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ORIGINAL ARTICLE

OPTIMAL SURGICAL MANAGEMENT OF HIGH VELOCITY POSTERIOR TIBIAL PLATEAU FRACTURE SUBLUXATIONS (DUPARC, REVISED CLASSIFICATION, GROUP – V: POSTERO-MEDIAL FRACTURE) BY DIRECT, DORSAL APPROACH – A CHANGING TREND: A PROSPECTIVE STUDY

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ABSTRACT: INTRODUCTION: High-energy tibial plateau fractures are infrequent and technically demanding to treat especially if those are shearing type, coronal plane, displaced fractures. The most widely used the Schatzker system of classification,[1] (Based on the AP radiograph) is more than likely to miss postero-medial and postero-lateral shear fractures, best visible on the lateral, than the AP radiograph. These fractures have recently been characterised by two studies, highlighting their clinical relevance [2,3] and showing that less invasive surgery and indirect reduction techniques are often inadequate. Hohl described unicondylar coronal plane splitting fractures of the medial tibial plateau, noted that these injuries be considered as fracture-dislocations. Connolly and others have suggested that the mechanism involved in this fracture pattern is one of knee flexion, varus, and internal rotation of the medial femoral condyle.[4,5,6] Consistent among these and other authors is that the occurrence of this fragment is relatively unusual and that the use of a posteriorly based exposure with direct fracture visualization, anatomic reduction and absolute stability appears to result in satisfactory outcomes. Though variations of a postero-medial approach been previously described (by Trickey et al and also by Burks et al.,), more recently, Lobenhoffer et al described direct posterior exposure, Wang et al described postero-medial approach and Luo et al. described the approach for the management of posterior bicondylar tibial plateau fractures.[7,8] These approaches have been used in isolation or as a dual-incision approach for treating tibial plateau fractures.[9,10,11,12,13,14,15] **PURPOSE:** The purpose of this study is to describe this unfamiliar direct posterior surgical (Medial Gastrocnemius) approach to a general orthopod, highlighting the relevant anatomy and presenting our experience using this approach in treating a series of 15 patients with complex tibial plateau injuries with associated posterior shear fractures. **MATERIALS AND METHODS:** This prospective study included 15 cases of patients with mean age of 30 years (Age range 20 to 40 yr) who sustained high velocity posterior tibial plateau fracture-subluxations with or without associated Bicondylar fractures (Duparc, revised classification, Group – V: Postero- medial fracture and its associations). Surgical management includes by direct, dorsal approach and stabilisation with buttress plating and or also postero medial and or antero lateral approach as needed. The patients were followed up at six week, three month, six month and one year postoperatively and assessed using Oxford Knee Score and Lyshom Score. **RESULTS:** The mean

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OKS score was 40 (range 36 to 44) at the end of one year. The main clinical measures were early post-operative non weight bearing ROM, post-operative complication & functional outcome. The time to full weight bearing, the rate of post-operative complications & functional outcome was significantly better as evident by over 94 % showing good to excellent OKS and Lyshom scores.
CONCLUSION: Fractures of the postero-medial tibial plateau are challenging to treat, owing to their complexity and unfamiliar surgical approach. Several recent anatomic and biomechanical studies have shown that a locked plate placed from the lateral side of the proximal tibia does not capture and stabilise a typical posteromedial fragment. A direct posterior (Medial Gastrocnemius) or posterior medial approach for these unstable posterior medial tibial plateau subluxations (which are otherwise irreducible by conventional approaches) and antiglide plate are usually needed to reduce the fractures anatomically, achieving absolute stability and mobilise early NWB, ROM of the knee joint to optimize the functional outcomes and minimise the complications, without the need for revision surgery.
KEYWORDS: Posterior tibial plateau fracture subluxations, Duprac revised classification, Direct Posterior approach, OKS and Lyschom scores.

INTRODUCTION: The severity of a tibial plateau fracture and the complexity of its treatment depend on the energy imparted to the limb. Low energy injuries typically cause unilateral depression type fractures, whereas High energy injuries can lead to communited fractures with significant osseous, soft tissue, and neurovascular injury and some leading to long term sequelae Instability, OA, Pain and Disability) In spite of recent resurgence of highly sophisthecated implants, ingenious surgical approaches, and precise imaging modalities, these injuries remain a great challenge to deal with.

The Posterior fracture of the Tibial Plateau: Is most commonly associated with fracture dislocations of the knee wherein the tibia subluxates anteriorly and the femoral condyles impact the posterior aspect of the proximal tibia. Rotation and degree of knee flexion at the time of injury determine condylar involvement, whereas degree of axial loading drives the amount of joint impaction.

The Postero medial fragment[16] is defined as, posteriorly based articular fracture of medial tibial plateau with fracture line exiting medial cortex as shown in the radiographs & CT scans below (Fig. 1).

Fig. 1: Showing Radiographs of Posteromedial condyle fracture and CT Films showing the same

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Most common in Moore Type I & II knee fracture Dislocations, Duparc (revised classification 1990) Group V, Schatzker's Type IV variants in alpine Skiers as described by Potoconik et al,), and Bhattacharyya et al[10] reported on an uncommon posterior shearing tibial plateau fracture (treated through a posterior approach in 13 patients) similar to the skier Type IV variant. Such fractures defied classification as Schatzker Type IV, V, or VI fractures and did not fit fully into the system of Khan et al.[11] - all these are kind of fractures are best dealt by either by Postero medial approach (between Pes & medial gastrocnemius) or a Direct posterior approach(Medial Gastrocnemius)

Moore Classification of Knee Fracture - Dislocations of the knee (CORR 1981, 156:128-40,[4]) Fig. 2 Below;

1.Postero Medial Condyle 2. Entire Medial/ Lateral condyle 3 Rim avulsion 4.Rim compression 5)4 part FD

Duparc & Ficat classification(1960),[17] revised in 1990,[18] is used in France, in to 5 groups. G Group I: Unicondylar Fractures, Group II: Bicondylar fractures.

Group III: Spinocondylar – Medial, Group IV: Spinocondylar – Lateral,

Group V: Postero-Medial Fracture (Isolated or associated) Fig. 3 below;

Clinical appearance :
- isolated
- associated to :
  - a combined lateral tibial plateau fracture
  - a complex bicondylar fracture
  - a spinocondylar fracture

Fig. 3

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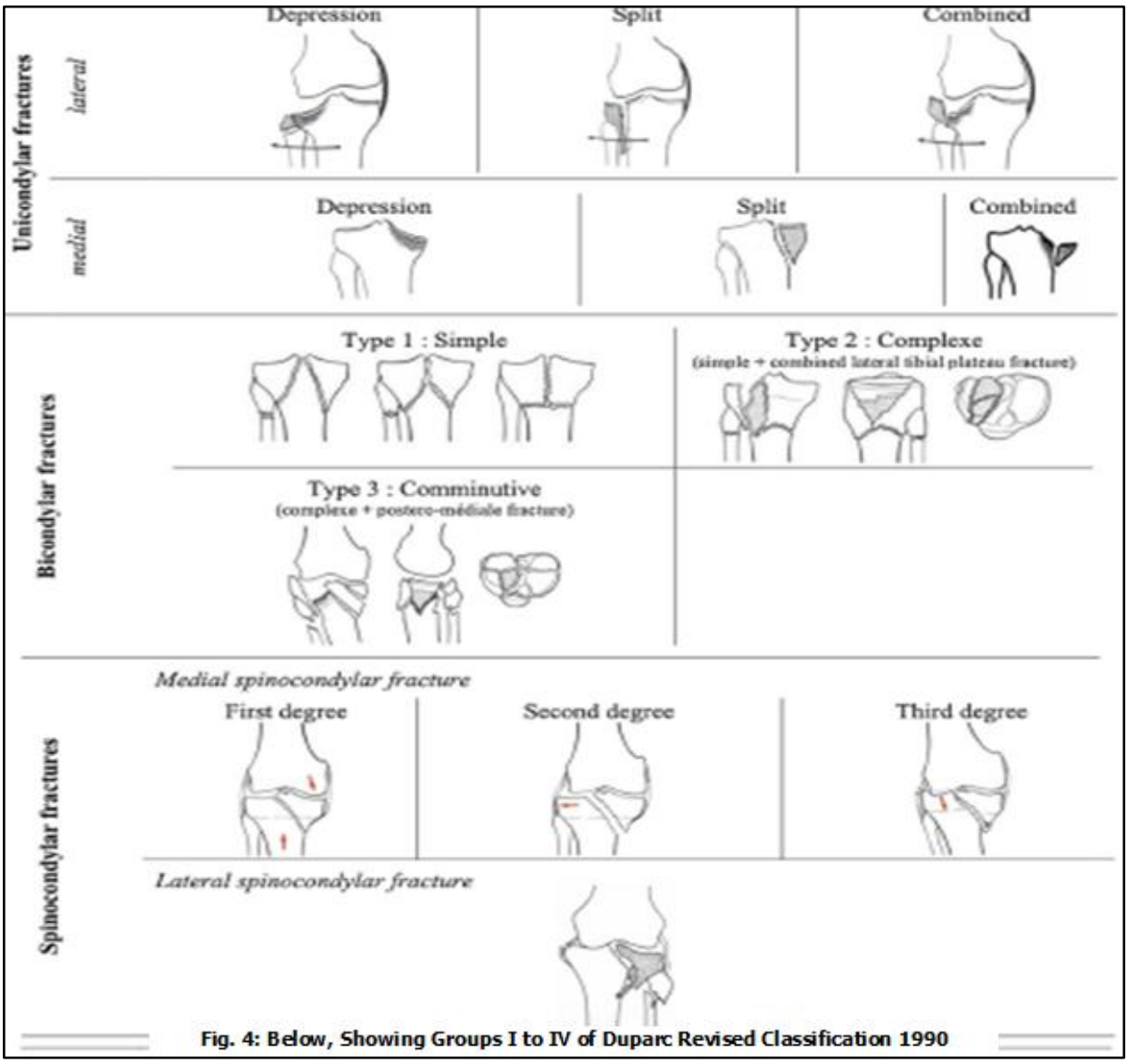

Fig. 4: Below, Showing Groups I to IV of Duparc Revised Classification 1990

The Optimized treatment protocol should include assessing and reconstructing the stability apparatus in primary fixations but it is not realistic to accomplish all these surgical aims in one single approach. Georgiadis used combined anterior and posterior approaches for ORIF of complex tibial plateau fractures involving a large postero-medial fragment[12] and Carlson treated five patients with posterior bi-condylar tibial plateau fractures by direct fracture exposure and fixation through postero-medial and postero-lateral incisions.[14] Two or more incisions are sometimes inevitable for exposure, reduction, fixation of fractures and restoration of soft tissue injuries.

MATERIALS AND METHODS: This Prospective study conducted at Government general Hospital, Kakinada from July 2014 to July 2015. We prospectively enrolled 15 patients with predominantly posterior medial condylar fractures of tibial plateau including a few Bicondylar tibial plateau fractures (Fig. 1). All patients were managed according to our treatment protocol. There were 11 men (69 %) and four women (31 %), with an average age of 40 years (range, 20–60). The left knee was involved in eight cases and the right in seven. They were all classified as Schatzker type VI or Duparc Group V-

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postero medial fracture and its associations (AO/ OTA classification not been used). All these are closed fractures, and no associated acute problems like compartment syndrome or neurovascular injuries were found at the time of admission. The soft-tissue integument injury grade, according to Tscherne-Oestern closed fracture classification,[19] was grade I in three cases, grade II in 12 cases.

These fifteen patients (eleven male, four female) with "medial split fractures" and its associations were treated via the direct posterior/ posteromedial approach plus other approaches (Anterolateral/ posterolateral) as needed. Six patients had isolated "medial split fractures" (Bhattacharya's Shearing type), seven patients bicondylar fractures of the tibial plateau, and two patients entire medial condyle fracture subluxation (Wahlquist et al. Type C[20]) All these are primary injuries and none are Malunions. All these could be grouped under Group V Duparc- Postero medial condyle and its associations.

Age	No of Cases	Percentage
21-30	3	20 %
31- 40	4	26.6 %
41-50	4	26.6 %
51-60	4	26.6 %

SEX		
MALE	11	69 %
FEMALE	04	31 %

Table 2: TABLE SHOWING PATIENT AGE GROUPS & SEX INCIDENCE

PERIOD OF IMMOBILISATION	NUMBER OF CASES
Under 10 Days	5
Under 3 weeks	6
Under 6 weeks	4

Table 3: TABLE SHOWING PERIOD OF IMMOBILISATION

The fractures are initially stabilized with a spanning external fixator (four cases) or calcaneal traction (six cases) in a Brown brace for one to two weeks to allow for soft-tissue injury and subsiding of swelling. If a spanning fixator is used, care with pin placement should be taken to avoid pin-site insertion into the area of the planned incisions for future surgery. The interval period between primary injury and definite internal fixation was 11 days (range seven to 21 days).

Preoperatively, radiographs, including antero posterior, lateral and both oblique views of the knee joint as well as CT scans/3D reconstructions, were taken to evaluate the severity of articular depression and cortical split, which were very useful for pre-operative planning.

Surgical Protocol: Under General Anaesthesia or Spinal Anaesthesia, the patient is placed in the Floating supine position. A high thigh pneumatic tourniquet is applied to the injured extremity. We prepare and drape both legs. The Floating supine position involves, the contralateral hip is flexed, adducted, with the pelvis rotated towards the injured side. This manoeuver places the patient's pelvis and lower trunk in a semi-lateral position, and the injured leg is rotated laterally, allowing access to the posterior aspect of the knee the leg in position.

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Figure 5

General anaesthesia and sufficient padding and support from the back keep the position easily. Once the posterior approach and fixation been done. The healthy leg is put back, and the support on the patient's back is removed; this returns the patient to a true supine position for a lateral plateau operation. A bump added under the ipsilateral hip further internally rotates the lower limb. The lateral tibial plateau is exposed through a conventional anterolateral approach. After submeniscus arthrotomy, the comminuted lateral plateau is visualized. The depressed articular fragments are elevated with a large amount of cancellous and subchondral bone. Another T- or L shaped heavy plate with long screws is used to buttress the reduced lateral plateau fracture, hold the tibial condyles together, and connect them to the tibial shaft.

Surgical Technique (Lobenhoffer's Direct, Posterior approach[21]): After pre-op antibiotics given, time out called, confirming the correct side, as the patient is in prone position or in Floating supine position high thigh tournique is applied. Land marks are marked (includes Flexion crease of the knee, medial and lateral Gastro soleal heads, and incision on the medial side). Surgical incision is a straight vertical incision (about 10 cm – 15 cm) just distal to the flexion crease medial to the medial head of Gastrocnemius, subcutaneous tissue and popleteal facia are incised by sharp dissection, saphenous vein and medial sural cutaneous nerve are usually not identified because the dissection stays medially. Then the head of the medial gastrocnemius is identified, mobilised with a cob elevator and retracted laterally, cob is then replaced with a Homan's retractor as shown the fig below the head of the medial gastrocnemius is retracted laterally and hamstrings medially, throughout the procedure, all neurovascular structures are retracted laterally under protection of the medial head of the gastrocnemius and then proceed with sub perosteal dissection of the popleteus to visualise the fracture, dissection being performed with a bovie cautery or a sharp knife. Then the fracture is visualised, hyper extension of the knee, postero medial fragment reduces antomically, this can be facilitated with the use of a ball tipped spike. Then place the second Homan's retractor to get full visualisation of the posteromedial aspect of the proximal tibia. The Hohmann retractor is to be positioned in the subperiosteal plane behind the lateral cortex of the tibia. This maneuver must be performed carefully to avoid indirect shearing injuries to the neurovascular bundle of the popliteal fossa. The insertion of the hamstrings is then retracted medially with a Langenbeck retractor and the

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popliteus is identiỳed and dissected through Bovie cautery with a vertical incision along its medial border and is detached subperiosteally with a Cobb elevator. The posteromedial fracture fragment is then visualised. Rarely, if needed for better medial visualization, the tibial insertion of the hamstrings is partly incised and released.

Fig 5 The subcutaneous tissue & popliteal fascia are incised by sharp dissection medial to the med hd of gastrocnemius saphenous vein& the medial sural cut. Nerve not seen

Fig 6 With the medial head of the gastrocnemius muscle retracted laterally and the hamstring muscles medially,di dissection of the popliteus is performed using a scalpel/ bovie

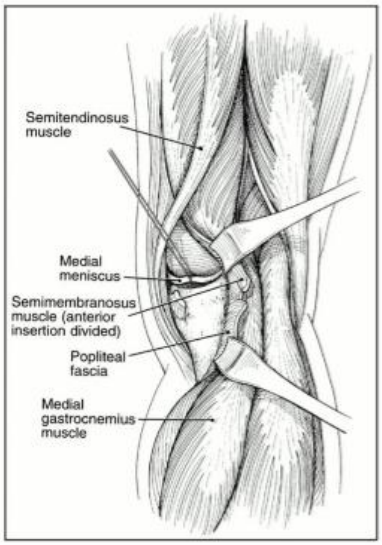

Fig. 7. Postero–Medial Tibial Plateau exposure

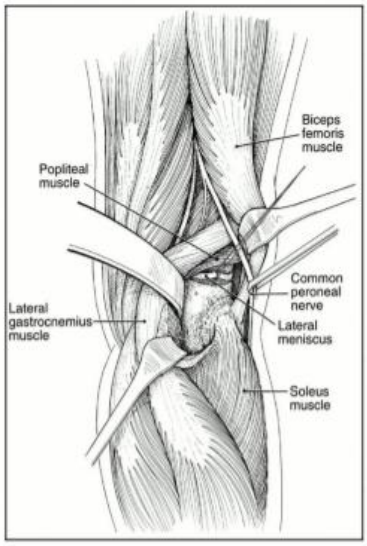

Fig. 8. Postero–Lateral Tibial Plateau exposure

Advantages & Drawbacks of Direct Posterior approach

Advantages	Drawbacks
1) Safe and efficient approach for posterior fractures 2) Biological and Biomechanically stable fixation through posterior approach 3) No risk of NV injury with diligent surgical dissection and careful placement of retractors 4) Nil or minimal complications	1) Prone position & its attended complications 2) Needs repositioning for additional surgical approaches 3) Newer approach with a little awareness of antomic details 4) Potential complications, NV injury

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Postero Medial approach (Fig. 9 to 14) of Wang et al[22,23]: Incision starts 3cms proximal to the joint line and follows the postero-medial border of tibia, saphenous nerve and great saphenous vein are identified and retracted along with anterior or posterior flaps. The Sartorius facia is incised in line with the incision. The Pes-anserinus tendons are identified and retracted distal-posterior or proximal –anterior, while medial gastrocnemius and soleus are retracted posteriorly. This exposes the junction between the popliteal fascia (posterior and distal), the SM muscle insertion (posterior and proximal), and the MCL. Incise the periosteum sharply, longitudinally down to the bone while staying posterior to the posterior border of MCL. The proximal exposure is limited because of the insertion of the SM. Using sub-periosteal dissection, the insertion of popliteus muscle is elevated off from the posterior tibia, which allows direct visualization of the triangular apex of the fracture at the meta-daiphyseal level. During sub-peiosteal dissection, there is a chance to avoid injury to the NV structures, including infero medial genicular vessels. Reduction of the joint line is generally done indirectly by direct of the apex and confirmed using fluoroscopic imaging.

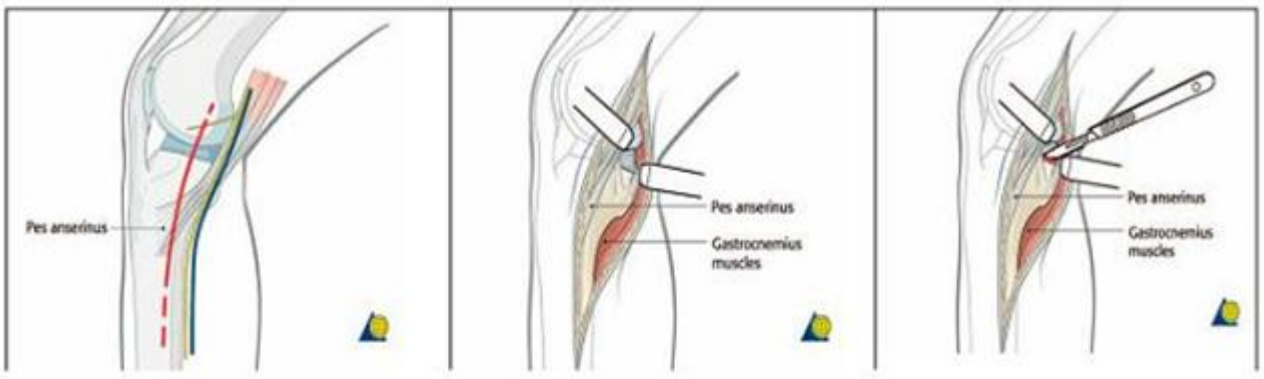

Fig. 9, 10. 11. Shows the AO described postero-medial approach (2) to the plateau

Fig. 12. Shows the surface anatomy of the plateau and positioning of incision

Fig. 13. Shows the position of the buttress plate.

Fig. 14. Today most of the bi-condylar fractures are addressed using a combined antero-lateral and postero-medial approach

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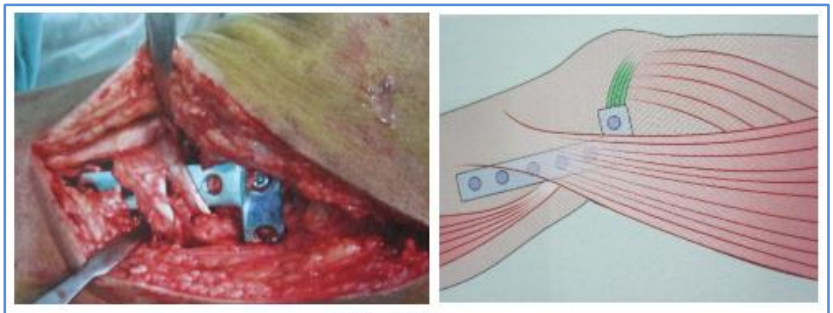

Fig. 15

RESULTS/OUTCOMES: All patients were followed up for 6 to 18 months, and the mean follow-up duration was 12 months. Fractures united on average of 24weeks (range, 18-32weeks). Average range of flexion of affected knee is 45-120 degrees at 12th month follow up and no loss of reduction or Mal alignment (varus or valgus) occurred on follow up nor any patient developed leg-length discrepancy. One case developed superficial infection, which settled with IV antibiotics and dressings. One case developed knee stiffness (20- 95 degrees ROM). None of our cases had deep sepsis, DVT, nor any NV injuries or compartment syndrome. At final follow-up nearly 18 months, no evidence of radiological OA was in any of our cases although follow up period is short.

The Functional outcome was analysed using Oxford Knee Score (OKS), and Lyshom Score and radiological outcome by plain radiographs. The mean OKS score was 40 (range 36 to 44) at the final follow up and results been Excellent to Good in 94 % of cases (14/15) and fair in 6.6 % of cases (1/15).

Clinical results	Number of cases	Percentage
Excellent	12	80
Good	2	13.3
Fair	1	6.6
Poor	0	0

Table 4: Clinical results of surgical treatment

Pre Op Radiographs Post Op Radiographs ROM at Final Follow up

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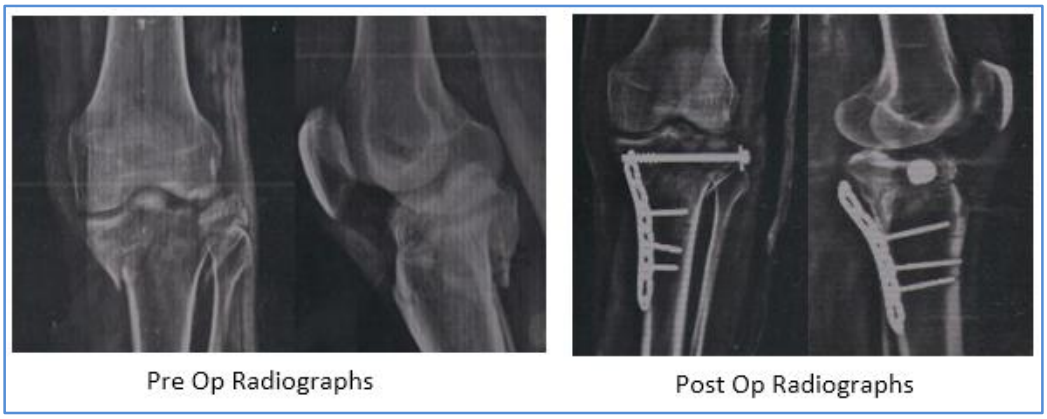

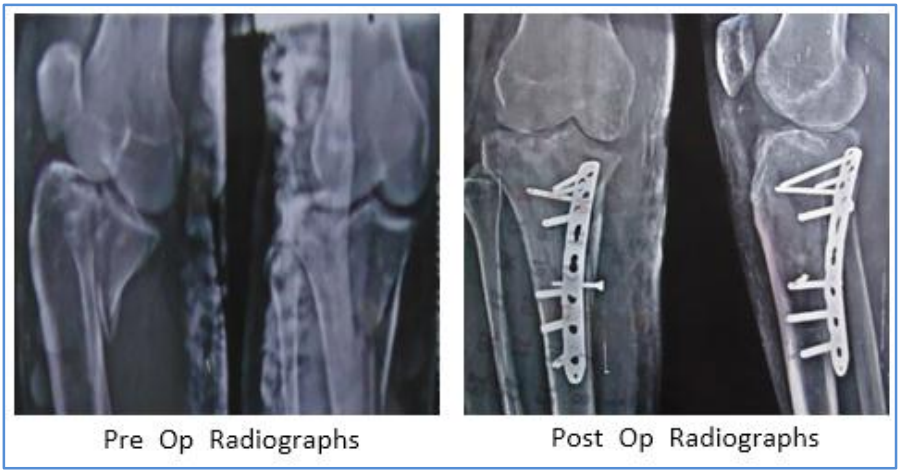

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Post ROM at final follow up Felxion

Extension

Pre op Radiographs

Post Op Radiographs

Post ROM at final follow up: Extension

FLEXION

DISCUSSION: The mechanism concerning high-energy fractures of the tibial plateau is complex. Low-energy fractures of tibial plateau could be categorized as Schatzker type I–III. Several authors have pointed out that fractures of Schatzker type IV–VI are mostly caused by high energy; however, the Schatzker classification just limits to morphological assessment in sagittal plane and could not be used in coronal fractures of posterior condyles.[24,25] There are only few clinical reports concerning high-energy fractures of tibial plateau until now, and it might be associated with complex mechanism of injury, difficult reduction and fixation, and unpredictable prognosis.

Anterior approaches are main method for treating tibial plateau fractures in the past decades. Even for single posterior condyle fractures, a plate-screw system or a lag screw is

employed to fix the posterior fractures from anterior. This kind of osteosynthesis does not conform to the principle of biomechanics; meanwhile, it is hard to achieve the high standard of articular reduction, and flexion of the knee joint is not permitted for fear of fragment redisplacement. Although Lobenhoffer,[21] Fakler,[25] Tao,[26] and Chang[27] have illustrated different anatomic spaces in minor details to posterolateral and posteromedial condyles, the aim and essence is similar, that is, the expectation to expose, reduce, and fix the fragment. Compared with anterior approaches, the value of PM and PL approaches is in accordance with biomechanics, easy anatomical reduction of articular surface, which could be stabilized with antiglide or buttress plate.[9,10,28] The concomitant injury of soft tissue always locates anterior; moreover, posterior soft tissue is thick and rich in blood supply. Good condition of posterior soft tissue allows an early operation, and postoperative problems of soft tissue are rare. Treatment protocol of tibial plateau fractures through posterior approaches is indicated in predominately posterior tibial plateau injuries, but as we know, anterior approaches still mean cardinal in the treatment of anterior fractures, ligament and meniscus injury, and metaphyseal comminution. When major fractures locate posterior condyles of tibial plateau, one PL or PM approach could be adopted for ORIF first. The evaluation of articular surface and knee stability is carried out during operation, which is determinant in whether anterior approaches should be added. Dual incisions are inevitable in fractures obviously displaced to anterior and posterior (burstlike), and proven ligament, meniscus injury needing reconstruction. As the fracture of posterior condyle is split-like and simple, ORIF could be started first in posterior with patient prone, and then, anterior approach is used with patient supine. Generally, combinations of PL and AM, PM and AL approaches are formed, which not only benefit for wide exposure, direct reduction, and fixation of fractures, but also for the wide soft-tissue bridge between two incisions, which could prevent skin necrosis. The restoration of knee stability seems more important than the reduction of articular surface, though Weigel and Marsh concluded that the knee joint cartilage appears to be tolerant of both the injury and mild-to-moderate residual articular displacement.[29] However, several studies have proven that the knee instability is the most important factor for a poor prognosis. The varus and valgus deformity could be well prevented with maintaining the tibia in alignment in both sagittal and coronal planes, through precise preoperative planning, careful reduction, and biomechanical fixation. Soft-tissue injury, which is concomitant with plateau fractures, is quite common in high-energy trauma, and the interruption of surgery makes it more fragile. It is well demonstrated that complications of soft tissue after ORIF of tibial plateau fractures are notorious to deal with in past decades.[30] As above-mentioned techniques of percutaneous and external fixations have lowered the rate of soft-tissue problems, however, they could not perform satisfactorily in articular comminution and instability. Posterior approaches are relatively complex in anatomy, but complications concerning soft tissue are rare. Soft-tissue complications in anterior approaches could be prevented through as minimal time as possible for operation time, careful handling of soft tissues, and early rehabilitation, though the majority of tibial plateau fractures could achieve satisfactory results with a single anterior or posterior approach.[31,32] Various external fixators or hybrid of external and internal fixation play a critical role when severe soft-tissue damage exists. The principles of staged treatment and individual characteristics proposed by Tscherne and Lobenhoffer[33] should be noted if polytrauma or concomitant soft-tissue problems do not permit

an optimized treatment. It could be concluded from the cases that soft-tissue complications in posterior approaches are fewer than those in anterior.

The morphological characteristics of the complex bicondylar four-quadrant tibial plateau fractures follow a regular pattern, which was also described by many authours.[2,3,34,35,36] The concave medial plateau is usually split into two large fragments (posteromedial and anteromedial) without articular depression, while the convex lateral plateau is split-depressed into various degrees of multi-fragments with broadening of the lateral compartment (anterolateral and posterolateral). The coronal posteromedial quadrant fragment usually has an inferior V-shaped cortical spike, which can intra operatively be used as a landmark. Some cases have a separate anterior tubercle fragment. Additionally, the attachment of the ACL/ PCL may be isolated from the intercondylar spine and form a solitary fragment. Clinically, because the posterolateral quadrant fragments are very difficult to approach and fix, involving the posterolateral quadrant is a marked feature of the term "severe and complex bicondylar tibial plateau fractures".[37] The combined approaches used in our cases includes posteromedial inverted L-shaped and traditional anterolateral incisions. The distance between the two skin incisions is large, and the risk of wound complications is relatively low. In our case series, 94% of the incisions (14/15) healed primarily. Through the posteromedial inverted L-shaped approach exposure of three quadrants, the PM, AM and PL, can be visualized and manipulated, although exposure of the PL quadrant is somewhat difficult because the gastrocnemius-soleus muscles are very strong in some cases and it is difficult to retract them laterally. Our fixation construct can be summarized as a medial posterior enclosure and lateral raft-buttress. For those complex bicondylar fractures, anatomic reduction of the PM fragment is of paramount importance.[7,37,38] By exact reposition of the distal V-shaped fracture spike, the fragment height and tilt angle can be anatomically restored. Small plates with short screws are used to stabilize the PM, AM and PL quadrant fragments, so that no interfere with the later placement of lateral long raft screws. The working mode of these medial posterior small plates is likely to set up a fence that can keep the fragments from collapse, and the construct can be termed enclosure fixation. The lateral heavy locking compression plate with long rafting screws works as suspending arms that hold the lifted articular surface, connecting the reconstructed tibial condyle to the shaft via bicortical long screws.

A prolonged operation time and repeated pneumatic usage are related to an increased overall risk for surgical site infection after open plating of the tibial plateau fractures. In our case series, the average operation time was 94±24 minutes Most of the cases were finished within two hours, which may be one of the important reasons for the low wound complication rate. With early knee joint motion exercise, we achieved 80 % excellent and 6.6 % good results (overall 86.6 % acceptable results) with our treatment protocol.

CONCLUSIONS: The limitation of this study is that the sample size is quite small and follow up period is only maximum 19 months. Although it was found that postoperative complications were low and short-term prognosis was satisfactory, we cautiously conclude, for severe and complex bicondylar four quadrant tibial plateau fractures, multiple medial-posterior small plates combined with a lateral strong locking plate through dual incisions can provide stable fixation to allow for early stage rehabilitation and the Lobenhoffer's (direct, posterior) approach is an easy, safe,

simple and an efficient surgical approach that is worth learning to keep the procedure quick and the soft-tissue complication low. Good clinical outcomes can be anticipated.

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