterior aspect of the fracture gap, improving stability at the articular surface failures are often directly attributable to errors in operative technique.

The Modified tension band technique is currently the most widely accepted and several studies have shown a high percentage of good results.²⁴ The application of AO tension band principles in the operative management of patella fracture has gained great popularity and in many trauma or Orthopaedic centres this method is the treatment of choice.^{8,30,31} The AO tension band method of fixation of fractured patella has given excellent results of internal fixation because it is a simple, effective means of immobilizing the fracture, has very sound biomechanical background theory, and allows early mobilization of the knee joint.^{8, 31,32,33,34}

MATERIALS AND METHODS

This prospective study was done in Department of Orthopaedics at R L Jalappa Hospital and Research Centre, attached to Sri Devaraj Urs Medical College, Kolar during the period from December 2010 to June 2012. This study consists of 30 cases of displaced transverse fracture patella treated by modified tension band wiring. The cases were selected based on inclusion and exclusion criteria.

Inclusion criteria:

1. All closed and type I open displaced transverse patellar fractures.
2. Transverse fracture with displacement of more than 2 to 3 mm and articular step of more than 2mm.
3. Comminuted fractures where reconstruction and fixation by modified tension band wiring are still possible.

Exclusion criteria:

1. Type III compound fractures.
2. Grossly comminuted, vertical or marginal fractures.
3. Old fractures (more than 2-3 weeks).

METHOD OF COLLECTING DATA:

Once the patient was admitted to the hospital, the details of the case regarding the name, age, sex, occupation, and address were recorded. All the Patients are personally interviewed for mode of injury and duration was recorded, thorough general and clinical examination was carried out and radiographs were taken. The patients were selected according to the protocol and routine laboratory investigations were carried out.

The limb was immobilized by an above knee plaster of Paris posterior (POP) slab and operation was done at a later date. In the meanwhile patient was prepared for surgery.

OPERATIVE PROCEDURE:

The fracture site was exposed through transverse incision/ midline longitudinal incision in front of the knee; the fragments were reduced and held in position with the help of patellar clamp or towel clips. Two K-wires of 2 mm thickness were passed parallel to each other from above down wards starting at its superior border till lower pole of patella is reached. 18 G stainless steel wire was taken and passed deep to ligamentum patellae inferiorly and behind the quadriceps tendon superiorly making a figure of '8' in front of the patella sufficient tension was given. Tear in the quadriceps expansion was sutured with vicryl and wound closed in layers. Above Knee slab or pressure bandage was given as a temporary immobilization. Check X-Rays were done post operatively.

POST-OPERATIVE MANAGEMENT:

The operated knee was immobilized in extension in an above knee posterior slab, and advised to do straight leg raising test and weight bearing started from third post-operative day. Sutures were removed from 12th to 14th day; later on knee flexion was started with quadriceps board and with continuous passive motion (CPM) machine. They were advised to do dynamic quadriceps exercises (isometric) which they could do themselves at home regularly and patients were discharged 14th to 20th post-operative day.

FOLLOW UP:

The discharged patients were advised to report for follow up every month, during each follow up the patients were examined for both subjective symptoms and objective signs which was recorded. The patients were questioned about subjective complaints like pain, difficulty in walking, squatting, climbing and getting down stairs and ability to perform routine work. The patient's objective assessment was done for Extensor lag, Range of knee movement, circumference of thigh (wasting) and Efficacy of quadriceps (power).

OBSERVATION AND RESULTS

In our study, 30 cases of displaced transverse fractured patella are treated by modified tension band wiring, the findings and the end results of our study were analysed in the following discussion.

Table No. 1: Age distribution

Age in years	No. of cases	Percentage
0-10	0	0%
11-20	1	3.33%
21-30	5	16.67%
31-40	10	33.33%
41-50	6	20%
51-60	6	20%
61-70	2	6.67%

Fracture of patella occurs in any age, but it occurs rarely below 30 years, in our series the range of age was between 19-70 years, the mean age was 42 years and the incidence was high in the age group of 31-40 years.

Chart No. 1: Age distribution

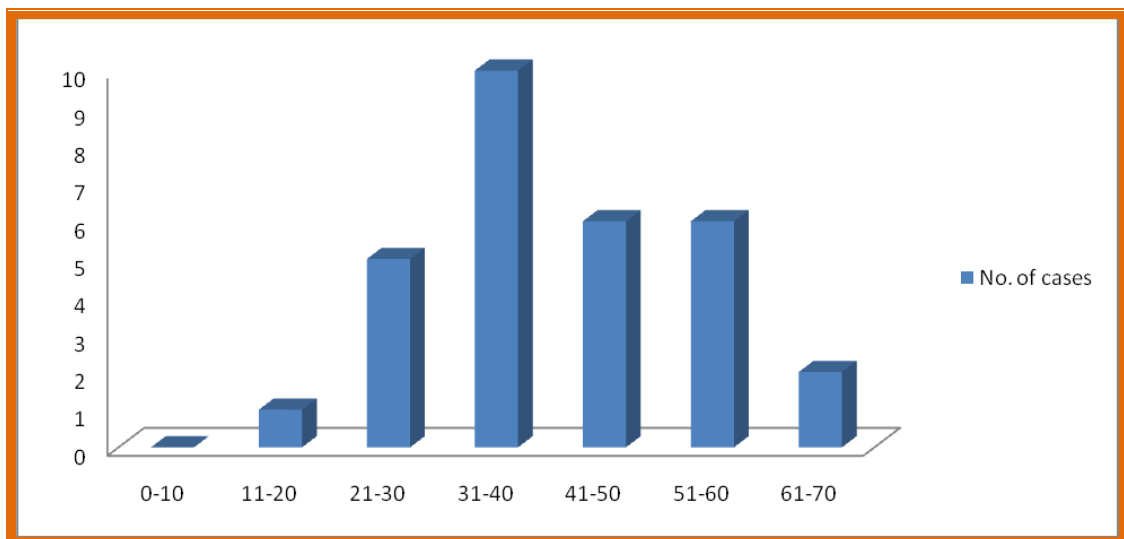


Table No.2: Sex distribution:

Sex	No. of patients	Percentage
Male	24	80%
Female	6	20%

In a total of 30 cases, 24 fractures were in men and 6 fractures were in females.

Chart No.2: Sex distribution.

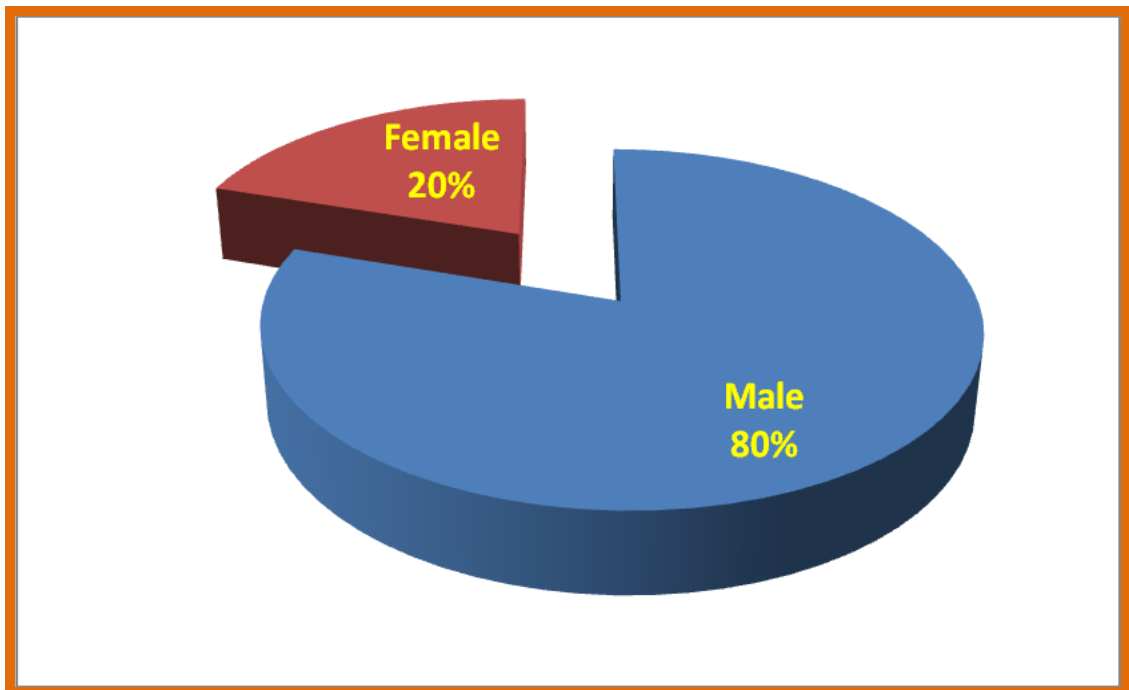


Table No.3: Mode of Injury

Mode of Injury	No. of cases	Percentage
Indirect	22	73.33%
Direct	8	26.67%

In our study of 30 cases, 22 fractures were as a result of indirect mechanism (forceful flexion of the knee against a contracted quadriceps as in fall from height) and 8 cases were due to direct trauma to the patella as in RTA.

Chart No.3: Mode of Injury

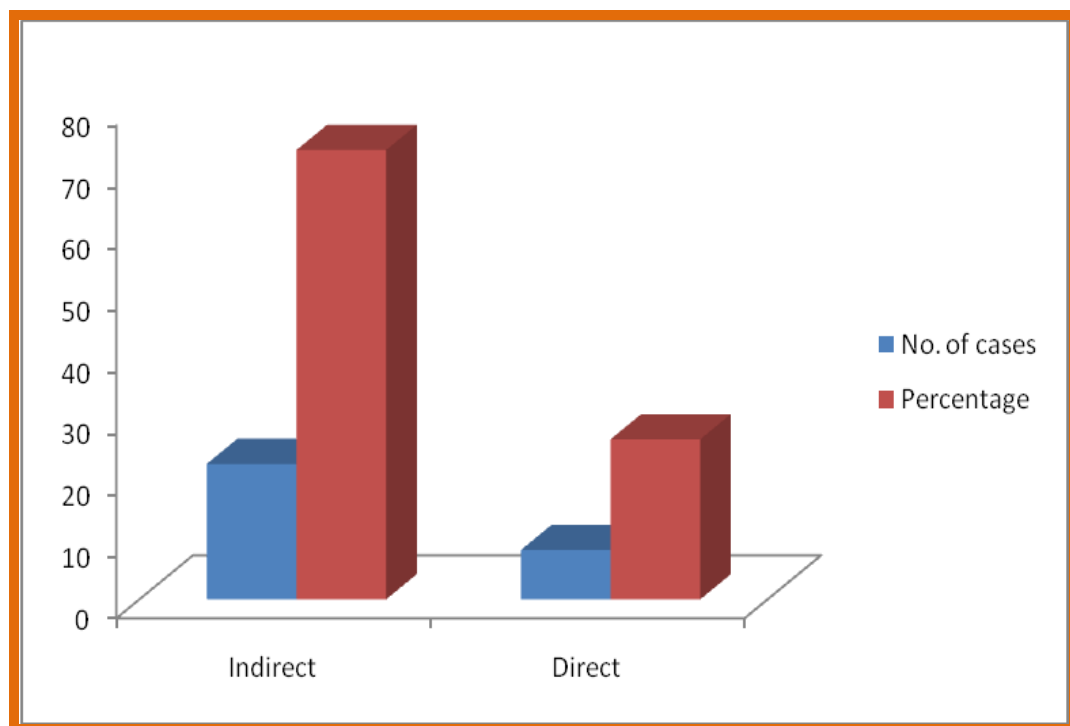
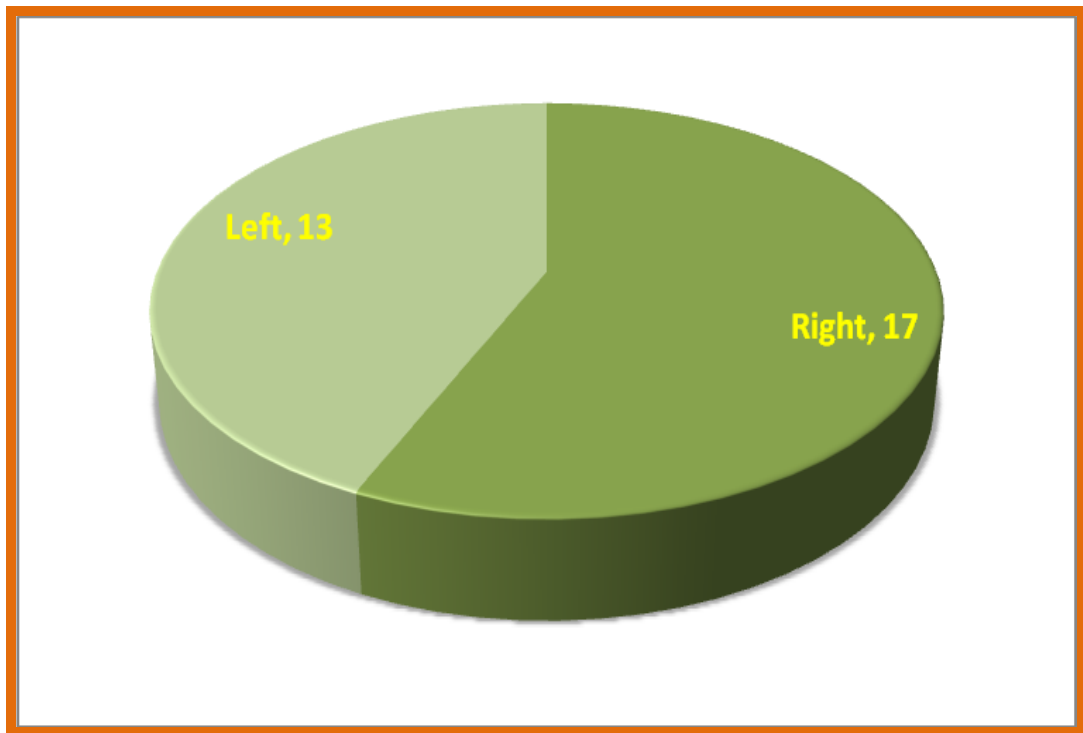


Table No.4: Side of fracture

Side of fracture	No. of cases	Percentage
Right	17	56%
Left	13	44%

In our study of 30 cases 17 patients had fracture on the right side and 13 patients had fracture on the left side. There were no cases of bilateral fracture patella seen in our study.

Chart No.4: Side of fracture



Associated Injuries

Two patients of patellar fractures had other associated injuries. Both had ipsilateral fracture shaft femur that were treated with intramedullary fixation.

Hospital Stay

Average duration between injuries to hospital admission was about 1.16 days. The average duration between the days of admission to the day of surgery is about 2.93 days and the average duration of stay in hospital is about 13.2 days (ranging from 11 to 22 days). Longest stay was 22 days in a patient due to superficial infection of the wound and this was healed by 3rd week under antibiotic cover and sterile dressings.

Post-Operative Immobilization

As all the cases of patellar fractures in our study were associated with tear of the extensor retinaculum which was repaired during surgery, all the patients were immobilized in an above knee POP slab for 2 weeks. After which patients were thought quadriceps exercises and knee bending exercises.

In patients with ipsilateral femoral shaft fractures that were treated with intramedullary fixation, quadriceps exercises and knee bending exercises were started after 2 weeks, and non-weight bearing crutch walking was advised for 8 weeks.

Post-Operative Complications

No intra operative complications like fragmentation at wiring, difficulty in closure were encountered. In the immediate post-operative period we had a case of wound gaping after suture removal and a case of superficial infection of the wound.

As for the delayed complications all the fractures were united at an average of 13.6 weeks, so we had no cases of delayed or malunited fractures. But we had a case of migration of pin through the skin after 11 weeks for which implant was removed and another case of limitation of flexion by 25 degrees.

Follow Up

All our patients were discharged after teaching them quadriceps exercises, and they were followed up every month for 20 weeks (5 months).

During the follow up patients were asked about the subjective symptoms, and the objective signs were elicited and recorded. All the cases were assessed based on **WEST'S CRITERIA**²⁶ which is graded as:

EXCELLENT -

- Patient does not have any limitation of activities
- No loss of flexion
- No extensor lag
- No subjective complaints
- No quadriceps wasting or subsequent reduction in power

GOOD (1 or >1 criteria) -

- Moderate limitation of activity
- Extensors lag of 5-10 degrees
- Minimal wasting of quadriceps and power of Grade 4
- Some subjective symptoms
- Flexion loss not >30 degrees

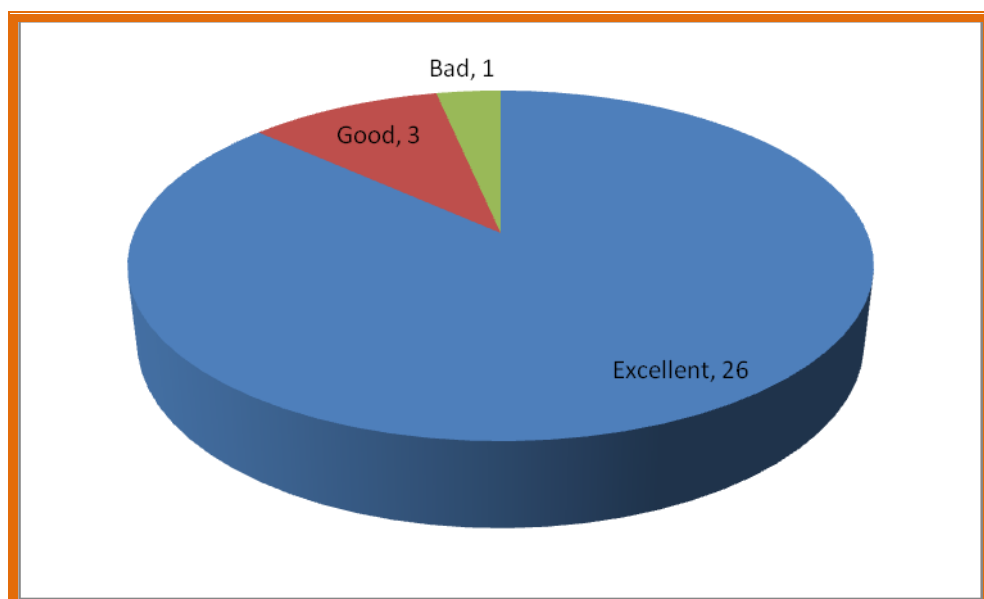
POOR (1 or >1 criteria) -

- Marked limitation of activities with significant complaints of pain and weakness
- Marked quadriceps wasting and power <3
- Extensor lag >10 degrees
- Flexion loss >30 degrees

Table No. 5: Based on WEST'S CRITERIA our results were graded as:

Results	No. of cases	Percentage
Excellent	26	86.6%
Good	3	10%
Bad	1	3.3%

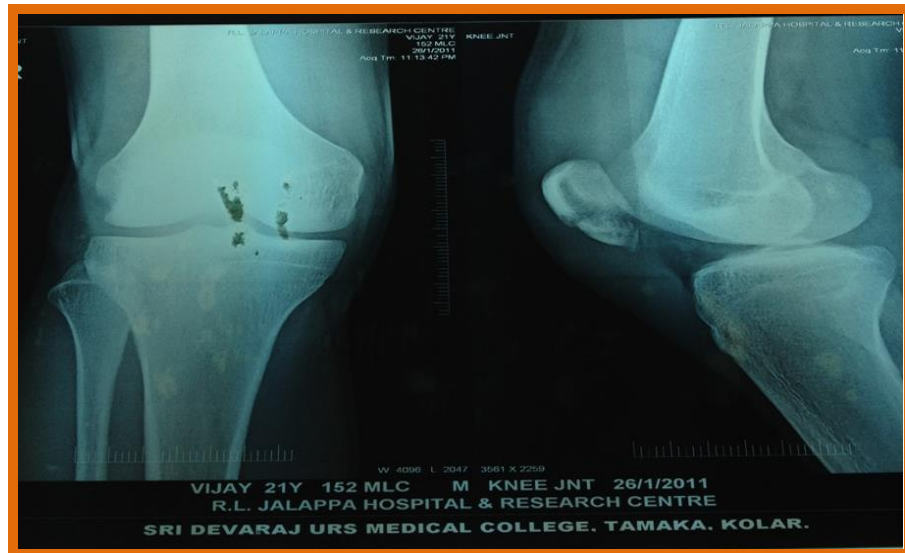
Chart No. 5: Based on WEST'S CRITERIA our results were graded as



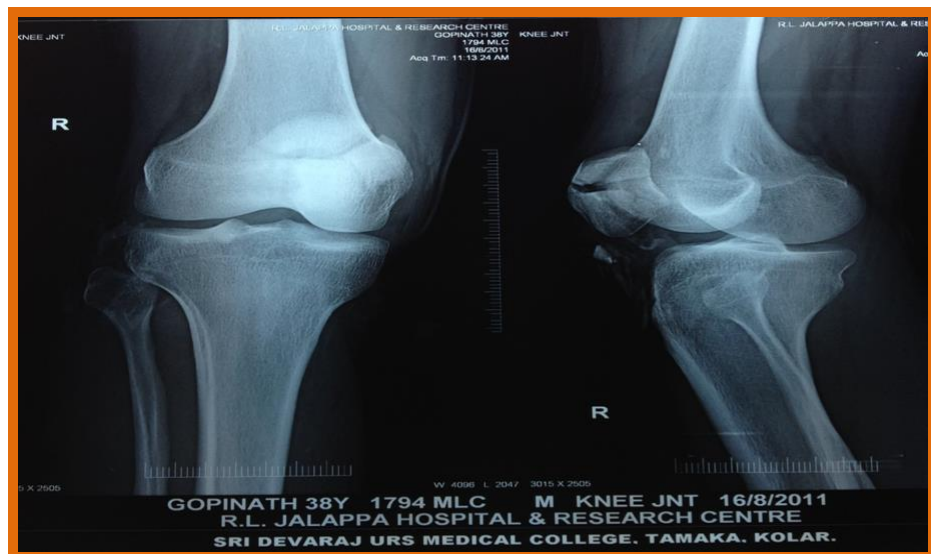
IMPLANTS



PRE-OP X-RAYs



Case No.4



Case No.8



Case No.16

PROCEDURE



Incision

Fracture site Exposure



K-Wires Introduction

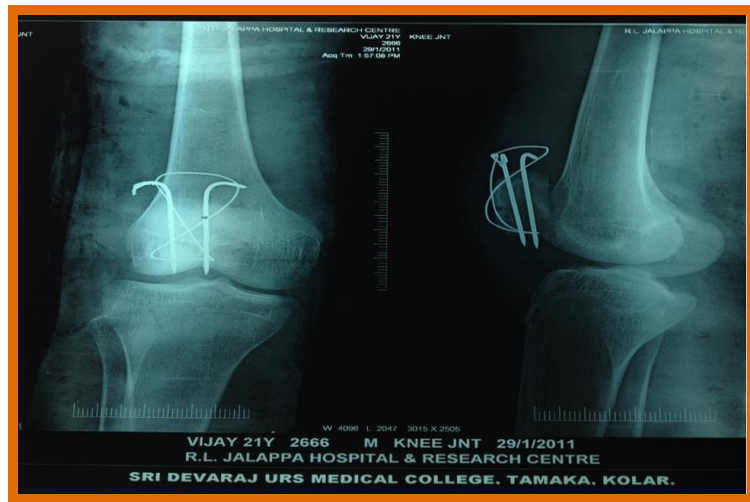


Figure of "8" Application

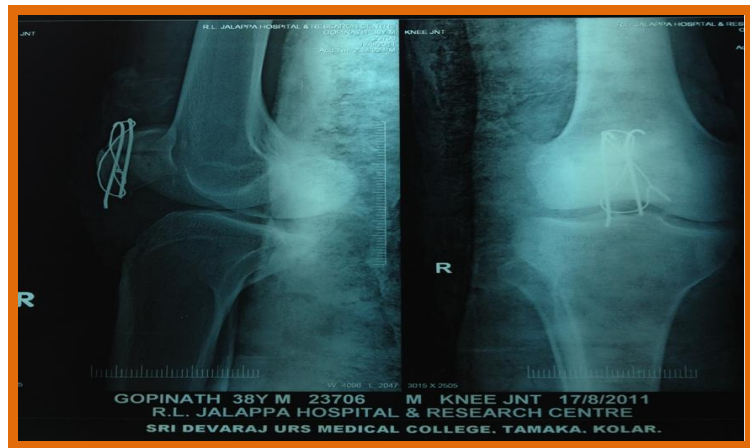


POST-OP X-RAYs

Case No.4



Case No.8



Case No.16



FOLLOW UP PICTURES

Case No.16



Case No.8



COMPLICATIONS



A-P VIEW (Pin migration through the skin)



LATERAL VIEW (Pin migration through the skin)

DISCUSSION

Patellar fractures are common and it constitutes about 1% of all skeletal injuries resulting from either direct or indirect trauma. The subcutaneous location of the patella makes it vulnerable to direct trauma as in dashboard injuries or a fall on the flexed knee. Whereas violent contraction of the quadriceps results in indirect fractures of patella. These fractures are usually transverse and are associated with tears of medial or lateral retinacular expansions. Any improper and inadequate treatment would inevitably lead to a great deal of disability which would be most perceptibly felt in a country like India, where squatting is important activity in daily life.

Controversy exists regarding treatment of patellar fracture since the earliest times. There were two schools of thoughts, one school of thought, led by Brooke (1936) and supported by Watson Jones (1945) favour patellectomy. And another school of thought lead by Haxton (1945) believed in complete, accurate and anatomical reduction of patella fracture. Thomson (1942) advocated excision of the smaller fragment and reattachment of the larger fragment to the ligamentum patellae.

In this study a series of 30 cases of fracture patellae have been studied where the results were obtained after treating with Modified Tension Band Wiring.

Age of the patients was ranging from 19 years of minimum to 70 years of maximum with an average age of 42years. In the present study there were 26 males (80%) and 6 females (20%).

In study done by Einolas et al, there were 71% males and 29% females. Their study also showed involvement of 63% cases on right side.⁷

The present study showed the involvement of right side in 17 cases (56%) and 13 cases on (44%) left side. In the present study 22 fractures (73%) were as a result of indirect mechanism as in forceful flexion of the knee against the contracted quadriceps, and 8 cases (27%) were due to direct trauma (RTA) to the patella.

In the present study we have included only transverse pattern of patellar fractures which were displaced. And this type of fracture pattern showed excellent results with modified tension band wiring irrespective of the age of the subject.

In the present study 2 out of 30 cases had associated injuries and this was attributed to the road traffic accidents. These associated injuries did not influence the end result of the treatment.

In this study the average follow up was five months, where as in Einolas et al⁷ study and Dudani et al¹¹ study the average follow up was 12 to 18 months.

Thus for complete assessment of outcome and for seeing the late complications like patello-femoral arthritis we need an extended follow up of 6 months to one year.

In all the cases, fractures were anatomically reduced and were internally fixed. We had four cases with complications, among which one case had wound gaping for which secondary suturing was done, another with superficial skin infection which was controlled by 3rd week post operatively. The 3rd case had terminal 25° of flexion restriction. And in the fourth case there was migration of the pin through the skin, for which implant removal was done and the limb was immobilized in a cylindrical cast for 4 weeks.

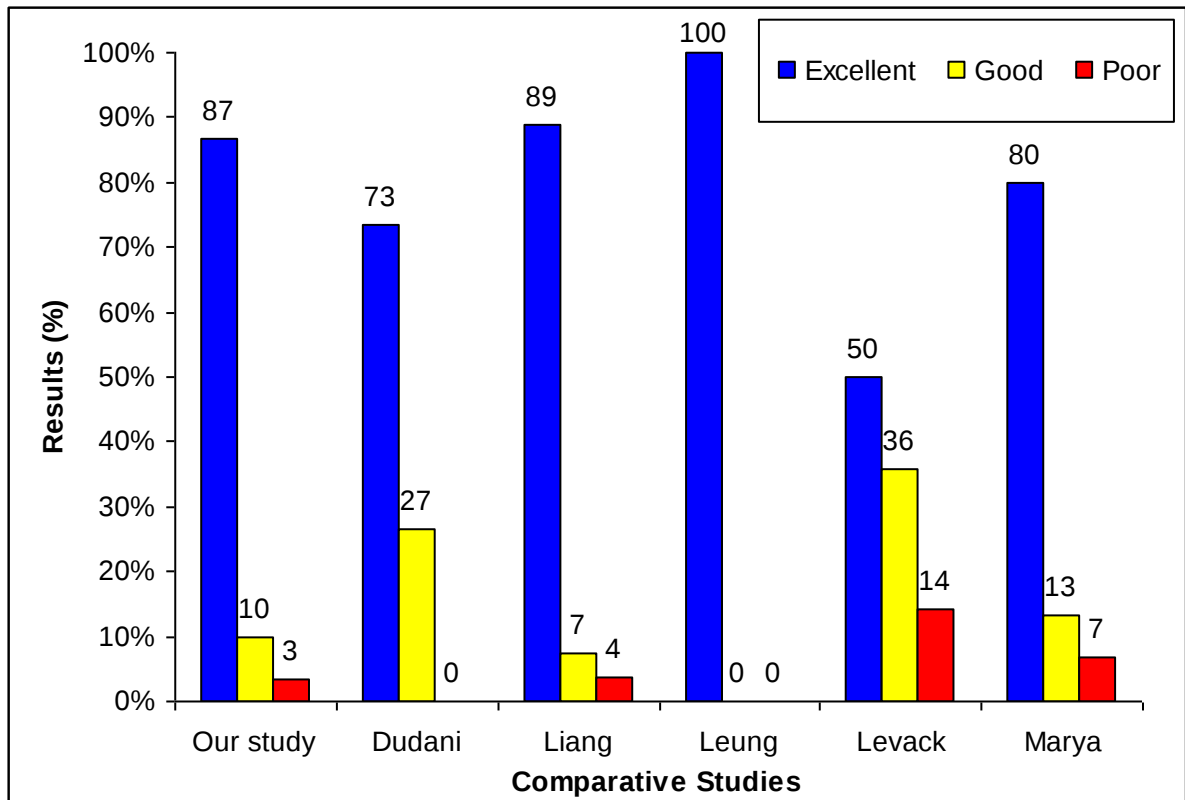
The results of the present study are similar to that in the literature. This study showed 86.6% excellent, 10% good and 3.3 % poor results.

Dudani et al¹¹ showed 74% excellent and 26% good results in his study.

Table No. 6: RESULTS COMPARED WITH OTHER STUDIES:

S. No	Series	Cases	Excellent	Good	Poor
1	Our study	30 (100%)	26 (86.6%)	03 (10.0%)	01 (3.3%)
2	Dudani ¹¹	15 (100%)	11 (73.33%)	04 (26.66%)	00 (0%)
3	Liang ¹²	27 (100%)	24 (88.88%)	02 (7.40%)	01 (3.7%)
4	Leung ³¹	05 (100%)	05 (100%)	00 (0%)	00 (0%)
5	Levack ³⁵	14 (100%)	07 (50%)	05 (35.71%)	02 (14.28%)
6	Marya ¹³	30 (100%)	24 (80%)	04 (13.33%)	02 (6.66%)

Chart No. 6: RESULTS COMPARED WITH OTHER STUDIES:



SUMMARY AND CONCLUSION

We have done a prospective study for the management of patellar fractures treated by modified tension band wiring in 30 patients over a period of one and half year from December 2010 to June 2012 in the Department of Orthopaedics, R.L.Jalappa Hospital and Medical Research Centre attached to Sri Devraj Urs Medical College, Kolar.

All the patients were preoperatively assessed both clinically and radiologically and operated by modified tension band wiring. Follow up of the patients was done clinically and radiologically at 4th, 8th, 12th, 16th and 20th week.

In our study we observed good to excellent result in about 86.6% and good in about 10% and poor in 3.3% of cases. 4 Out of 30 cases had complications.

The results of our study were comparable with other studies in the literature. Physiotherapy is a very essential tool of success in the management of these fractures, which helps in reducing complication like stiffness of knee and in providing good functional. Our outcome was not influenced by the associated injuries. Long-term follow up is necessary to assess late complications like osteoarthritis and late functional outcome.

Thus we concluded that

1. Anatomical reduction and stable fixation in patellar fracture is necessary for the normal integrity and stability of the joint.
2. Our study shows that modified tension band wiring is a definitive procedure in management of displaced transverse patellar fracture with least complications.
3. Since most cases of patellar fractures are associated with extensor retinacular tear, repair of the tear is necessary for early mobilization.
4. This surgery of modified tension band wiring helps for early mobilization post-operatively.
5. Early post-operative physiotherapy plays an important role in final outcome.

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ANNEXURES

ANNEXURE - I

PROFORMA

NAME	:	IP NO	:
AGE/SEX	:	DOA	:
ADDRESS	:	DOS	:
OCCUPATION	:	DOD	:

HISTORY

1. Nature of Trauma
 - a) RTA
 - b) Fall from a height
 - c) Sports injuries
 - d) Assault
2. Mechanism of injury
 - a) Direct
 - b) Indirect
3. Duration since injury in hours
4. Pain in the knee joint
5. History of massage
6. Any associated injuries

PAST HISTORY

1. History of chronic illness- DM/HTN/BR.ASTHMA/TB
2. Past surgical history
3. Personal history

GENERAL PHYSICAL EXAMINATION:

- ☐ Pulse rate
- ☐ Blood pressure

LOCAL EXAMINATION:

- ☐ Swelling:
- ☐ Presence of Wound:
- ☐ Presence of Infection
- ☐ Compound or Simple fracture:
- ☐ Deformity
- ☐ Tenderness:
- ☐ Presence of distal neurovascular deficits:

RELEVANT INVESTIGATIONS

- ☐ Complete blood count
- ☐ Mini renals
- ☐ Urine routine
- ☐ X-ray of the knee joint- AP & LATERAL

FINAL DIAGNOSIS

MANAGEMENT

PRE OPERATIVE TREATMENT

- FIRST AID: Elevation of the limb
- Parental antibiotics & analgesics
- I.V Fluids
- Knee aspiration and POP slab

OPERATIVE TREATMENT

- Duration since trauma
- Type of Anesthesia
- Approach
- Complications during surgery.

POST OPERATIVE TREATMENT

- Antibiotic and analgesics
- Slab
- Suture removal on
- Follow up X-ray
- Post op rehabilitation

FOLLOW UP:

Follow-up	2rd week	4th week	8th week	12th week	Final Follow Up
PAIN • MILD • MODERATE • SEVERE					
RANGE-OF MOTION(ROM) • FLEXION • EXTENSION					
EXTENSOR LAG					
QUADRICEPS STRENGTH (MRC grading)					
ACTIVITY • Unlimited • Limited due to pain • Limited for self-care.					
IMMOBILIZATION • Period					
INFECTION					
FOLLOW UP X-RAYS					

FOLLOW-UP x-rays are taken immediate post-operatively, after 8 weeks and after 20 weeks.

Annexure - II : Master Sheet

S. NO	NAME	IP.NO.	Age in years	Gender	Mechanism of Injury	Side	Flexion in Degree	Extension in Degree	Quadriceps Power / Wasting	Complications
1	GAYATHRI	614531	35	F	I	R	135	0	GRADE V	NIL
2	LAKSHMANA	616713	48	M	I	R	135	0	GRADE V	NIL
3	MARAPPA	669231	55	M	D	R	120	0	GRADE V	SUPERFICIAL WOUND INFECTION AND TREATED WITH ANTIBIOTICS
4	VIJAY	671826	21	M	I	R	135	0	GRADE V	NIL
5	MUNIYAPPA	683956	69	M	I	R	135	0	GRADE V	NIL
6	SOMASHEKAR	707345	24	/M	I	R	135	0	GRADE V	NIL
7	NARAYANA SWAMI	709614	25	M	D	L	135	0	GRADE V	NIL
8	GOPINATH	726745	38	M	I	R	135	0	GRADE V	NIL
9	NARAYANA SWAMY	732315	28	M	I	R	135	0	GRADE V	NIL
10	RAMASWAMY	737112	55	M	D	R	135	0	GRADE V	NIL
11	DODAPAI AH	755971	70	M	I	L	135	0	GRADE V	NIL
12	SUBRAMANYAM	766089	45	M	D	R	135	0	GRADE V	NIL
13	PRAKASH	766520	35	M	D	R	110	0	GRADE V	NIL
14	NATARAJ	772191	45	M	I	L	135	0	GRADE V	NIL
15	SUBRAMANI	779586	35	M	D	R	135	0	GRADE V	NIL
16	KONAPPA	780811	60	M	I	L	135	0	GRADE V	NIL
17	VENKATESHAPPA	781804	60	M	I	L	135	0	GRADE V	NIL
18	HANUMAPPA	783013	58	M	I	L	135	0	GRADE V	NIL
19	SRINIVAS	789960	34	M	I	R	135	0	GRADE V	NIL
20	GU VAPPA	813570	45	M	I	R	110	0	GRADE V	NIL
21	MUNIYACHARI	814533	45	M	I	L	135	0	GRADE V	NIL
22	CHINAMMA	817759	60	F	I	L	135	0	GRADE V	NIL
23	PAPAMMA	821845	32	F	I	L	120	0	GRADE V	PIN MIGRATION THROUGH THE SKIN
24	NARSIMHA	835581	19	M	D	R	110	0	GRADE V	FLEXION LOSS BY 25 DEGREES
25	SAVITHRAMMA	839095	38	F	I	L	135	0	GRADE V	NIL
26	SIDDAMMA	842254	48	F	D	R	135	0	GRADE V	NIL
27	MUNIVENKATA	842364	30	M	I	L	110	0	GRADE V	WOUND GAPING FOR WHICH SECONDARY SUTURING WAS DONE
28	RAMESH	855381	36	M	I	R	135	0	GRADE V	NIL
29	JAYARAMAPPA	855394	38	M	I	L	135	0	GRADE V	NIL
30	LAVANAYA	857409	36	F	I	L	135	0	GRADE V	NIL