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Tibial Plateau Fractures with Knee Dislocation: A Literature Review

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ABSTRACT

Tibial plateau fractures and knee dislocations frequently occur concurrently as a result of high energy trauma, such as motor vehicle accidents, falls from height, or sports related injuries, which not only compromise bony structures but also severely damage surrounding soft tissues, major vascular structures, and peripheral nerves. [1] Tibial plateau fractures account for approximately one percent of all orthopaedic fractures, with an annual incidence of 10.3 per 100,000 individuals. These injuries predominantly affect young adult males following severe trauma, as well as women over 50 years of age after low energy mechanisms.[2,3] Although knee dislocation is relatively uncommon, with an incidence of only 0.02 percent of orthopaedic injuries, it carries a substantial risk of vascular and neurological complications in every case.[3] In Indonesia, the high rate of traffic and occupational accidents contributes to the increased occurrence of both injuries. A study from Cipto Mangunkusumo Hospital in Jakarta reported that two percent of orthopaedic trauma cases involved tibial plateau fractures, while 0.5 percent involved knee dislocations.[4] The combination of these two injuries presents unique diagnostic and management challenges and significantly increases the risk of soft tissue necrosis, permanent knee dysfunction, or even amputation if treatment is delayed.[5] Optimal management requires early stabilization in the emergency department, followed by targeted surgical intervention for reduction and stabilization of both the fracture and dislocation, as well as multidisciplinary rehabilitation. A thorough understanding of the epidemiology, clinical characteristics, and appropriate management strategies is therefore crucial to minimize complications and maximize functional recovery of the knee.

Keywords: Tibial plateau fracture, knee dislocation, and trauma

INTRODUCTION

Tibial plateau fractures and knee dislocations frequently occur concurrently as a result of high energy trauma, such as motor vehicle accidents, intensive sports activities, or falls from height. In most cases, the damage is not limited to the bone itself, but also involves periarticular soft tissues, major vascular structures, and peripheral nerves. [6] A tibial plateau fracture refers to a disruption of the proximal tibia that supports the knee joint, whereas a knee dislocation occurs when the anatomical relationship between the femur and tibia is lost, resulting in significant joint instability. [7]

Tibial plateau fractures and knee dislocations most commonly occur in individuals exposed to high energy trauma, such as athletes, motor vehicle riders, or high-risk workers. However, plateau fractures may also develop in elderly patients following low energy mechanisms. Tibial plateau fractures account for approximately one percent of all orthopaedic fractures, with an annual incidence of 10.3 per 100,000 population, predominantly affecting young men due to traffic accidents and women over 50 years of age due to falls.[8] In contrast, knee dislocation is rare, representing approximately 0.02 percent of orthopaedic injuries, yet it carries a serious risk profile, frequently associated with fractures or vascular injury, and its incidence is increasing in parallel with the rising frequency of traffic accidents and extreme sports activities.[9]

In Indonesia, the incidence of these injuries remains significant, consistent with the high rate of road traffic accidents and the growing number of occupational injuries. Data from the Indonesian Ministry of Health indicate that trauma resulting from traffic accidents represents one of the leading causes of orthopaedic injury, including tibial plateau fractures and knee dislocations. [10] A study conducted at Cipto Mangunkusumo Hospital in Jakarta reported that approximately two percent of all orthopaedic trauma cases involved tibial plateau fractures, while around 0.5 percent were associated with knee dislocations. Although relatively uncommon, both conditions often require urgent medical management due to the potential for complications such as impaired blood flow or nerve injury, which may worsen the patient's long term prognosis.

The combination of tibial plateau fracture and knee dislocation presents substantial diagnostic and therapeutic challenges, as delayed or inadequate management may result in tissue ischemia, necrosis, amputation, or permanent loss of knee function. [11] Therefore, accurate early diagnosis followed by surgical intervention for reduction and stabilization of both the fracture and dislocation is essential to achieve optimal clinical outcomes. Given the complexity of these injuries and the risk of vascular, neurological, and long-term orthopaedic complications, multidisciplinary management involving orthopaedic, vascular, and rehabilitation teams is crucial to accelerate functional recovery and minimize morbidity. [5]

Anatomy and Biomechanics of the Knee Joint

The knee joint is a large and complex synovial articulation connecting the femur and tibia. The femoral condyles articulate with the tibial plateau, a structure that divides the joint into medial and lateral compartments, supports body weight, and is covered by hyaline cartilage to reduce friction. The patella, embedded within the quadriceps tendon, functions as a lever mechanism and provides protection against traumatic forces.

Knee stability is primarily supported by the anterior cruciate ligament and posterior cruciate ligament, which prevent excessive tibial translation relative to the femur, as well as the medial and lateral collateral ligaments, which maintain varus and valgus stability. The medial and lateral menisci, crescent shaped fibrocartilaginous structures, increase the contact surface area and contribute to load distribution and shock absorption. The medial meniscus is more prone to tearing due to its stronger capsular attachment.

Tibial plateau fractures, classified according to the Schatzker system from type I to type VI, disrupt the articular contour and compartment stability and may be associated with articular depression. Vascular supply to the knee is facilitated by the genicular anastomosis arising from branches of the popliteal artery. In addition, the common peroneal and tibial nerves are at risk of injury in high energy trauma, potentially resulting in motor and sensory deficits that may significantly affect long term prognosis.

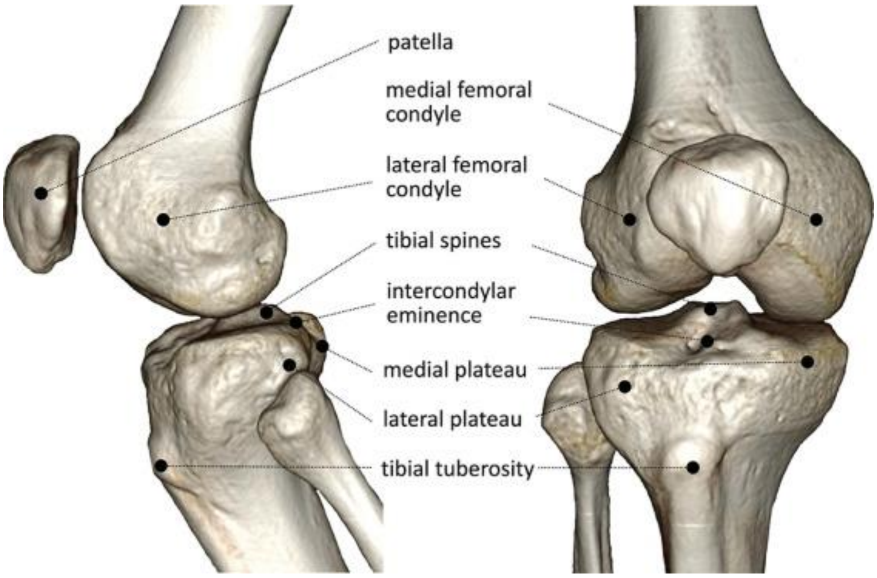

Figure 1. Anatomy of the Knee Joint.[12]

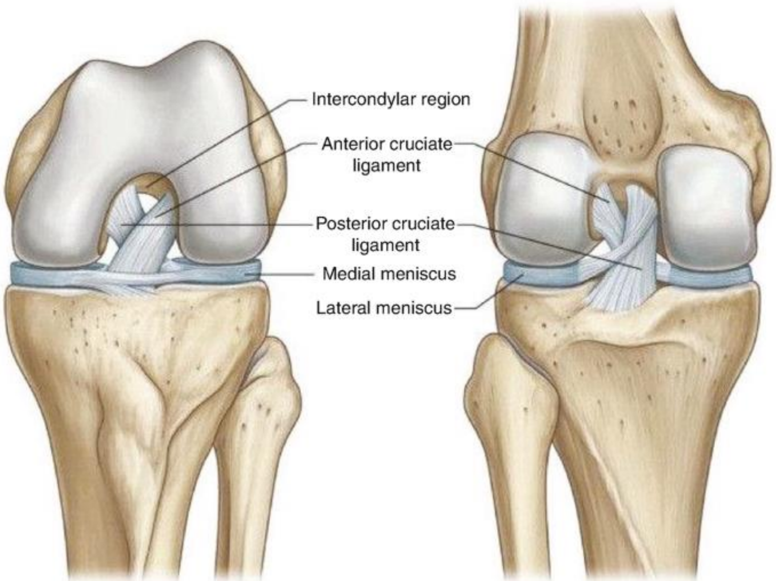

Figure 2. Knee Joint Ligament.[13]

The knee joint functions as a modified hinge joint that balances the demands of stability and mobility by allowing primary flexion and extension, accompanied by a small degree of internal and external rotation during flexion. During flexion, the femoral condyles undergo a rolling and shifting motion over the tibial plateau, while the menisci contribute to pressure distribution and maintenance of articular surface congruency.[2,14] The synergistic interaction between bony structures, ligaments, menisci, muscles, and the joint capsule produces complex kinematic control and an adaptive response to dynamic loading.

The anterior and posterior cruciate ligaments regulate anteroposterior translation of the tibia relative to the femur, whereas the medial and lateral collateral ligaments resist valgus and varus forces, particularly at 20 to 30 degrees of flexion when the knee is most vulnerable to lateral stress.[15] The menisci serve a dual role as load absorbers and secondary stabilizers by increasing the contact area and reducing stress on the articular cartilage. During the stance phase of the gait cycle, compressive forces across the knee may reach two to three times body weight, increasing to five to seven times body weight during running or jumping activities. Therefore, the structural integrity of the bone, ligaments, and menisci is essential to prevent injury and to maintain normal knee function. [16]

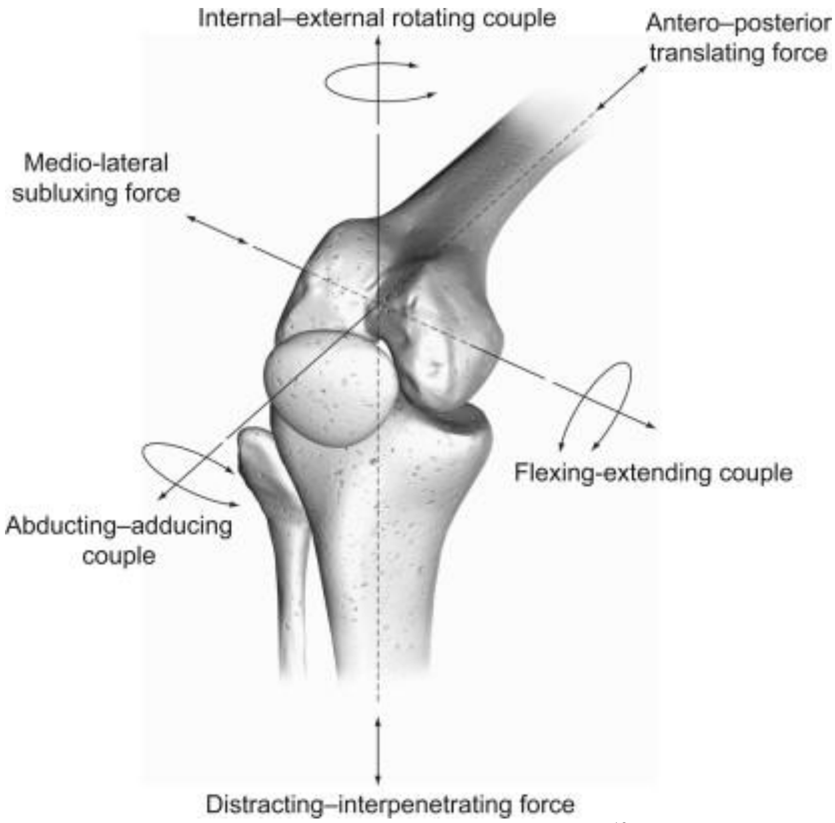

Figure 3. Knee Joint Biomechanics.[13]

Tibial Plateau Fractures and Knee Joint Dislocation

Tibial plateau fractures represent complex injuries involving the articular surface of the proximal tibia, most commonly resulting from high energy trauma, although low energy mechanisms may also cause fractures in elderly osteoporotic patients. The Schatzker classification system distinguishes fracture patterns according to the affected compartment and the mechanism of injury, including split, depression, or combined patterns. Disruption of articular continuity increases the risk of knee instability, axial deformity, and post traumatic osteoarthritis if not managed optimally.[17] Knee joint dislocation, defined as complete loss of tibiofemoral contact, is frequently associated with multiligamentous injury involving the anterior cruciate ligament, posterior cruciate ligament, medial collateral ligament, and lateral collateral ligament. It carries a substantial risk of serious vascular and neurological complications and is therefore considered an orthopaedic emergency.[18] The combination of tibial plateau fracture and knee joint dislocation reflects severe axial and translational trauma with comminution and multisystem structural damage, involving osseous components, surrounding soft tissues, and neurovascular structures. This injury pattern poses significant challenges in diagnosis, stabilization, reconstruction, and rehabilitation, and it increases the risk of long-term complications such as early osteoarthritis, joint stiffness, chronic instability, and even amputation.[19]

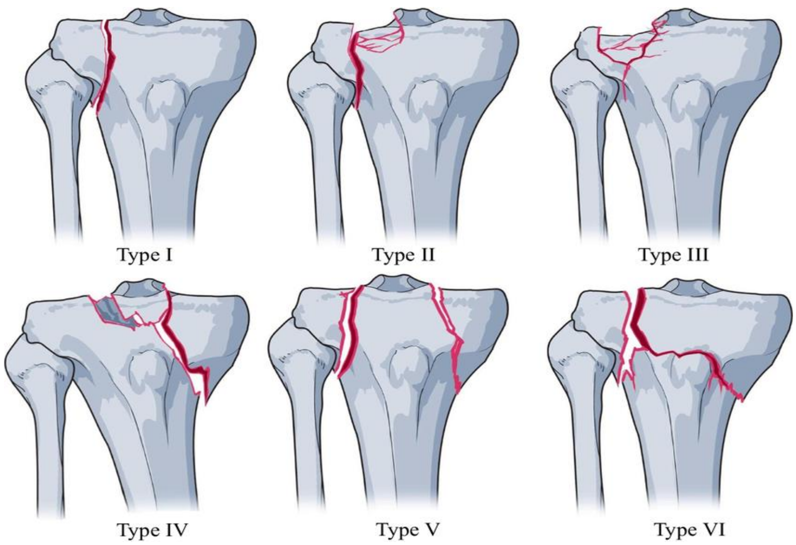

Figure 4. Tibial Plateau Fracture Classification of Schatzker[18]

Tibial plateau fractures are severe intraarticular injuries, accounting for approximately one percent of all fractures and eight percent of joint fractures, with an annual incidence ranging from 10.3 to 13.3 per 100,000 population. Young men aged 30 to 50 years typically sustain these fractures following high energy trauma, such as motor vehicle accidents or falls from height, whereas elderly women over 60 years of age are more susceptible to low energy fractures related to osteoporosis. Knee dislocation, although much rarer at approximately 0.02 percent of musculoskeletal trauma, is often underdiagnosed due to spontaneous reduction. It most frequently occurs in men aged 20 to 40 years after high energy impact, with a strong tendency toward multiligamentous disruption and a high risk of vascular and neurological injury.[20]

The combination of tibial plateau fracture and knee dislocation is relatively uncommon but highly severe. Schatzker type IV to VI fractures are most frequently associated with profound joint instability and dislocation. The literature reports that approximately 30 to 40 percent of severe fracture patterns are accompanied by significant ligamentous injury, 10 to 20 percent involve limb threatening vascular injury, and 2 to 9 percent develop post traumatic compartment syndrome. Common peroneal nerve injury and popliteal artery injury have been reported in 14 to 40 percent and 18 to 64 percent of knee dislocation cases, respectively. Despite advances in reconstructive techniques and implant technology, long term prognosis is strongly influenced by the severity of vascular compromise, the extent of soft tissue involvement, the timeliness of diagnosis, and early intervention. The risk of post traumatic osteoarthritis following severe tibial plateau fractures and or knee dislocation has been reported to reach 23 to 44 percent in longitudinal studies.[21]

Pathomechanism of Tibial Plateau Fractures and Knee Dislocation

Tibial plateau injuries and knee dislocations reflect exposure to high mechanical energy across the knee joint that exceeds the tolerance capacity of its supporting structures. Tibial plateau fractures occur when substantial axial forces, such as those sustained in motor vehicle accidents or falls from height, are combined with torsional, varus, or valgus components. This results in impaction of the femoral condyles onto the proximal tibial surface, producing fracture lines, articular depression, or subchondral fragmentation. These lesions are almost invariably accompanied by meniscal damage, ligament rupture, and injury to the joint capsule and articular cartilage, thereby disrupting joint congruency, load redistribution, and biomechanical stability.[20]

Knee dislocation represents complete failure of the primary stabilizing system and occurs when hyperextension forces, rapid deceleration, extreme valgus or varus stress, or forced rotational mechanisms displace the tibia anteriorly, posteriorly, medially, laterally, or rotationally relative to the femur. Anterior dislocation is typically associated with rupture of the anterior cruciate ligament, posterior cruciate ligament, and collateral ligaments, whereas posterior dislocation, particularly in dashboard type trauma, carries a high risk of popliteal artery injury. [22,23]

The combination of these two injuries results in extensive disruption of both articular structures and ligamentous integrity, further aggravating dynamic instability and increasing the potential for vascular and neurological complications. Therefore, prompt diagnosis and appropriate surgical intervention are essential to restore anatomical stability and optimize functional recovery of the knee.[23]

DIAGNOSIS

History Taking and Physical Examination

History taking in suspected tibial plateau fracture associated with knee dislocation must be systematic, with particular emphasis on the mechanism of injury, such as high axial loading, varus or valgus stress, or rotational forces, for example dashboard type trauma or a fall with the knee in flexion. Key symptoms include severe pain, rapid swelling due to hemarthrosis, visible deformity, a snapping sensation, subjective instability, and sensory or motor complaints suggestive of common peroneal or tibial nerve injury. A history of peripheral vascular disease, diabetes mellitus, or coagulopathy should also be documented, as these conditions may influence the risk of complications and impair healing. [19]

Physical examination begins with inspection for deformity, alteration of the limb mechanical axis, swelling, ecchymosis, and skin color changes such as pallor or cyanosis. Palpation helps confirm localized tenderness, crepitus, and joint instability. Ligamentous stability tests, including the Lachman test for anterior cruciate ligament integrity, the posterior drawer test for posterior cruciate ligament injury, and varus or valgus stress testing for lateral or medial collateral ligament involvement, should be performed gently and ideally after appropriate imaging, as excessive manipulation may worsen the injury. Active and passive range of motion is typically limited because of pain. [19]

Neurovascular assessment is the highest priority to identify limb threatening emergencies. This includes bilateral evaluation of the popliteal, posterior tibial, and dorsalis pedis pulses. Absence of distal pulses or signs of ischemia, such as pallor, coolness, or capillary refill time greater than two seconds, strongly suggests popliteal artery injury and requires ankle brachial index measurement. An index value below 0.9 warrants urgent computed tomography angiography or formal arteriography, as well as serial monitoring over 24 to 48 hours to detect intimal thrombosis. Motor and sensory examination of the common peroneal nerve, including ankle dorsiflexion, toe extension, and sensation over the dorsum of the foot, as well as assessment of the tibial nerve, including plantar flexion and plantar sensation, is essential to determine the need for further nerve exploration. [19,24]

Surveillance for compartment syndrome must be maintained by recognizing disproportionate pain, particularly pain with passive stretch, paresthesia, paresis, and eventual pulselessness. When clinical suspicion is high, compartment pressures should be measured immediately, for example using a Stryker device. A compartment pressure greater than 30 mmHg or a perfusion pressure differential, defined as diastolic blood pressure minus compartment pressure, below 30 mmHg constitutes an indication for emergency fasciotomy. [24]

Diagnostic Investigations

Diagnostic evaluation of tibial plateau fractures, with or without associated knee dislocation, begins with conventional radiography. Anteroposterior views demonstrate fracture lines across the tibial plateau surface and fragment displacement that may indicate dislocation, whereas lateral views reveal angular deformity and articular step off, reflecting incongruity between the tibial and femoral articular surfaces. Skyline projections facilitate detection of associated patellar fractures or dislocation. [25]

For detailed characterization of fracture morphology, three-dimensional computed tomography is essential for Schatzker classification from type I to type VI. It enables accurate identification of complex fracture fragments, depth of articular depression, and associated cartilage injury, all of which influence long term prognosis. [26] Magnetic resonance imaging complements bony assessment by evaluating soft tissue structures, including anterior and posterior cruciate ligament tears, medial and lateral collateral ligament injury, meniscal displacement or defects, and tibial or femoral cartilage damage. [19]

Doppler ultrasonography plays a role in assessing lower extremity vascular flow to detect thrombus formation or popliteal artery compression, while computed tomography angiography or conventional angiography is indicated when rupture or occlusion of major vessels is suspected. In cases of suspected nerve involvement, such as muscle weakness or sensory loss, electromyography and nerve conduction studies are required to evaluate motor and sensory function of the common peroneal or tibial nerves, which are frequently injured in association with knee dislocation. [24]

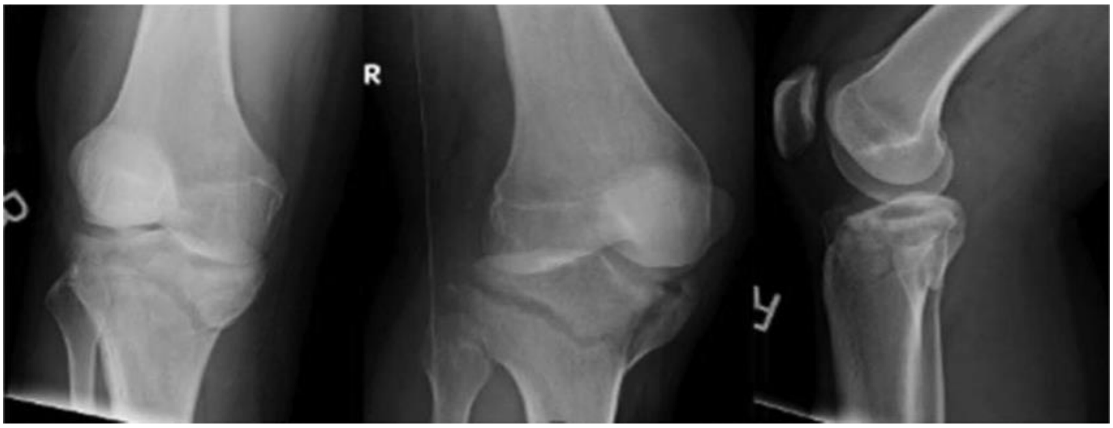

Figure 5. Severe tibial plateau fracture and knee dislocation visualized on radiography[27]

Figure 6. Tibial Plateau Fracture on CT-Scan findings[28]

Management

Management of tibial plateau fractures associated with knee dislocation requires a comprehensive and multidisciplinary approach addressing the bone, joint surface, ligaments, menisci, as well as vascular and neural structures. In general, treatment can be divided into two major aspects, namely acute emergency management and long-term care aimed at restoring and preserving function while preventing complications. [19]

Acute Management in the Emergency Setting

During the initial phase of tibial plateau fracture with concomitant knee dislocation, the first priority is immobilization of the affected extremity using a splint or brace to maintain knee alignment and prevent movements that may exacerbate injury, while ensuring overall hemodynamic stability. Acute pain control must be initiated promptly through analgesic administration, ranging from non-steroidal anti-inflammatory drugs to opioids for severe pain, with consideration of regional nerve blockade such as femoral or popliteal blocks to reduce the risk of pain induced shock. [24]

Simultaneously, a thorough neurovascular assessment is essential, including evaluation of popliteal artery pulsation and sensorimotor function of the common peroneal and tibial nerves, to detect early circulatory compromise or neurological deficits. If impaired blood flow or paralysis is identified, further procedures such as angiography, vascular decompression, or nerve exploration must be urgently planned to prevent tissue ischemia and minimize functional loss of the limb. [25]

Operative Treatment

Following initial stabilization, most patients with tibial plateau fractures accompanied by knee dislocation require surgical intervention to restore articular continuity, joint stability, and knee function. In stable fractures without major displacement or minimal fragmentation, non-operative measures such as closed reduction under regional anesthesia with manual realignment and external immobilization may restore bony fragments to their anatomical position. [26] Closed reduction may also be considered when ligamentous or meniscal injury is not significant. This approach is often selected due to its relatively low infection risk and shorter procedural time. However, unsuccessful reduction may lead to long term instability and an increased risk of osteoarthritis. [29]

In complex tibial plateau fractures involving substantial comminution, major dislocation, or significant ligamentous and meniscal disruption, open reduction and internal fixation is required. Through a surgical approach to the tibial plateau, fracture fragments are anatomically reduced and stabilized using compression plates and titanium or stainless-steel screws, allowing early mobilization and reducing the risk of malunion. [30] Nevertheless, because of the larger surgical exposure, infection risk is higher, and fixation related complications such as plate or screw failure may occur, potentially resulting in recurrent instability or refracture. [30]

Associated anterior or posterior cruciate ligament injuries may be reconstructed arthroscopically using autografts, commonly from the patellar tendon or hamstring tendons, or allografts from donors, in order to restore dynamic joint stability. [31] Meniscal injuries may be managed through meniscal repair or partial arthroscopic meniscectomy to optimize load absorption and prevent cartilage degeneration. [32]

When vascular injury is present, particularly involving the popliteal artery, urgent vascular decompression and reconstruction with grafting must be performed after diagnostic angiography to restore distal perfusion and prevent limb threatening ischemia.[24] The choice of surgical procedure depends on fracture morphology, degree of dislocation, and the extent of ligamentous, meniscal, and vascular involvement, with the ultimate goal of achieving anatomical reduction, mechanical stability, and long term functional recovery.[26]

Postoperative Care and Rehabilitation

Postoperative management of tibial plateau fractures with knee dislocation requires a holistic protocol to optimize bone healing, prevent complications, and restore joint function. Early mobilization once hemodynamic stability is achieved is essential to avoid joint stiffness and reduce the risk of deep vein thrombosis.[27]

Individualized physiotherapy includes active and passive range of motion exercises, edema reduction through compression and cryotherapy, and progressive strengthening of the quadriceps and hamstring muscles to support joint stability. Rehabilitation protocols must be tailored to the type and severity of injury as well as the surgical procedure performed.[28]

Long term pain management involves non-steroidal anti-inflammatory drugs and non-pharmacological modalities to control inflammation and reduce the progression of secondary osteoarthritis. Regular radiological follow up is necessary to confirm fracture consolidation without malunion or infection, while routine clinical assessment of range of motion and muscle strength guides rehabilitation adjustment. In cases of residual instability or progressive joint degeneration, further surgical intervention may be considered.[29]

Complications and Their Management

Tibial plateau fractures with knee dislocation carry substantial risks of both short term and long-term complications. Post traumatic osteoarthritis is the most common chronic complication, resulting from articular surface damage and persistent instability. Long term management may include conservative therapy such as walking aids, analgesics, and activity modification, whereas severe osteoarthritis may ultimately require total knee arthroplasty.[30]

Postoperative infection, particularly at internal fixation sites, may delay bone healing and requires monitoring for clinical signs such as fever, erythema, or wound drainage, along with prophylactic antibiotics and urgent surgical debridement when indicated. Additional complications include malunion, nonunion, compartment syndrome, deep vein thrombosis, and neurovascular injury. Therefore, prevention and early detection through continuous clinical and radiological surveillance remain crucial to optimize long term outcomes.[31]

Table 1. Complications of Tibial Plateau Fractures With Knee Joint Dislocation

Complication	Explanation	Management
Infection	Infection may occur at the surgical incision site or within the bone, potentially leading to osteomyelitis. Postoperative infection represents a serious complication that may delay healing and compromise functional outcomes.	Antibiotic therapy should be administered according to bacterial culture and sensitivity results. Abscess drainage and thorough irrigation are required, and surgical debridement is performed to remove necrotic tissue. In cases of severe infection, further operative intervention may be necessary to eradicate infected tissue and prevent progression.
Bleeding and Hematoma	Bleeding may result from injury to major blood vessels or postoperative hematoma formation. This can cause swelling, pain, and impaired circulation.	Direct compression should be applied to control active bleeding. Blood transfusion may be required if hemorrhage is significant. Surgical drains can be placed to prevent hematoma accumulation, and vessel ligation may be indicated when bleeding persists.
Joint Instability	Joint instability may develop when ligaments such as the anterior cruciate ligament or posterior cruciate ligament, as well as the menisci, are damaged, thereby affecting knee stability and overall joint function.	Ligament reconstruction may be performed using autograft or allograft tissue. Joint alignment should be restored through stronger internal fixation when instability remains. Rehabilitation is essential to recover knee stability and functional outcomes.

Non-union or Malunion	Nonunion occurs when the fracture fails to heal adequately, whereas malunion refers to bone healing in an incorrect anatomical position, which may result in deformity and long term dysfunction.	Revision fixation with external or internal devices may be required in cases of nonunion or malunion. Bone grafting can be used to stimulate fracture healing, and reoperation may be necessary to correct malalignment and restore anatomical position.
Circulation Decomposition & Gangrene	Vascular compromise may lead to impaired blood flow and subsequent tissue necrosis, particularly in cases of knee dislocation involving major vessels.	Vascular reconstruction using grafts is indicated to restore adequate blood flow. If extensive gangrene develops and limb salvage is not possible, extremity amputation may become necessary.
Joint Stiffness and Contracture	Joint stiffness and contracture may occur due to restricted range of motion following trauma, significantly limiting knee function.	Physical therapy is required to improve flexibility and restore range of motion. Joint manipulation under anesthesia may be considered to address severe stiffness. Knee bracing may provide additional stability and help prevent contracture formation.
Post Traumatic Osteoarthritis	Post traumatic osteoarthritis may develop as a consequence of irreversible cartilage damage, leading to chronic pain and progressive functional deterioration of the joint.	Pain management includes analgesics and non-steroidal anti-inflammatory drugs to reduce discomfort. Total knee arthroplasty may be considered if degenerative changes progress. Ongoing rehabilitation remains crucial to optimize long term knee function.

PROGNOSIS

Prognosis in tibial plateau fractures associated with knee dislocation is strongly influenced by fracture severity, ligament involvement, vascular and neurological status, the success of anatomical reduction and internal fixation, and adherence to postoperative rehabilitation.[32] Stable reduction and fixation combined with adequate ligament reconstruction generally result in knee range of motion greater than 90 degrees within 6 to 12 months, with return to light activities in 6 to 9 months, whereas return to heavy physical activity typically requires more than 12 months.[33]

However, complications such as limb threatening popliteal artery injury, common peroneal neuropathy reported in 25 to 40 percent of cases, and failure of ligament stabilization frequently worsen prognosis, increasing the risk of amputation and chronic instability.34 Post traumatic osteoarthritis develops in approximately 30 to 50 percent of patients within 5 to 10 years, with residual axial deformity greater than 5 degrees and articular depression exceeding 2 mm identified as independent predictors.[35]

Risk factors associated with poorer outcomes include age over 50 years, comorbidities such as diabetes mellitus and peripheral vascular disease, complex fracture patterns classified as Schatzker type V to VI, multiligamentous injury, and delayed diagnosis or intervention. In contrast, early management, particularly within 6 hours in cases of ischemia, surgical techniques that restore articular congruency, strong internal stabilization, and progressive rehabilitation protocols significantly improve the likelihood of optimal recovery. Limb salvage rates of up to 85 to 90 percent and near normal knee function, defined as flexion of at least 90 degrees, have been reported in 60 to 70 percent of patients.[36,37]

CONCLUSION

Tibial plateau fractures associated with knee dislocation represent severe orthopaedic injuries most commonly caused by high energy trauma, such as road traffic accidents or falls from height. These injuries are characterized by extensive disruption of the tibial articular surface and periarticular soft tissues, including the ligaments, menisci, joint capsule, and the popliteal neurovascular structures. This injury pattern is considered an orthopaedic emergency due to the high prevalence of vascular and neurological compromise, as well as the risk of acute compartment syndrome, which may lead to limb ischemia if not promptly managed.

Accurate diagnosis requires careful assessment of the trauma mechanism, a focused physical examination emphasizing joint stability and neurovascular function, and multimodal imaging, including radiography, computed tomography, magnetic resonance imaging, ankle brachial index measurement, and angiography. These modalities are essential to evaluate fracture morphology, the degree of dislocation, and the presence of vascular involvement.

Management begins with immediate joint reduction and immobilization to relieve vascular and neurological pressure, followed by open reduction and internal fixation for fracture stabilization and soft tissue reconstruction, with emergency revascularization when indicated. Although meticulous surgical intervention and structured rehabilitation may restore knee function, long term complications remain challenging. These include post traumatic osteoarthritis, joint stiffness, chronic instability, nonunion, and persistent neurological deficits. Therefore, a multidisciplinary approach and long term follow up are crucial to optimize clinical outcomes and improve the patient's quality of life.

Declaration by Authors

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