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Management of Comminuted Intraarticular Proximal Tibial Fractures with Dual Fixation

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Abstract: Proximal tibia fractures make for 5–11% of tibial fractures and 1.2% of total fractures. High-energy trauma causes tibial plateau fractures (Schatzker type V and VI). Due to the stress and soft tissue injury frequency, problems are common. Optimal Schatzker type V and VI tibial plateau fracture therapy is disputed and difficult. There is no established therapeutic procedure. Though open reduction and internal fixation reduce and stabilize these fractures. In recent years, proximal tibial fracture therapy has changed. Treatment still aims for stability, mechanical axis restoration, and smooth articular surfaces, but procedures have improved. Technical advances in CT and MR imaging have improved three-dimensional damage diagnosis.

Keywords: Comminuted Intraarticular Fractures, Proximal Tibia, Dual Fixation.

Introduction

Proximal tibia fractures make for 5–11% of tibial fractures and 1.2% of total fractures. Knee fracture pattern depends on force amount, kind, and direction. Complex tibial plateau fractures are one of the most complex orthopaedic surgery difficulties, and their management remains disputed [(1)]

Mechanism of Injury

Can be divided into 4 categories by knee forces [(2)]

In abduction, Nutcracker hypothesis states that the prominent anterolateral section of the lateral femoral condyle is wedged in the lateral tibial plateau by the medial collateral ligament. When the knee is flexed, the collateral ligament has weak hinging action, the posterior convex femoral condyles touch the tibia, and a wedge fracture is unpredictable. Abduction force may be dispersed elsewhere with slight flexion because the ligament is less tense and allows greater rotation.

In flexion Compressive pressures, especially when paired with abduction forces, cause lateral plateau compression fractures or mixed fractures. Stronger compression causes a "type V" bicondylar fracture.

Age and bone quality affect fracture pattern and ligamentous damage (Figure 1). Strong, inflexible bones in young patients can cause split fractures and ligament damage. Split-depression fractures without ligamentous damage occur when the subchondralbone becomes less able to sustain axial strain with aging. Unlike the conventional lateral plateau fracture, the crushed fragment hinges laterally and may have lateral ligamentous lesions. A vigorous impact accompanied with tibia flexion and external rotation may cause posterior medial condyle split fractures [(3)]

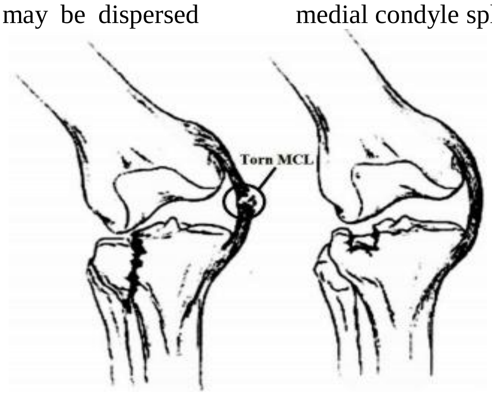

Fig.(1) Split fractures and ligamentous dislocation are common in strong, rigid bone patients [(4)]

Classification

Tibial Plateau fractures are topographically separated into lateral, medial, or bicondylar fractures [(5)]

1. Hohl Classification

Hohl classification, based on over 900 fractures, is extensively used and has 6 kinds [(6)]

- **Type I:** Undisplaced fracture
- **Type II:** Local compression fracture
- **Type III:** Split compression fracture
- **Type IV:** Total condvlar depression fracture
- **Type V:** Split fracture
- **Type VI:** Comminuted fracture

2. Schatzker Classification

The classification of Schatzker is the most widely accepted classification there are 6 types. (Figure 2) [(7)]

- **Type I:** Split fracture
- **Type II:** Split depression fracture
- **Type III:** Pure central depression fracture of the lateral tibial plateau
- **Type IV:** Fractures of medial tibial plateau
- **Type V:** Bicondvlar fractures

- **Type VI:** Tibial Plateau fracture with dissociation of metaphvsis and diaphvsis

Fig. (2) Schatzker Classification [8]

3. **Orthopedic trauma association classification (OTA):** Figure 3

OTA adopted AO/ASIF categorization [9]

- **Type A:** Fractures are extra-articular
- **Type B:** Fractures are partial articular
- **Type C:** Fractures are complete articular fractures

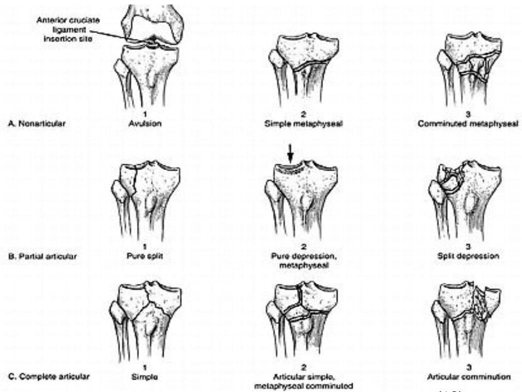

Fig 3: The AO/OTA classification [10]

Diagnosis

A complete history should include the mechanism of damage, medical state, age, and functional and economic needs.

1. **Imaging Studies**

Imaging of tibial plateau fractures is needed to assess injury severity, nature, and classification.

- **Plain Radiograph:**

The usual knee trauma radiographs contain anterior-posterior, lateral, and both oblique views. (Figure 4). These images may not accurately determine articular depression due to the tibia's 10-15o posterior slope. To measure articular step-off, utilize a 10- 15o caudally inclined plateau view. (Figure 5). A 15° caudal or lateral radiograph may assess condylar depression from the undamaged articular surface[11]. Atero-posterior radiographs do not account for the tibial plateau slope and do not show the real depression. Varus/valgus stress testing may detect ligament damage. Plain radiographs commonly underestimate articular depression. Cross table lateral projections typically show the fat-blood interface indication, indicating an intra-articular fracture (Figure 6) [12]

Fig.(4) Standard radiographic trauma series
Internal oblique (A), lateral (B), anterior-posterior (C), and external rotation oblique (D) show a slightly displaced lateral plateau split fracture [13]

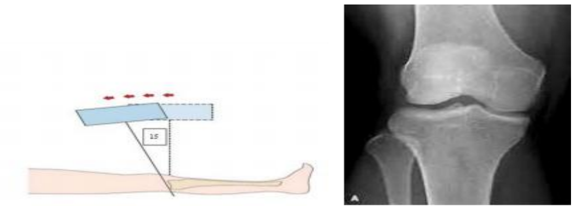

Fig 5: Schematic (A) and radiograph (B) depicting the 15o caudal radiographic view
This view may evaluate condylar depression by considering the posterior slope of the tibial plateau [14]

Fig 6: The Fat-blood sign in Lateral X ray of the knee with tibial plateau fracture [15]

- **Computed Tomography:**

If more three-dimensional fracture pattern information is needed, choose this research. It adds fracture pattern information (Figure 7). sophisticated spiral CT can perform a full investigation in minutes, and sophisticated software can produce 2-D and 3-D reconstructions with great quality. CT provides great bong detail but not soft tissue injury evaluation. (Figure 8). CT images after spanning fixation may show fracture pieces better in severe comminution[16]

Fig7: Sagittal (A) and coronal (B) CT reconstructions of the tibial plateau fracture reveal articular impaction and help to further define all fracture fragments [17]

Fig 8: Tibial plateau fracture CT. A comminuted medial tibial plateau fracture is shown in the proximal tibia axial CT. (B) Sagittal reformatted picture indicates the anterior plateau is mostly damaged. Coronal reformatted picture shows depression and comminution. (D) The 3D reformatted anterior picture indicates proximal fibula

fracture and medial anterior tibial plateau depression. A bird's-eye view of the 3-D reformatted picture displays fracture line orientation.

Magnetic Resonance Imaging:

Because of its soft-tissue imaging capabilities and the high incidence of ligamentous and meniscal injuries, many propose regularly employing MRI to examine high-energy tibial plateau fractures. See Figure 9 [(18)]

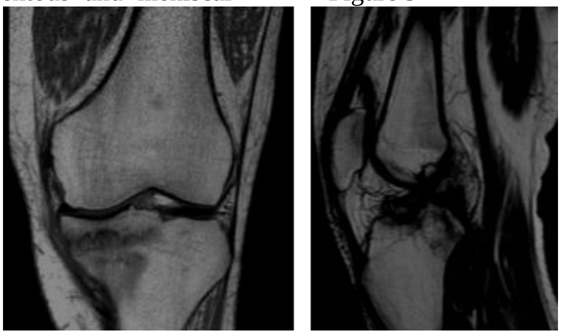

Fig 9: MRI of fracture of the tibial plateau.

In the T2-weighted coronal image, a broad-based band of low signal intensity crosses the lateral tibial plateau. Soft-tissue edema is extensive superficial to the iliotibial band. (B) Proton density-weighted sagittal image demonstrates central tibial plateau depression. Well-depicted comminution and depression

Arthroscopy:

Arthroscopy for tibial plateau fractures is becoming increasingly common. Arthroscopy allows direct inspection of the articular surface, menisci, and cruciates. You may also irrigate the joint to remove dirt and hematoma. Artroscopy fluid extravasation may cause compartment syndrome, as documented in the literature [(19)]

Treatment

Tibial plateau fracture therapy aims for a well-aligned, stable joint with painless functional range of motion [(20)]

1) Non-surgical Treatment:

Non-operative therapy is best for stable, non-displaced fractures. Hinge fracture braces with protected weight bearing and early knee mobility are ideal. The fracture should be operated on if ROM exercises fail brace reduction. Starting with isometric quadriceps and gradual passive, active-assisted, and active range-of-knee motion. After 8–12 weeks, partial weight bearing is allowed, then full as tolerated [(21)]

2) Surgical Treatment

The same principles apply to treating tibial plateau fractures as other articular fractures. After reconstructing the articular surface, tibial alignment is restored. Bone graft or ca-p cement may support high articular portions. Finally, optimal soft tissue restoration must include meniscus preservation and/or repair, intra- and extra-articular ligamentous structures[(22)]

Different Types of Surgical Intervention:

A. Fixation with Conventional Plates:

This procedure may be used on almost every tibial plateau fracture if the soft tissue envelope allows surgery. For high-energy complicated tibial plateau fractures with severe soft tissue compromise, such as schatzker V and VI, plate-based open reduction and internal fixation are not possible. Other methods are indicated [(23)]

B. Fixation with Locked Plates:

Anatomical, angle-locked locking screw-plate implants. Medial condyle lateral buttressing in the fixed-angle build may minimize the need for a medial plate in bicondylar fractures (Figure 10). Without plating or posterior-medial incision, locking plates may heal the medial condyle fracture. An extra plate is recommended for tiny, comminuted, osteoporotic, or coronal split medial condyles [(24)]

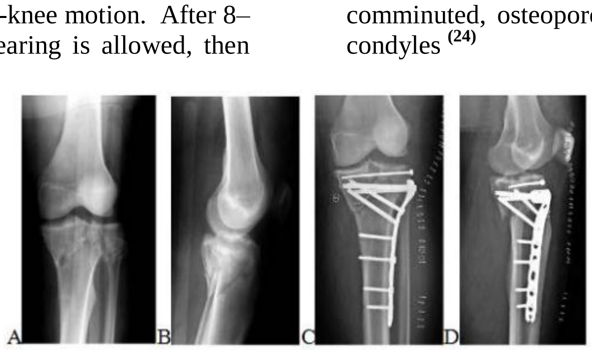

Fig10: Single bicondylar fracture locking plate.Anterior-posterior and lateral radiographs of a 22-year-old male with a bicondylar high-energy tibial plateau fracture before surgery. Lateral and post-operative radiographs. Post-operative radiographs show the mechanical axis and articular congruity restored by a locking lateral plate on the proximal tibia. Fixation into the big medical piece was good, therefore no medial plate was needed [(10).]

Dual-fixation treatment of comminuted intraarticular proximal tibial fractures:

Open reduction and internal fixation (ORIF) determine knee function and long-term osteoarthritis risk [25] :

1. Ligamentous and osseous stability with correct mechanical axis.
2. Reconstruction of joint surfaces.

However, soft tissue management is crucial. Careless treatment of surrounding tissues may induce wound healing, infections, and delayed bone union even with mild injuries.

Recent advances in tibial plateau fracture therapy suggest the following strategy, The picture intensefire (C-Arm) controlled closed reduction and preserved ligamentotaxis fracture reduction with traction. Careful attention was made to reducing the articular surface to approximate anatomical levels (< 2 mm fracture end displacement).Reducing condyles and stabilizing the tibial shaft underneath them are the goals.open reduction and internal fixation of medial and posteromedial fragments using a butress plate.Always evaluate anatomic reduction to <2 mm following first reduction in both antero-posterior and lateral views.Checking reduction and position using the picture intensifier. Closing wound and applying Ilizarov external fixator. Before fastening to rings, wire tensioners or spanners at both ends on simple wires tensioned all the wires.Hydrogen peroxide and Bethadiene (pyodeine) gauzes covered the wires. Figure 11

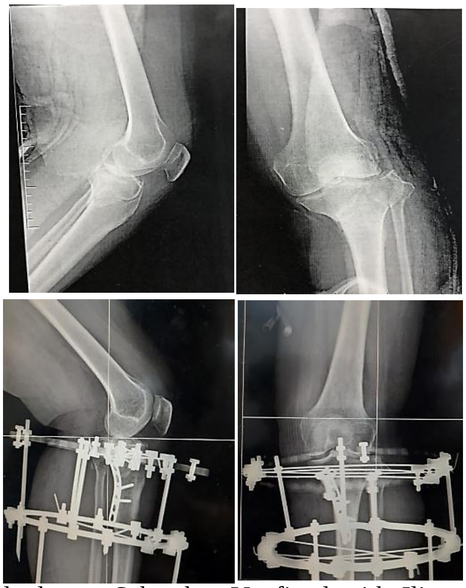

Fig 11: Plain X-ray showing fracture tibial plateau Schatzker V fixed with Ilizarov external fixaton and posteromedial plate.

Triple plating for comminuted intraarticular proximal tibial fractures:

Clinicians grapple with complicated tibial plateau fractures. These fractures are Schatzker Type V and VI or C, according to the AO/ORTA. This fracture often requires bilateral dual plating. This may not work for multiplanar articular comminution fractures. This is especially true for coronal or posterior shearing fractures. Figure 12-13 [26]

Fig12: Comminuted 3-column fracture following a traffic collision with complicated right tibial plateau fracture and postoperative x-ray after combination approach[(27)]

Fig 13: Comminuted 3-column fracture following a traffic collision with complicated left tibial plateau fracture and postoperative x-ray after combination approach.

External Fixation:

Complex tibial plateau fractures including bicondylar and metaphyseal dissociation usually include a high-energy mechanism that injures soft tissue.Internal fixation may stabilize such lesions, but the severe soft tissue damage increases the risk of wound collapse, infection, and osteomyelitis. In 2005, Brouwer and colleagues found 23% infection in bicondylar fractures following internal fixation. Eight of 11 knees treated with medial and lateral plates showed wound dehiscence [(23)]

Definitive Treatment:

Fixators for metaphyseal tibial plateau fractures seldom span the knee, inhibiting knee motion. These fixators replace plates as final treatment. This application works with hybrid Ilizarov, monolateral, and half-pin thin-wire ring fixators. With double plating-like mechanical strength, hybrid external fastening has performed well. These fixators use lag screws, Kirschner wires, or small plates for internal fixing. See Figure 14 [(28)]

Over the last 20 years, external fixation has gained popularity to reduce plating difficulties. The Ilizarov-invented external circular fixator is commonly used to treat open fractures, numerous closed and comminuted fractures, pseudoarthrosis, and contractures and deformities. The Ilizarov frame has been modified multiple times to reduce problems and treatment duration [(29)]

A B C D E F

Fig 14: Mixed exterior fixation. CT scan of a 22-year-old man with compartment syndrome-related high-energy proximal tibia and ipsilateral shaft fractures. D and E postoperative lateral and anteroposterior radiographs. Hybrid fixation followed fasciotomy and temporary external fixation. One lag screw and thin olive wires supported the joint line and prevented soft-tissue damage. Posterior view 6 months postoperatively, good tibial alignment despite poor lateral joint-line reduction.

Complications

Complications vary by fracture type and therapy. Tibial plateau fractures cause compartment syndrome, deformity, knee instability, and late-onset osteoarthritis. Divide complications into[30]:

I. **Early** (e.g., compartment syndrome, loss of reduction, deep vein thrombosis).
II. **Late** (e.g., implant breakage, post-traumatic arthritis, malalignment, delayed or nonunion).

Most early complications can be viewed as biological failures, while late failures are often associated with mechanical problems.

Conclusions

Treatment method and outcome depend on tibial plateau fracture soft tissue injury degree. For difficult Schatzker V and VI tibial plateau fractures, ilizarov external fixator with postero-medial plate fixation is safe and successful. It aids bone union, soft tissue healing, function, early weight bearing, and range of motion.

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