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Fractures of Upper End Tibia

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Introduction

Knee joint is a major weight bearing joint. Because of increasing high velocity injuries fractures of proximal end of the tibia are becoming more common. Being a subcutaneous bone, articular fractures of proximal tibia demands significant thinking during treatment.

This article reviews the literature and restricts the discussion to open reduction, articular reconstruction, bone grafting and stabilization of proximal tibial articular fractures in adults.

Surgical anatomy of proximal end of the tibia.

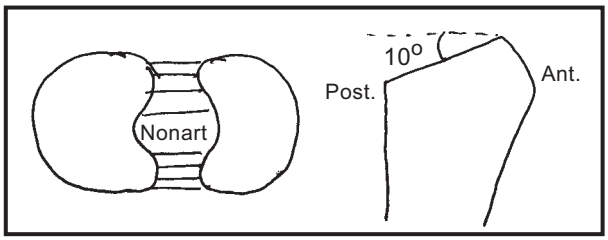


Fig. 1 :

(A) The proximal end of the tibia expands to form two articulations for medial and lateral femoral condyles with a central nonarticular area for attachment of menisci and cruciate ligaments.

(B) The proximal articular surface slopes posteroinferiorly by 10°. This casts a oval shadow on AP x-ray, the lower edge represents posterior border.

(C) The medial tibial condyle is,

(a) Broader

(b) Oval anteroposteriorly to allow anteroposterior glide and external or internal rotation of medial femoral condyle during flexion and extension.

(c) concave

(D) The lateral tibial condyle is

(a) Smaller

(b) Circular

(c) Convex

(d) There is posterolateral overhang for articulation of fibula.

(E)

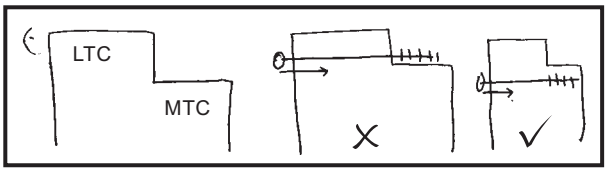


Fig. 2:

The lateral tibial condyler articular surface is at higher level than medial tibial condyle.

This fact is important to prevent intra articular placement of lag screw when passed from lateral to medial side.

(F) The menisci :

1. Help in transmission of weight over a broader surface area.

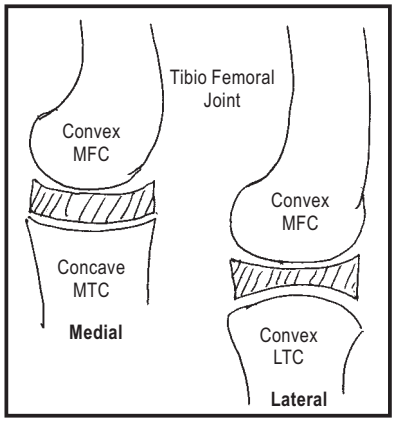


Fig. 3 :

2. Improve gliding because of articular upper and lower surfaces.

3. Improve stability by adopting to different shapes of femoral and tibial condyles. This deepens the tibiomeniscal articular surface, more on lateral side.

(G) Because of flat articular surfaces knee is a potentially unstable joint. The stability is given by soft tissues around the joint (collateral ligaments, menisci, cruciate, ligaments and capsule) and large muscles.

(H) Collateral ligaments, cruciate ligaments, cupsule and muscles help in proprioception.

✷ Force of Injury ✷

Vertical thrust and bending are two important forces responsible for this injury

(A) Vertical thrust :

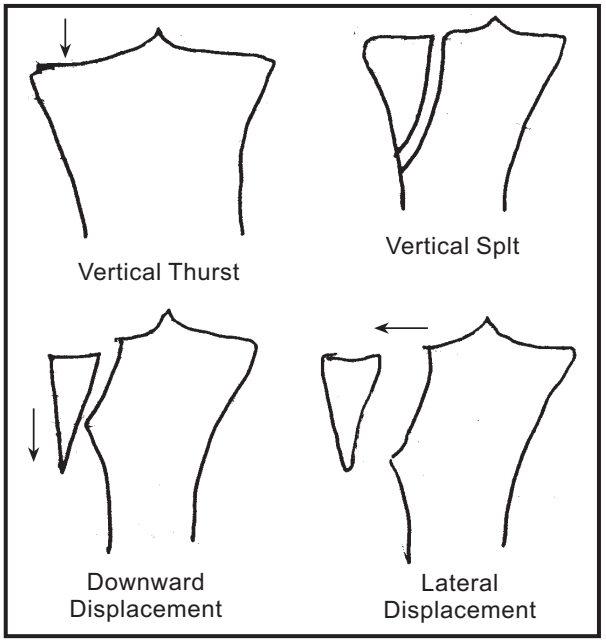


Fig. 4 :

Vertical thrust splits the condyle. This creates a wedge fracture. This wedge may displace laterally causing widening of tibial condyle or displace inferiorly causing a step.

Both these displacements cause joint incongruity, reduction in area for articulation and varus or vulgus instability.

Meniscus may get entrapped when the wedge fragment displaces laterally and prevent reduction

(B) Bending :

This produces tension force on side of distraction and compression force on other side.

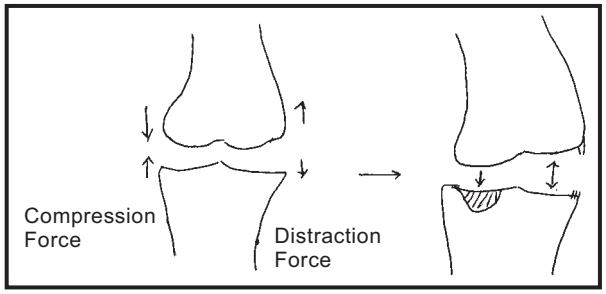


Fig. 5 :

This results in —

(a) Stretching or rupture of collateral ligaments, capsular attachment or cruciate ligament on side of distraction.

(b) Meniscal damage (tear, peripheral avulsion or entrapment in fracture surfaces) or articular depression, on side of compression.

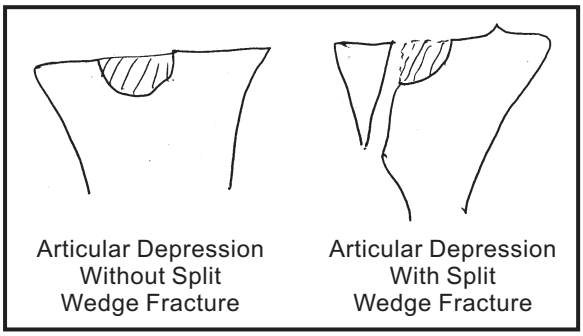


Fig. 6 :

This causes articular incongruity, varus or valgus angulation and instability.

The extent of soft tissue and bony injury depends upon

✦ Direction of force

✦ Velocity of injury

✦ Density of bone

- With dense bone the soft tissue injury is more,with porotic bone the soft tissue injury is less.

- With significant force the joint subluxates or dislocates.

✷ Effect of Injury on Joint Function ✷

- Mechanisms of deterioration of knee joint function.

For proper functioning the joint requires

(a) Adequate articular surface area.

(b) Articular congruity.

(c) Stability on weight bearing and movement.

(d) Axial alignment-Absence of deformity.

(e) Satisfactory range of movement.

(f) Absence of pain.

The effects of injury to tibial condyle are

(A) Reduction in area of articular contact.

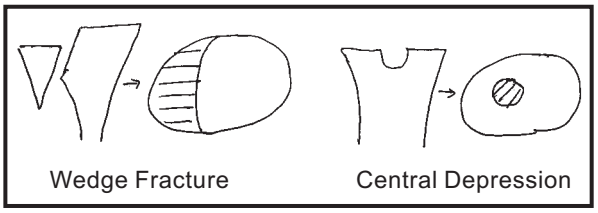


Fig. 7 :

This happens due to,

1. Outward and /or distal displacement of wedge fragment

2. Depressed articular area : This depressed area does not fill with fibro cartilage and remains as a permanent defect. This depression if more than 4 mm (2 mm according to some authers) causes axial malalignment.

(B) Articular incongruity : This is because of

1. Displaced (laterally or distally) split wedge fragment.

2. Depressed articular surface.

3. Combined

(C) Axial malalignment : The weight bearing axis is shifted to the side of defect due to

1. Tilted articular surface.

2. Reduced articular support - because of displaced wedge fragment and / or depressed articular surface.

3. Stretched or ruptured articular ligaments and capsule.

(D) Instability :

1. Due to bony causes : articular incongruity and axial malalignment

2. Due to soft tissue causes : stretched or ruptured articular ligaments and capsule or menisci.

(E) Increased shear or glide :

1. Due to bony malalignment.

2. Due to ligamentous or capsular laxity.

(F) Damage to articular cartilage :

1. At time of trauma.

2. Due to immobilization.

3. Due to early weight bearing.

All these factors are responsible for residual pain, stiffness, deformity, recurrent effusions and give way.

All poor results of open or closed treatment are proportional to residual articular incongruity, axial malalignment and instability.

So we should aim at stable, aligned joint, congruous articular surface with painless movements having satisfactory range of movement.

✷ Other Pararticular Injuries ✷

(A) Popliteal vessles : This injury is common with fracture dislocation - Type IV The deficit may be obvious at time of presentation. There may be intimal tear with clinically good circulation. This may occlude with thrombus during surgery and cause limb ischemia

(B) Peroneal nerve : This is seen with fracture dislocation - Type IV. This is a traction injury and the nerve usually is in continuity. The intranural damage extends to a variable length depending on the amount of displacement and force of traction.

✷ Fracture Anatomy ✷

The anatomy of fracture is governed by

(a) Force of injury- low /medium/high.

(b) Direction of force-vertical thrust, bending.

(c) Bone quality.

Knee joint is a major weight bearing joint. The movements are governed by large muscle groups. So these two forces alone or in combination are responsible for displacement of fracture fragments during treatment.

There are various classifications. Out of these Schwatzkar classification appears to be simpler. It groups the fractures into six types, each type represents a group of fractures that are similar in pathogenesis and pattern, pose similar problems in treatment and have a similar prognosis. The main features of these fractures are

✦ Vertically split fracture with wedge fragment.

✦ Depression of articular surface.

✦ Both.

✷ Type I ✷

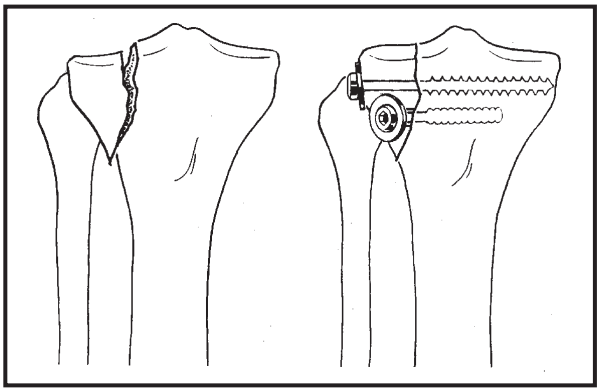


Fig. 8 :

(A) Pathogenesis :

✦ Fracture of Lateral tibial condyle.

✦ This fracture occures in patients having dense cancellous bones usually before 40.

✦ Due to vertical thrust and bending.

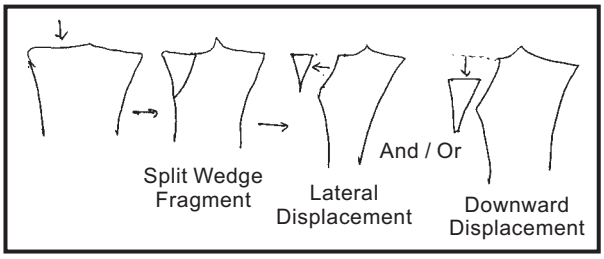


Fig. 9 :

✦ The vertical thrust generates a shearing force which causes a vertical split fracture of LTP creating a wedge fragment. The dense cancellous bone of LTC resists depression.

(B) Fracture Pattern

1. There is no depression as dense cancellous bone resists depression.

2. Vertical split fracture.

✦ Wedge fragment may be lateral or postero-lateral.

✦ Displacement.

(a) Undisplaced.

(b) Displaced.

✦ Spread apart resulting in widening of plateau.

✦ Displaced downward.

✦ Combination.

✦ If there is significant displacement and widening there is possibility of entrapment of lateral meniscus.

✦ Intact fibula supports the wedge fragment. Fracture of the fibula makes the fragment more unstable.

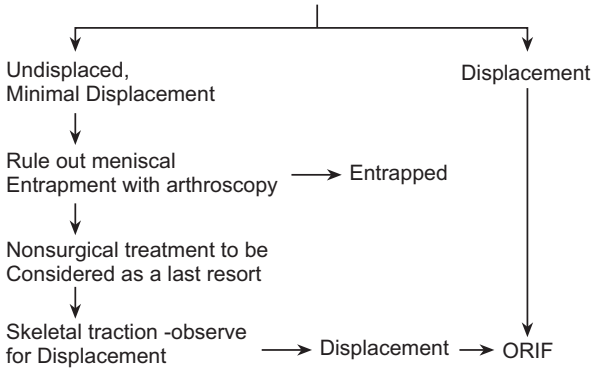
(C) Treatment :

Problems :

1. Think about meniscus entrapment even if the displacement is minor-confirm with arthroscopy.

2. This fracture occurs at young age so proper reconstruction should be considered.

(D) Protocol :



(E) Prognosis : Excellent if proper joint reconstruction is done.

✷ Type II ✷

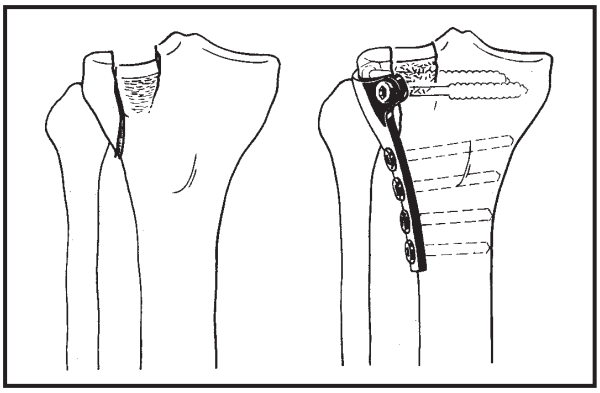


Fig. 10 :

(A) Pathogenesis :

- ✦ Fracture of the lateral tibial plateau.
- ✦ This occurs in a moderately osteoporotic bone :- age 40 to 60
- ✦ Due to vertical thrust and bending

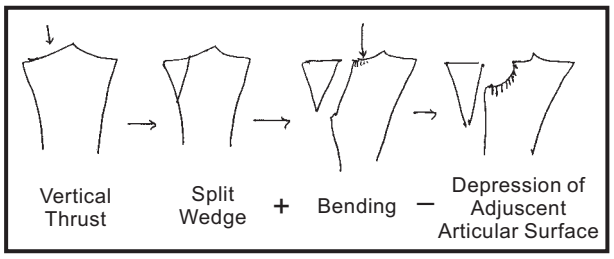


Fig. 11 :

The vertical thrust generates a shearing force which causes vertical split fracture of LTP as in type I As the force continues the wedge fragment displaces laterally and the femoral condoyle presses on the intact articular surface medial to the fracture. This causes depression of articular surface of adjacent remaining weight bearing portion of LTP.

(B) Fracture pattern :

1. Vertical split fracture and wedge fragment.

- ✦ Size-wedge vary from thin rim to one third of the articular surface.
- ✦ Site - lateral or posterolateral.
- ✦ Displacement -

(a) Spread apart (lateral displacement) resulting in widening of plateau.

(b) Displaced downward.

(c) Combined.

Because of intact soft tissue attachments the wedge fragment can be reduced by traction.

2. Depression of articular surface :

Site : Depression may be anterior, posterior, central or combined.

Assessment of Depression

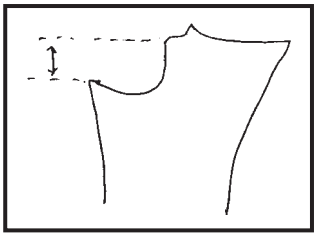


Fig. 12 :

Measure the vertical distance between the lowest recognizable point on the medial plateau and the lowest depressed part of the lateral plateau.

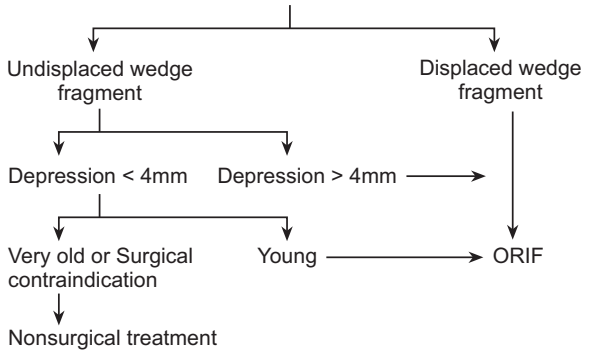
Impaction of depressed fragment occurs in metaphysis. It is not possible to pull the impacted fragments by traction.

This depression does not fill with fibrocartilage. It remains as permanent defect in articular surface.

Depression more than 2 mm is significant, and if it is more than 4mm it causes joint incongruity, valgus deformity and instability.

(C) Treatment : Traction can reduce the split wedge fragment but can not disimpact and elevate the depressed and impacted articular fragment.

D) Protocol :



(E) Prognosis : Good prognosis if joint is properly reconstructed.

✷ Type III ✷

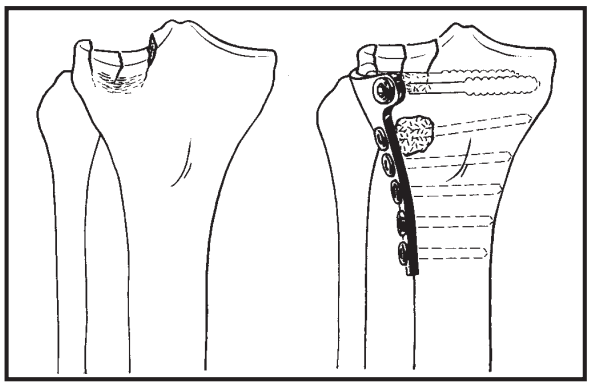


Fig. 13 :

(A) Pathogenesis :

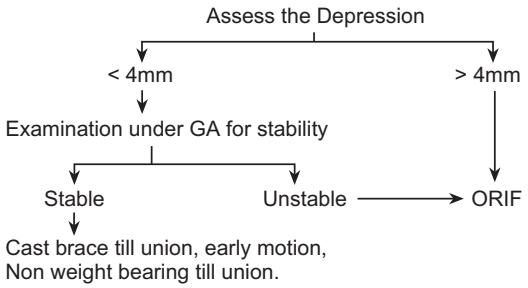
- ✦ This is a fracture of the lateral tibial condyle.
- ✦ This occurs in osteoporotic bone age 55-60.
- ✦ This occurs when a smaller force is exerted on weaker bone.
- ✦ Due to vertical thrust.

(B) Fracture pattern :

- ✦ Pure depression without a associated lateral wedge fracture.
- ✦ **Size :** vary from small area to whole condyle
- ✦ **Site :** usually central and lateral but may involve any part of condyle
- ✦ **Stability :** Usually the joint remains stable except in postero lateral depressions where a greater degree of instability is seen.

(C) Treatment : Examine each fracture under anasthesia. If stable treat with cast brace, early motion without weight bearing If unstable do open reduction and internal fixation.

(D) Protocol :



(E) Prognosis : This fracture pattern is least serious of all fracture types. Stability is rarely affected so the outcome is good in both operative and nonoperative treatment.

✷ Type IV ✷

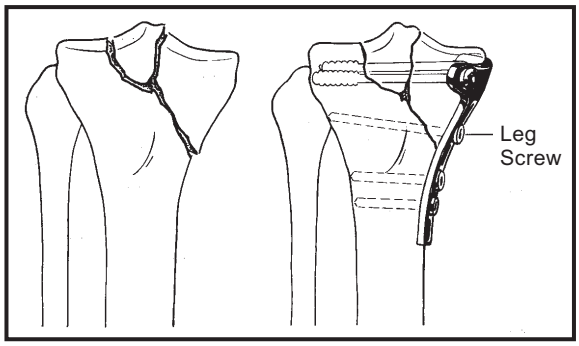


Fig. 14 :

(A) Pathogenesis :

- ✦ This is a fracture of the medial tibial plateau
- ✦ The medical tibial plateau is more difficult to overload, so the force required to fracture the MTC is of higher magnitude. So this happens with
  1. high velocity trauma in dense cancellous bones- young adult
  2. Low velocity bending force in grossly osteoporotic bone - old age.

(B) Fracture pattern : There are two patterns depending on amount of osteoporosis

1. In old people with severe osteoporosis the medial condyle fractures with trivial trauma but usually the comminution is so severe that it is not possible to reconstruct.

2. In young patent with less osteoporosis, force required is much higher and the MTC fracture represents a part of fracture dislocation.

This includes

(a) Split fracture of MTC without depression

(b) Fracture of intercondylar eminence and adjacent bone with attached cruciate ligaments.

(c) Lateral collateral ligament injury- stretching, division in substance or avulsion with bone.

(d) Capsular injury : stretching, avulsion

(e) Popliteal vessles : Division, thrombus or intimal tear.

(f) Peronial nerve : Traction injury-stretching or rupture.

So this fracture usually represents a subluxation or dislocation which has been spontaneously reduced.

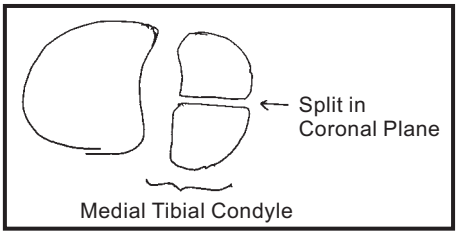


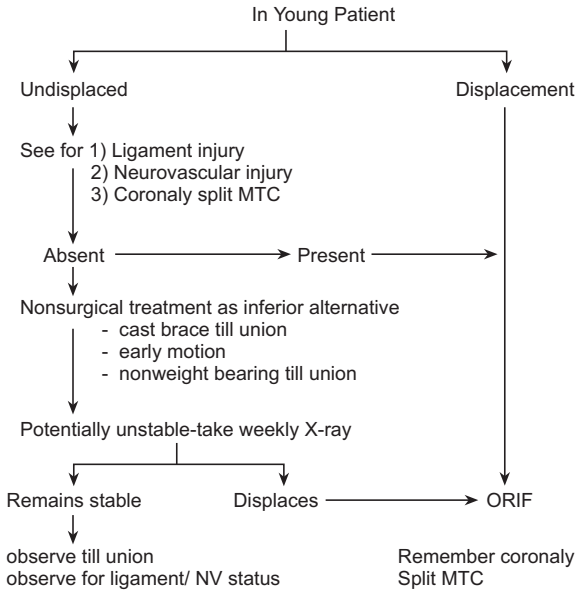
Fig. 15 :

The split wedge fragment involving MTC may have a second split in coronal plane. The posterior wedge fragment displaces distally and posteriorly. Failure to recognize and treat this fragment gives poor results.

(C) Treatment : This is a potentilly unstable injury. Undisplaced fracture can displace during treatment due to muscular forces during movement even without weight bearing. So most of the fractures require ORIF.

One has to see for poplitial vessle & peronial nerve injury. Remember coronaly split MTC.

(D) Protocol :



2) In old patient : Most of the time this fracture is severely comminuted. Reconstruction is not possible. Traction does not give reduction. So there is significant instability and joint incongruity. This gives very poor results.

(F) Prognosis : This type has worst prognosis.

This represents fracture dislocation, and association of ligament, vascular and neurological damage makes the prognosis worst.

✷ Type V ✷

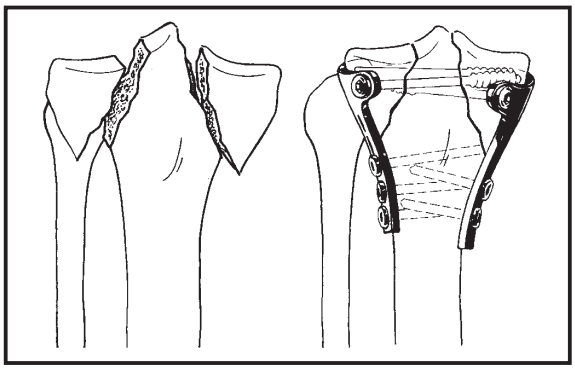


Fig. 16 :

(A) Pathogenesis : This is a Bicondylar fracture.

It results from equal axial thrust on both plateaus

There is no dissociation between metaphysis and diaphysis.

(B) Fracture pattern :

- ✦ Wedge fractures of medial and lateral tibial condyle
- ✦ Usually no depression but may occur.
- ✦ Two different patterns.

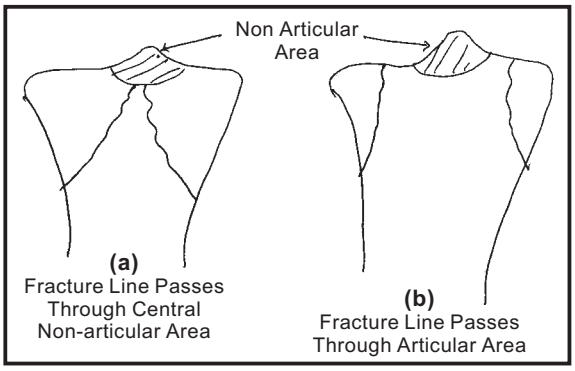


Fig. 17 :

(a) Fracture which does not involve articular surface and passes through central nonarticuler intercondylar area.

(b) Fracture which involves the articular surface.

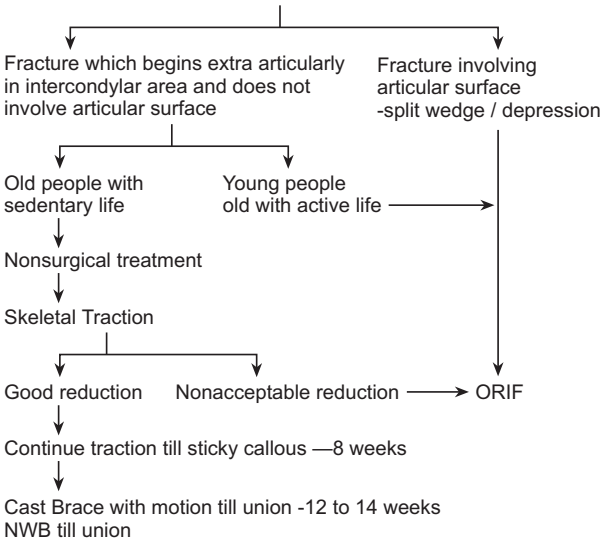
(C) Treatment :

1. Fractures involving articular surface need ORIF.

2. fractures not involving articular surface can be managed nonsurgicaly. As the soft tissue hinge is intact and there is no articular depression skeletal traction often brings a satisfactory reduction. But as soon as the patient is off the traction in cast brace the fragments collapse. This causes widening of condyles and laxity of collateral ligaments. The resultant varus, valgus instability is not acceptable in young people, and in old people with active life.

Continue on →→→→

(D) Protocol :



Some impaction occures once out of traction and results in residual varus or valgus instability.

(E) Prognosis : This depends upon :

- ✦ Residual varus or vulgus instability.
- ✦ Athetic demand / active life.
- ✦ Articular involvement.

✷ Type VI ✷

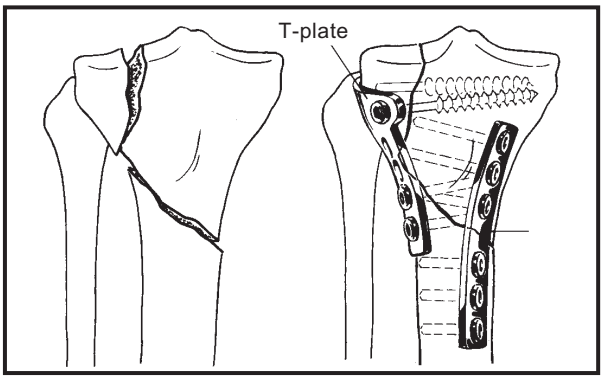


Fig. 18 :

(A) Pathogenesis : This is the most complex fracture type. There is involvement of articular and metaphysial area. The metaphysial fracture separates the diaphysis from metaphysis.

This is a high velocity injury,so there is marked displacement and depression of articular fragment.

(B) Fracture Type :

(a) Articular fracture

- ✦ Unicondylar or Bicondylar.
- ✦ Split wedge and / or depression.
- ✦ Wide displacement.
- ✦ Severe articular depression.
- ✦ Medical condyle being strong survives as single large split fragment.

(b) Metaphysial fracture :

- ✦ Seperates the diaphysis from metaphysis.

(C) Treatment : Traction is not effective because,

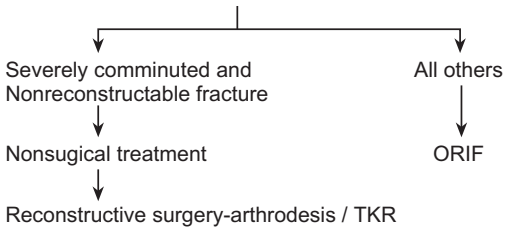
(a) It seperates the diaphysis from metaphysis.

(b) Might reduce the wedge fracture.

(c) Does not reduces the depressed articular fracture.

So there is no role of non surgical treatment except in severely comminuted and non reconstructable fracture.

(D) Protocol :



(F) Prognosis : This is a most complex fracture, but gives good results if surgery is done in properly selected cases.

✷ Other Associated Injuries ✷

1. Collateral ligaments : on bending stress the collateral ligaments on tension side gets streached and may rupture in substance or avulse with bone

2. Capsular injury : on bending stress the capsule on tension side undergoes streaching and may rupture.

3. Menisci : They are injured on bending or axial load.

On Tension side - avulsion through coronary ligament along with capsule.

On compression side-meniscus get trapped between tibial and femoral condyle.

- ✦ Substance tear, peripheral detachment.
- ✦ entrapment in fracture.

4. Cruciate : Common with type IV

Fracture dislocation.

5. Poplitial vessles :

- ✦ Common with Type IV.
- ✦ Tear, thrombosis or intimal tear.
- ✦ Acute ischemia.

Presentation :

- ✦ Compartment syndrome - acute / delayed.
- ✦ Internal tear may be present without clinical ischemia. This may occlude with thrombus during surgery and cause limb ischemia.

6. Peroneal nerve : Common with type IV.

- ✦ Undergo stretching due to bending strain or due to displacement in subluxation or dislocation.
- ✦ Traction injury.
- ✦ In continuity or division.
- ✦ Intraneural damage extends to a variable length.

✷ Assessment of Injury-General ✷

(A) Force of injury : Low / medium / high velocity injury.

(B) Direction of force : Axial thurst, Bending, rotation, Anteroposterior / Posteroanterior

(C) Age of the patient : Bone quality.

(D) Bone quality.

(E) Level of function and expectations

(F) Systemic assessment : CNS, cardiorepiratory, Abdominal, Polytrauma, diseases, drugs, allergy, immunity status.

✷ Assessment of Injury- Local ✷

(A) Skin : Oedema, abrasion, wound, marked swelling and bruising indicates potentially severe injury to soft tissues.

(B) Bone : Local tenderness, abnormal movement.

(C) Joint : Haemarthrosis, Absense of bony injury indicates capsular injury and leak into periarticular space.

(D) Collateral Ligaments and cruciate ligaments.

- ✦ Local tenderness may be the only sign of injury.
- ✦ Marked instability.

(E) Vesseles : Carefully evaluated in type IV, V, VI.

- ✦ Ischemia.
- ✦ Compartment syndrome.

Intimal tear may be present without clinical signs of ischemia.

(F) Peronial nerves :

- ✦ Also seen in hip dislocation

✷ Assessment of Injury-Radiological ✷

(A) X-Ray :

1. AP : The proximal tibial articular surface is angled 10° in posteroinferior direction. So a regular AP view shows a double articular line. The inferior articular line represents the posterior border of articular surface.

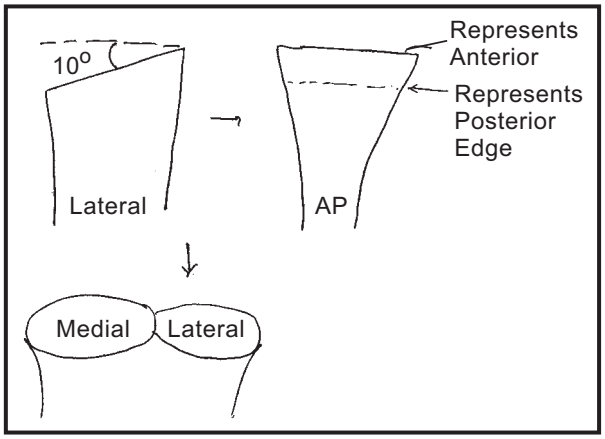


Fig. 19 :

2. AP with 10° caudal tilt. This angle gives more proper evaluation of articular surface injury.

3. Oblique : Internal and external.

4. Stress X-Ray : To confirm collateral ligament injury and assess instability.

(B) CT scan with reconstruction : Gives more information about fracture anatomy (displacement, rotation, depression) and helps for reduction of fracture fragments and implant placement.

(C) Angiography : Remember an intimal tear may be present without a clinically detectable deficit.

✷ Evaluation of Injury ✷

(I) Fracture Anatomy :

- ✦ Fracture lines and displacement to choose method of reduction and implant placement.
- ✦ Articular depression-site, size, depth to decide need of elevation, approach for elevation and bone grafting.

(II) Skin :

- ✦ To decide the timing for surgery.
- ✦ To decide site of incision and extent of elevation of skin flap.
- ✦ Possibility of skin loss or necrosis and need of cover by flap.

(III) Ligaments and capsule :

- ✦ Primary repair-capsule, collateral ligaments, cruciate ligament with bone piece.
- ✦ Delayed repair-Cruciate ligament with rupture in substance.

(IV) Meniscus iniury : Many times this is seen at time of arthrotomy.

(V) Neurovascular damage : Popliteal vessles, peronial nerve, sciatic nerve(hip dislocation).

(V) Associated polytraulma :

- ✦ Femur, hip, pelvis.

✷ Principles of Treatment-General Aim ✷

Knee is a major weight bearing joint, so aim at.

1. Articular Congruity : Confirm the articular surface.

2. Stability : Repair bony, soft tissue causes.

3. Axial alignment : Confirm axial, rotary angulatory alignment.

4. Satisfactory range of motion : Start early motion.

Principles of Treatment :

Nonsurgical treatment : Nonsurgical treatment has specific role. Most of these injures are unstable. The fragments can displace due to muscle forces on movement even in traction or cast Brace. So weekly radiological follow-up is necessary to detect displacement.

Role Of :

(A) Skeletal traction : Split and displaced wedge fragments have intact soft tissue attachment. Traction pulls the soft tissues and reduces the displaced wedge fragments by ligamento-taxis.

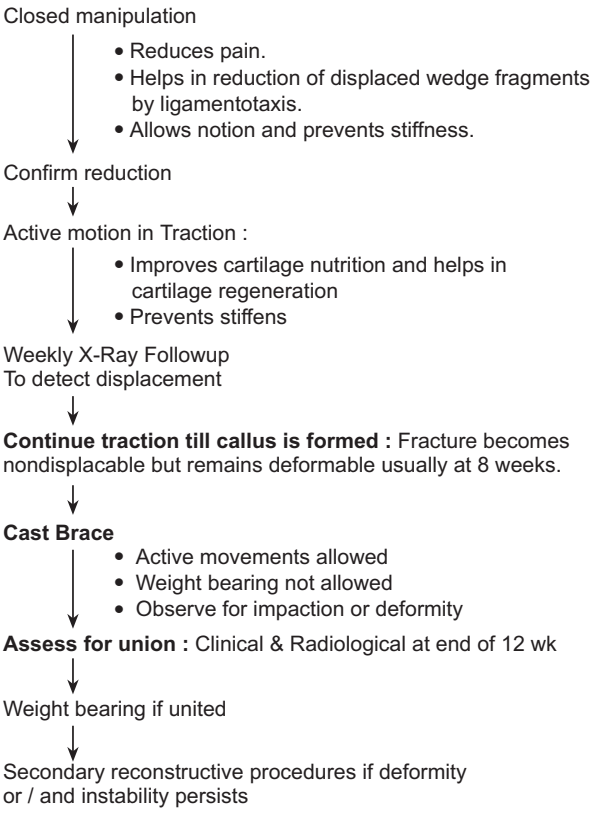
Traction usually reduces the lateral wedge fragments, but may not reduce anterior or posterior wedge fragments.

Depressed and impacted fragments do not have soft tissue attachment so traction does not disimpact and elevate these fragments.

(B) Cast Brace :

- ✦ This does not reduce the displaced wedge fragments or depressed fragments.
- ✦ Maintains the reduced wedge fragment once they become sticky (nondisplaceable but deformable).
- ✦ Displacement can occur in cast Brace due to muscle pull.

Treatment Protocol :



Cast Brace can be used primarily in certain nondisplaced fractures - Type III.

Role of nonsurgical treatment according to type of fracture.

Type I : If one plans to treat undisplaced fracture nonsurgicaly they should be assessed arthroscopicaly to rule out meniscal entrapment.

Type II : Traction might reduce lateral wedge fragment but ineffective in anterior or posterior wedge fragment.

Traction does not reduce depressed and impacted articular fragment. So Undisplaced wedge fracture and depression < 2mm may have a role of Non-Surgical Reduction (NSR).

Type III : This is seen in old people with minimal force.

So if the depression is < 4mm and there is no instability in extension or gradual flexion when examined under anasthesia NSR can be considered.

Type IV : No role of nonsurgical treatment unless surgery is contraindicated.

Type V : NSR can be considered where the fracture line does not involver articular surface & starts in intercondylor area, Once out of traction there occures some impaction of fragments which results in Laxity of soft tissues. This results in residual varus / vulgus instability.

Type VI : Nonsurgical treatment can be considered if,

- ✦ Significantly comminuted and non reconstructable.
- ✦ When expertise in not available.

Always observe for displacement during NSR. Treatment of failed open reduction and internal fixation are poor than results of non surgical treatment.

Surgical Treatment : Absolute indications.

1. Open fracture :

- ✦ Early debridement and stable fixation helps in prevention of infection.
- ✦ Debride and fix the articular fragments with lag screw.
- ✦ Do not stabilise metaphysis with plates. Use External fixator.
- ✦ Close the wound with flap.
- ✦ Do delayed metaphyseal fixation.

2. Acute compartment syndrome :

- ✦ Surgical decompression of compartment syndrome is must.
- ✦ This converts closed fracture into open fracture.
- ✦ Treat as open fracture.

3. Vascular injury :

- ✦ Repair the vessles.
- ✦ Then stabilize the fracture.
- ✦ Then stabilize the ligaments.

✷ Surgical Treatment - Timing of Surgery ✷

1. Emergency : In open fracture, with acute compartment syndrome, with vascular injury.

2. Delayed : With in 1-2 days

- ✦ Fractures with low velocity trauma having minimal soft tissue damage (oedema, abrasion, contusion) can be operated within 2 days after assessment and stabilization of patient status.

3. Late : Up to 3 weeks or more. Fractures with high velocity injury will have significant soft tissue trauma (type IV, V, VI) Assessment of soft tissue injuries in early hours is misleading. Early surgery might end up with devitalized soft tissue cover.

- ✦ See for velocity of injury and comminution.
- ✦ Wait till soft tissues heal - may take 2-3 week.
- ✦ Fracture reduction becomes difficult with this delay, but it is preferred over early surgery.

Surgical Treatment : Temporary Immobilisation

Aim :

- ✦ Pain relief
- ✦ Reduction of displaced fragments.
- ✦ Early movements : Reduces stiffness.
- ✦ Ambulahon.

(A) Skeletal Traction : Tibial pin should be distal to proposed incision or use calcaneal pin.

Benefit :

- ✦ Reduces pain.
- ✦ Reduces displaced wedge fragments.
- ✦ Early movement-reduces stiffness.

Disadvantage :

- ✦ Hospitalsation and bed confinement.

(B) Anterior 1/2 Pin Fixator :

- ✦ **Advantage :** Reduces period of hospitalization and bed confinement and allows early ambulation.

(C) Plaster splint : Causes fragment impaction and joint sttiffness, so avoided.

✷ Surgical Treatment-Use of Tourniquate ✷

- ✦ This makes the surgery bloodless and gives better exposure.

- ✦ Flex the knee to stretch the quadriceps before applying tourniquet.
- ✦ Remember intimal vasucular tear may be present without signs of ischemia. This may occlude during surgery by forming thrombus.

Surgical Treatment : OT Table

- ✦ Radiolucent OT table helps in intraoperative use of Carm.
- ✦ Ability to bend the knee helps in reduction of fracture.

Surgical Treatment : Principles of treatment

1. Atraumatic reduction.

2. Anatomic reduction.

3. Elevation of depressed pleateu en mass.

- ✦ This prevents seperation of bone pieces and maintains the stability of comminuted fragments.
- ✦ Preserves the blood supply.

4. Bone grafting of the subcondral defect below the elevated depressed articular area.

5. Stable internal fixation.

- ✦ Reduces or eliminates the pain and allows early movement

6. Early motion :

- ✦ Improves the articular cartilage recovery.
- ✦ Promotes joint motion and soft tissues function

7. Avoid weight bearing till union. 12 weeks.

- ✦ Prevents articular cartilage damage.
- ✦ Prevents displacement of fracture fragments.

Surgical Treatment : Aid for Visualizing Adequacy of Articular Reduction.

(A) C-arm : Not a very good aid.

(B) Arthroscopy : Useful in Type I, II, III.

- ✦ Do not use if possibility of capsular damage-fluid will leak into soft tissue and cause compartment syndrome.

(C) Submeniscal Arthrotomy :

- ✦ Better visualisation.
- ✦ Use in Type IV, V, VI.

Surgical Treatment : Positioning of Patient

1. Supine.

2. Head Low : Gives counter traction to dropped leg.

3. Drop the leg to flex the knee to 90°.

- ✦ The weight of limb gives traction and helps in reduction of fragments.
- ✦ Reduces the need of an assistant.
- ✦ Allows the surgeon to give varus or vulgus strain with his knees.
- ✦ Puts the illiotibial band posteriorly so the submeniscal incision can be extended without damaging the IT band.

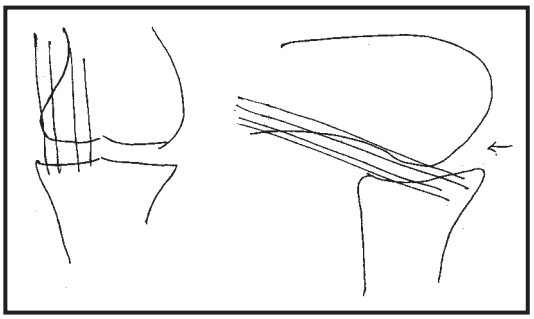


Fig. 20 :

Surgical Treatment :Assistance by Ext Fixature

- ✦ External fixator with one pin in femoral condyle and two in distal tibia with knee at 90° flexion.
- ✦ Helps in distraction and indirect reduction.
- ✦ Articular fragments fall in place.

The articular fragments can be stabilized with subcutaneous lag screws and the metaphysis can be buttressed through small incision.

Surgical Treatment - Incision

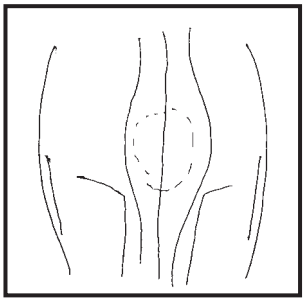


Fig. 21 :

(A) Vertical Straight :

- ✦ Midline.
- ✦ Medial parapatellar.
- ✦ Lateral Parapatellar.

(B) Short Angled :

- ✦ Medial.
- ✦ Lateral.

(C) Postero Medial :

- ✦ Postero lateral.

(D) Midline incision with Z plastic division of patellar tendon.

Aim :

1. Incision should not come on implant.

2. Incision should not hamper recon struction in future if osteosynthesis fails or TKR is indicated.

General Principles :

1. Develop a full thickness flap upto deep fascia or quadriceps expansion and reflect. This maintains the soft tissue viability and prevents necrosis.

2. We can safely divide the tensor fascia lata and resture without any functional deficit.

3. On medial side we can dissect subperio-stealy and raise skin + fascia + periosteal flap along with pes anserinus and place the implants directly on bone.

4. On lateral side dissect the skin + fasia + lateral muscle mass up to fibular head and postero lateral tibial border.

Be careful not to damage anterior peroneal vessles at fibular neck

5. If there is a wedge fracture, open it like a cover of book and work within it to elevate and reduce the depressed, impacted bone and put bone graft below it.

The intact soft tissue attachment preserves the blood supply of wedge fragment.

6. Submenisecal arthrotomy :

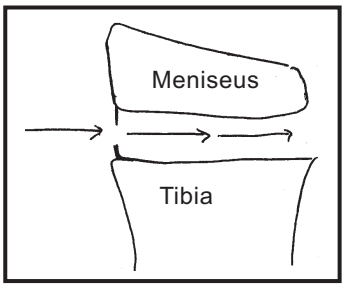


Fig. 22 :

- ✦ Divide the coronary ligament between the meniscus and the tibial attachment
- ✦ Protect the coronary ligament.
- ✦ TFL can be devided and resutured.
- ✦ Retract the meniscus along with femoral condyle.
- ✦ Improve visibility with vulgus strain : This gives excellent exposure of the articular surface upto posterior border.

7. At the end of the procedure :

- ✦ Suture the coronary ligament.
- ✦ Suture the TFL.
- ✦ Loosely suture the fascia with or without drain.
- ✦ Suture the skin with drain.

Surgical treatment : Incision

(A) Anterior midline or paramedian straight incisions are preffered.

(B) Small curved incision directly over involved plateu are less traumatic but this scar can not be incorporated if osteosynthesis fails during TKR.

(C) Posteromedial or posterolateral incision.

- ✦ The posterior or posteromedial / posterolateral fracture can not be approached from anterior midline incision because of fear of loss of flap due to ischemia
- ✦ So an additional posterlateral or posteromedial incision is preffered to reduce and stabilize the wedge fragment with buttress plate.

(D) Division of patellar tendon by Z plasty.

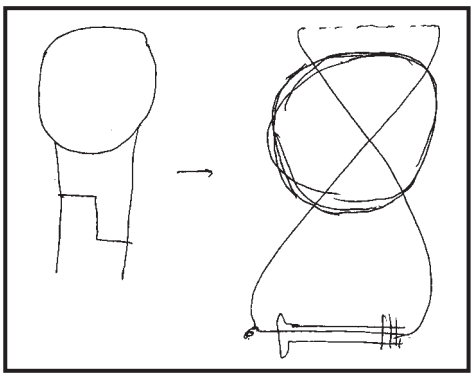
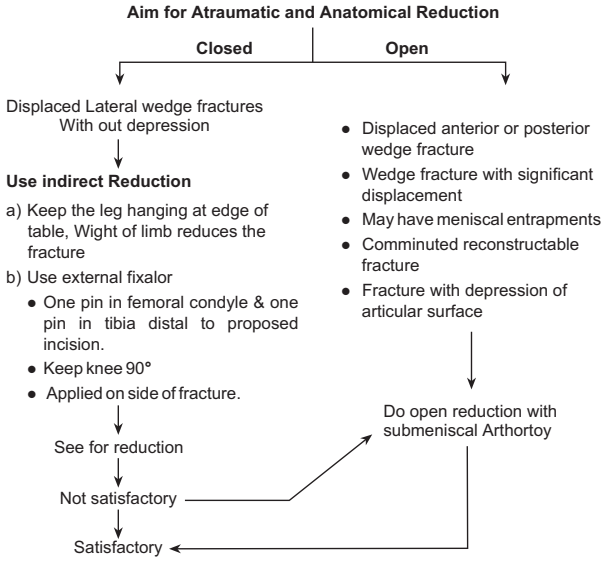


Fig. 23 :

- ✦ Used when both condyles are fractured and bilaleral arthrotomy is needed.
- ✦ Devide the PT by Z incision, devide the quadriceps expansion and coronary ligaments transversely.
- ✦ Reflect the quadriceps expansion upward to see both joints.
- ✦ At end of procedure suture the quadriceps expansion, coronary ligaments and patellar tendon.
- ✦ Protect the tendon during healing by a figure of 8 wire loop.
- ✦ Pass it proximally through patellar tendon absuting the superior surface of patella, cross it over patella and patellar tendon.
- ✦ Pass it through hole or cannulated cancellous screw passed though anterior 1/3 of tibia just distal to tibial tuberosity Maintain the wire for 8 weeks.

✷ Surgical Treatment : Reduction ✷



(a) Hold the reduction with K-wire or clamp.

(b) Stabilise articular fragments with two or more percutaneous cancellous screws passed perpendicular to fracture line if possible in different angle.

(c) Then butters the metaphysis with plate through small incision.

(a) Open the wedge fracture like a cover of book keeping the soft tissue attachment intact. This preserves the blood supply.

(b) Remove the soft tissues interposition : Sometimes a meniscus is entraped.

(c) Reduce the wedge fragment.

(d) Conform the reduction with Garm and through arthrotomy.

(e) Hold the reduction with K-wires or with clamps : Confirm the position again.

Difficult Reduction :

(a) Bicondylar fracture :

- ✦ Reduce the less comminuted fracture first.
- ✦ Usually the medial condyle

(b) Fracture of medial condyle with coronal split The posterior wedge fragment displaces posteriorly and distally taking femoral condyle with it. Flexion of knee causes posterior rotation of the

medial femoral condyle making reduction of posterior, wedge difficult/impossible. Extension of knee derotates the femoral condyle and reduces the posterior wedge fragment. Reduce and provisionally stabilize with K-wires.

(c) Displaced posterior, postrermedial, postero lateral wedge fragments often require additional postero lateral or posteromedial incision : To reduce and fix the buttres plate.

Surgical Treatment : Elevation of depressed and impacted articular fracture fragment and bone grafting to support elevated articular fragments.

The depressed articular fracture fragments get impacted in metaphyseal bone. This bone keeps the fragments together as well as keep them viable. Elevation of these impacted fragments en mass with subchondral bone keeps them in position and preserves vascularity.

(A) expose the articular surface through submeniscal arthrotomy.

(B) Elevate the depressed and impacted articular fracture fragments.

This is indicated when depression is > 4mm Some people elevate with 2mm depression.

1. For depressed fracture without split wedge fragment.

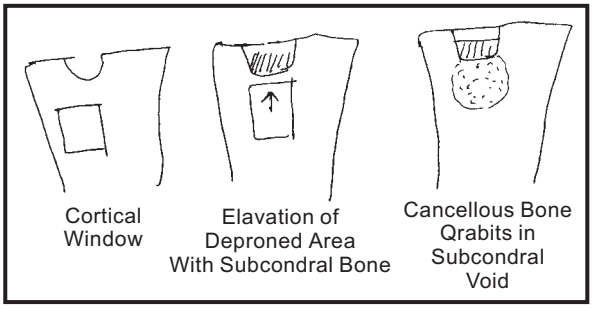


Fig. 24 :

- ✦ Make a window 1 × 1.5 cm below the depressed fragment.
- ✦ Pass the periosteum elevator and elevate the subchondral bone en mass (prevents seperation of bone fragments). Use a bone punch if necessary. Confirm the reduction through arthrotomy.

2. For depressed fracture associated with split wedge fragment.

Open the wedge like a cover of book and work through it.

- ✦ This elevation creates a bone void below the elevated articular surface. It is necessary to pack this void with bone to support the elevated fragments and prevent their collapse.

(C) Bone grafting in subcondyler bone void to support the elevated articular surface.

1. Cancellous bone chips are preffered over bone slab. Bone fills the irregular bony gap in a better way. After impaction this cancellous bone gives excellent support which is strong enough to mobilize but not sufficient to bear weight.

2. Auto grafts are preffered. Allograft or bone substitutes are used only when Autograft are insufficient in quality and quantity.

3. Fill the cavity with small chips of cancellous bone and impact with punch.

4. Reduce the wedge / cortical window over bone grafted area.

✷ Surgical Treatment : Internal-Fixation ✷

Internal fixation is done to protect the elevated articular surface from falling down and to prevent the displacement of metapyseal fragment.

(I) Selection of Implant :

(A) For fixation of articular area

1. Cannulated cancellous 6.5 mm screws.
2. Cancellous screws.

(B) Melaphyseal area - Buttress plating

1. Medial tibial T shaped condyler plate.
2. Lateral precontoured tibial condylar plate.

   T Shaped - right or left

   ⅂ Shaped - right or left

   – goes proximal to fibular head.
3. precontoured low profile plates.
4. Locking plate.
5. Reconstruction plate.

(C) For melaphyseal areas - screws

1. 4.5 cortical.

2. 3.5mm cortical low profile.

(II) Principles of Fixation of Articular Fragments by Lag Screw :

Lag screws function as :

(A) Mechanical transverse support below the elevated subchondral bone.

(B) Circumferentially compress the split wedge fragment against the remaining intact articular fragment.

Principle : Reduce the articular surface by closed or open method. Hold the reduction with clamp.

- ✦ Assess the fracture anatomy and pass provisional K-wires perpendicular to fracture plane.

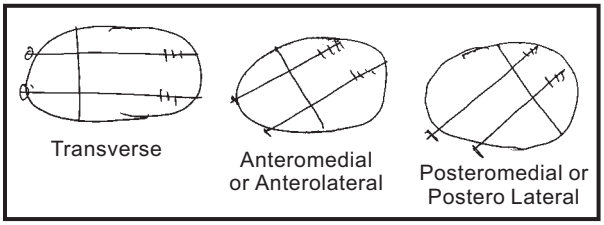


Fig. 25 :

- ✦ Posterior wedge can be stabilized with anteroposterior wires.
- ✦ Stabilize the condyles with two or more 6.5 mm cannulated cancellous or Cancellous screws : Pass the screws perpendicular to fracture.
- ✦ The position of lag screws is governed by fracture anatomy and not by position of plate. Screw can be above, below or through the plate hole.
- ✦ Lag screws should be placed at least 5mm below the subcondral level to prevent chondrolysis.
- ✦ Remember 10° posterior tilt of articular surface.
- ✦ Remember the lateral condyle is at higher level. So while passing screw from lateral to medial side, one can enter the joint.
- ✦ Avoid over compression and / or rotation of condyles.
- ✦ In bicondylar fracture posterior cortex may be the only intact cortex. So pass the screws to engage the posterior cortex.

(III) Principles of Butress Plating

Aim : These plates are not useful for articular reconstruction. They are useful for metaphyseal reconstruction.

These plates can not reduce the fracture so reduction is necessary before fixing the plate.

These plates support the cortex of the fracture fragment at metaphysis. This prevents the displacement under axial load. For this purpose the plates need careful contouring.

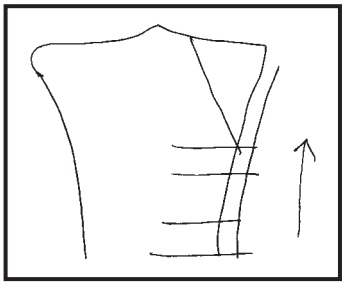


Fig. 26 :

Principles :

1. Perfect contouring of the plate is must. Even the precontoured plates need adjustment.

2. Reduce the metaphysis by closed or open method. Hold the reduction with K-wires or clamp.

3. Place the plate over bone and confirm contouring.

4. Insert first the distal most screw. Fix the remaining screws from distal to proximal.

5. Lag screw can be passed through, above or below the plate.

Things to remember

1. Improper contouring places the plates under tension. This force causes displacement of fragments.

2. Similar thing occurs when two ends of plate are fixed to bone first. There remains a gap between bone and plate. When other screws are passed the plate is brought under tension and this force causes displacement.

3. On medial side the plate is fixed to antero medial surface deep to pes anserinus, anterior fibers of MCL.

On lateral side because of head of fibula the plate must be fixed slightly obliquely with its distal end flush with anterior tibial border.

4. In bicondylar fracture begin with the less comminuted tibial plateau - usually the medial condyle. Reduce the condyle and buttress it with plate. Then reconstruct the other.

5. In severely comminuted bicondylar fracture fix a T-plate on antero medial and precontoured T-plate on antero lateral surface. Use these two plates as scaffold and reconstruct the proximal end.

6. For posterior, posteromedial or postero lateral displaced wedge fragment, use a separate postero medial or postero lateral incision to reduce and support with butterss plate.

7. In Open fracture :

- ✦ Debride and reconstruct the articular surface.
- ✦ Do not do primary metaphysical reconstruction Stabilize the fracture with bridge fixator or a hybrid ring fixator circular frame with a small crossed wire proximally and a half frame and large pins distally.
- ✦ Close the soft tissue defect with flap.
- ✦ Then reconstruct the metaphysis after some period.

8. In severe comminution (type IV in old or type VI) do not operate if fracture appears non reconstructable.

Buttress Plating

The application is dictated by thickness of the cortex and communition.

(I) TYPE I in young patients with strong cortex buttressing is not needed but one has to observe for a delayed slip. Buttressing is a must in old people.

(II) TYPE II buttressing is a must.

(III) TYPE III the vaccum in cortx for bone grafting weakens the bone and so support with a lag screw and plate is to be provided.

(IV) TYPE IV buttressing is a must. In posterior split wedge fragment a separate postero-medial exposure and buttressing is advisable. This is done first and then the reduction is achieved in extension.

(V) TYPE V the fracture needs buttressing on both sides.

(VI) TYPE VI there is dissociation of metaphysis. so there is need for one thick plate to act as a neutralization or compression plate. This can be applied medialy and a precontoured condyle plate laterally. You may have to use two separate incisions for this plating.

✷ Locked Compression Plating ✷

- ✦ These plates are not useful for articular reconstruction so reconstruction has to be done before fixing the plates.
- ✦ These plates are not useful for reduction-so reduce the fragments before fixation.
- ✦ These plates are bridge plates.
- ✦ Plates are fixed to boine and the plates so the chances of back-out are almost nil.
- ✦ These plates give elastic stability and union occurs rapidly.
- ✦ These plates can be fixed on only one condyle.
- ✦ There is a steep learning curve and chances of varus are more as it is fixed on antero-medial surface.

Ligament and Meniscul Repair

1. Capsule : Repair primarily.

2. Collateral ligaments : Repair primarily.

3. Cruciate ligaments : (a) if avulsed with a piece of bone fix it with a screw or steel wire. (b) if

ruptured in the substance, do not repair primarily if repaired primarily it requires period of immobilization that will produce permanent stiffness.

4. Menisci : Preserve the menisci. Repaire the tear in substance. Suture the circumferentially avulsed menisci.

Closure of Wound

- ✦ Achieve the hemostasis.
- ✦ Confirm reduction.
- ✦ Confirm stability.
- ✦ Close the sub-meniscal arthrotomy.
- ✦ Loosely close the fascia.
- ✦ Close the skin over the drain.
- ✦ Apply large padded dressing.

Treatment of Neuro-vascular Injury

(A) popliteal artery injury is common in any type especially in type IV.

Intimal tear may be there without clinical signs of ischimea this may present with thrombogenic occlusion after surgery. Vessels need to be explored and repaired before fixation of bones,

(B) peroneal nerve injury is seen in fracture type IV the nerve is in continuity. The stretched portion needs to be examined, excised and repaired and repaired. The results of nerve grafting are not encouraging.

Post-operative Care

(I) Fracture having good reduction and adequate stability.

Early movement improves articular cartilage repair and prevents stiffness.

Elevate for 2 days at 40-60degrees and start active movements after 2 days. Simple fracture can be mobilized without CPM.

Fractures with stability and repair of collateral ligament require cast brace to protect the tissues. Discontinue CPM when 90 degrees of flexion is achieved.

(II) fractures with inadequate stability.

Protect it from overload. Muscle activity without weight bearing can cause displacement..

Avoid weight bearing till union-12 weeks.

Early weight bearing interferes with healing of articular cartilage.

❋❋❋