B. L. D. E. (DEEMED TO BE UNIVERSITY)
SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA.

"TO STUDY THE FUNCTIONAL OUTCOME OF DUAL PLATING FOR BICONDYLAR TIBIAL PLATEAU FRACTURE-A PROSPECTIVE STUDY"

Submitted by

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Dissertation submitted to The

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In partial fulfilment of the requirement for the degree of

MASTER OF SURGERY IN ORTHOPAEDICS

UNDER THE GUIDANCE OF

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I hereby declare that this dissertation which is entitled **"TO STUDY THE FUNCTIONAL OUTCOME OF DUAL PLATING FOR BICONDYLAR TIBIAL PLATEAU FRACTURE-A PROSPECTIVE STUDY"** is a Bonafide and genuine research work carried by me under the guidance of **DR. ASHOK NAYAK** MBBS, M.S, Professor, Department of Orthopaedics at BLDE (Deemed to be University) Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapura.

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ABSTRACT

Background: Bicondylar tibial plateau fractures account for 10-30% of tibial plateau fractures. Despite recent advancements in the management of unstable bicondylar tibial plateau fractures, the outcomes are often poor. The present study aimed to evaluate the functional outcomes and complications of internal fixation of bicondylar tibial plateau fractures with the dual plating using two incisions.

Material and methods: A prospective clinical study was conducted from April 2023 to December 2024 at Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura. The study included 31 patients with proximal tibia fracture [type v and type vi] operated with bicolumnar plates. Functional outcomes were assessed using modified Rasmussen's criteria preoperatively and at 2 weeks, 6 weeks, 3 months and 6 months postoperatively.

Results: Significant improvements were observed in modified Rasmussens score at 2 weeks, 6 weeks, 3 months and 6 months postoperatively. All fractures united with a mean time of 18 weeks. The average knee range of motion was 1.5° - 130° (range: 0° - 10° for extension lag, range: 100° -135° for flexion). Mean Rasmussen's functional grading score at the final follow-up was 23.93. The post-operative radiographs showed mean MPTA was 87.51° (range 82° – 92°) and the mean PPTA was 8.1° (range 4° - 14°). In the present study, complications were encountered in seven patients. However, there were no cases of secondary loss of reduction, failure of the implant, malunion, or non-union.

Conclusion: The surgical treatment of bicondylar tibial plateau fractures with dual locking represents a significant treatment option and provides rigid fixation in these fractures with good functional and radiological outcomes.

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INTRODUCTION

Tibial plateau fractures are increasing in incidence, constituting 1.2% of all fractures [1]. Axial compression combined with valgus or varus force causes these fractures. It often occurs in older people over sixty years due to falls at the same level, but in young adults, it occurs due to road traffic accidents and falls from heights [2].

Postoperative complications from significant intraarticular damage, soft-tissue injury, or inappropriate therapy might include skin necrosis, infection, non-union, deformity, and traumatic arthritis. Treating bicondylar tibial plateau fractures remains challenging, even for experienced orthopaedic surgeons [3].

For tibial plateau fractures, the Schatzker classification is frequently used to assess the initial injury, develop treatment plans, and ascertain the prognosis. It classifies tibial plateau fractures into six groups: The lateral tibial plateau fractures classified as Type I, Type II splitting and depression of the lateral tibial plateau, Type III pure central depression of the lateral tibial plateau, Type IV medial tibial plateau fracture with a split or depressed component, Type V wedge fractures of the lateral and medial tibial plateau, Type VI transverse tibial meta diaphyseal fracture, as well as any tibial plateau fractures [3].

Among them, types V and VI are complex fractures, which are very often associated with soft tissue injury, risk of wound dehiscence, difficulty in intraoperative reduction and difficulty in sufficient fixation of fractures [4]. However, there is no effective surgical management but the treatment options include screws, Illizarov ring fixation, Hybrid external fixation, bicolumnar or dual buttress plating, unilateral locking plate etc [5,6].

The goals of surgical treatment include restoring articular congruity, anatomic reduction, and firm fixation to allow for early mobilisation [7].

One advantage of the dual-plate procedure is the preservation of proximal tibial alignment and its visible decrease. Nonetheless, soft tissue problems and periosteal blood supply damage pose serious safety risks. For complicated tibial plateau fractures, many surgeons continue to question the effectiveness of the fracture stabilization and reduction offered by an external fixator [8].

AIM & OBJECTIVES

To evaluate the functional outcome of proximal tibia fractures caused by Schetzker's type-VI and type-V using the bicolumnar dual plating technique.

REVIEW OF LITERATURE

In 2021, Dr. Dinesh Kumar Shrestha and colleagues conducted a study on the functional outcomes of bicolumnar dual plating for bicondylar fractures of the tibial plateau. They concluded that bicolumnar plating using lateral and medial/posterior-medial approaches is among the most effective options for treating bicondylar tibial plateau fractures, resulting in minimal complications and improved outcomes related to postoperative rehabilitation and pain management (9).

Dr. Pankaj Vir Singh and his team examined the clinico-radiological and functional results of bicolumnar plating in Schatzker type V and type VI proximal tibia fractures in 2021. They concluded that bicolumnar plating serves as an effective treatment for Schatzker type V and type VI fractures, yielding excellent results when performed by skilled surgeons, along with minimal complications and outstanding postoperative rehabilitation (10).

In 2019, Dnyanesh Dattatray Patil and associates conducted a prospective observational study involving 35 patients with bicondylar tibial fractures who underwent bicolumnar plating. They found that treating bicondylar tibial fractures (Schatzker Types V and VI) with bicolumnar plating yields promising outcomes, with good anatomical knee joint reduction, minimal complications, and early mobilization, proving particularly beneficial for younger patients (11).

Ceyun Cagler and colleagues performed a retrospective analysis in 2018 on 54 patients who received surgical treatment for bicolumnar tibial plateau fractures using DLP or SLLP.

Their analysis revealed that patients who underwent the DLP procedure achieved better results than those with the SLLP [(12).]

Abhishek P. Bhalotia used dual plating and a dual-incision approach to treat 24 patients with bicondylar tibial plateau fracture dislocations in a prospective study conducted in 2018. The study concluded that dual plating is essential for achieving articular congruity, stable fixation, early mobilization, and long-term limb alignment. The primary concern was soft-tissue complications, which can be reduced by allowing adequate time before the operation and employing careful surgical techniques [(13).]

APPLIED ANATOMY OF KNEE JOINT

The knee joint is the biggest and most intricate joint in the human body. Because it allows for flexion, extension, and a limited amount of limb rotation when flexed, the knee is classified as a modified hinge type synovial joint. This composite joint is made up of a saddle joint between the patella and femur and two condylar joints between the femur and tibia[14].

The following components make form the knee:

a. "Osseous structures
b. Extra-articular structures
c. Intra-articular structures" [14]

OSSEOUS STRUCTURES

Femoral Condyles

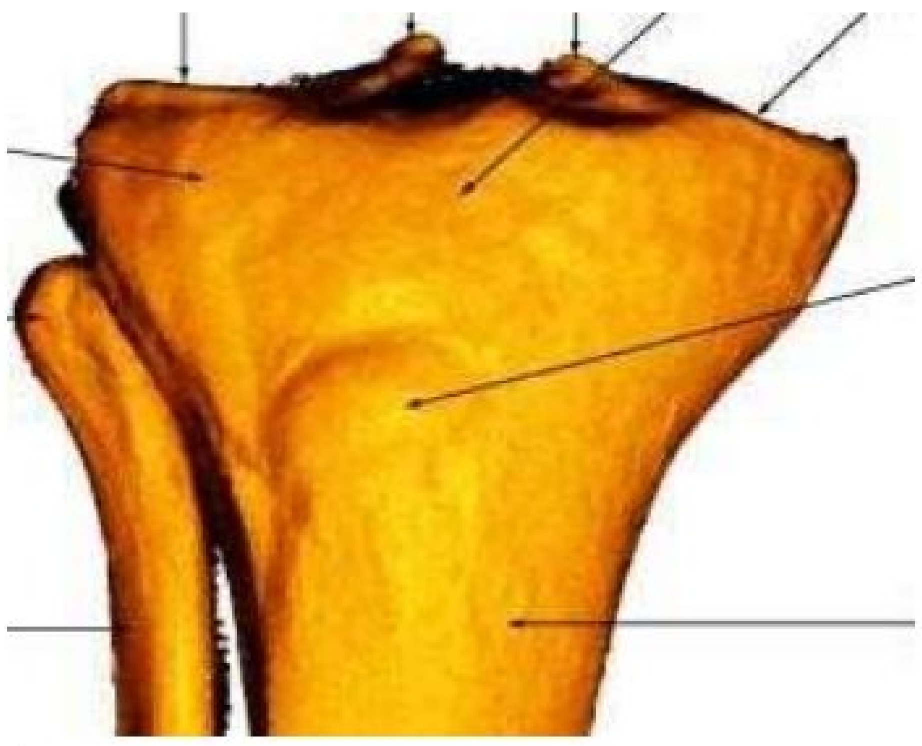
Femoral condyles are two circular projections with an eccentric curve; they are slightly flattened at the front to increase the surface area for weight distribution and contact. These condyles protrude more significantly to the back of the femoral shaft than they do in front. In contrast to the lateral condyle, which has a larger articular surface, the medial condyle has a longer one.

Tibial Plateau

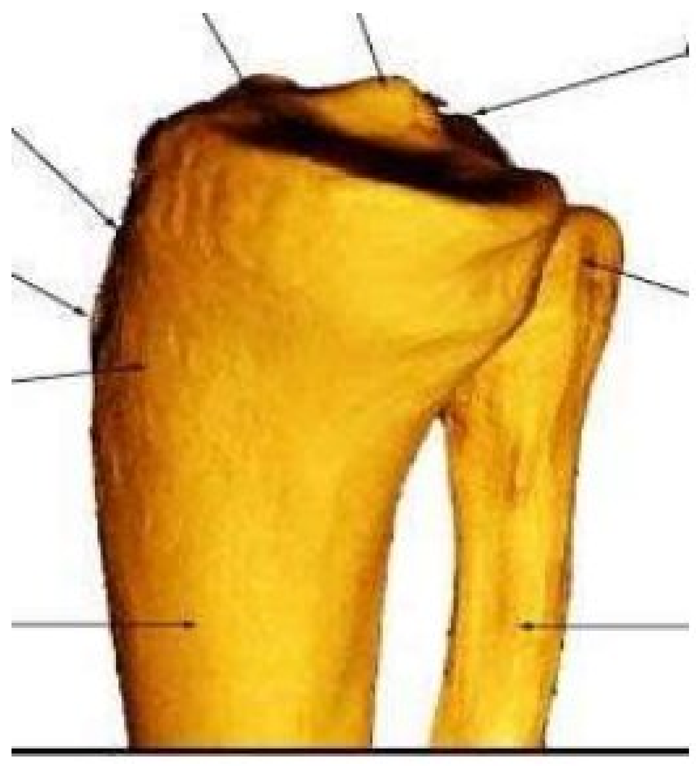
To sustain the weight transferred via the lower part of the femur, the proximal end of the tibia is expanded along the transverse axis. The medial and lateral tibial spines are located in an uneven, roughened, non-articulating intercondylar region that separates the two conspicuous masses, the medial and lateral condyles. The cruciate ligaments and menisci attach to regions both anterior and posterior to the intercondylar eminence. The top part of the tibial shaft's posterior surface is overhung by the condyles, which extend somewhat rearward. The upper articular surface has an oval shape with a bigger medial condyle. Particularly at its posterolateral portion, the lateral condyle overhangs the shaft. The articular surface has a roughly round shape and a somewhat hollowed-out centre.

Specifically at its posterolateral region, the lateral condyle overhangs the shaft, whereas the medial condyle is stronger and has an oval top articular surface. The lateral condyle's articular surface is almost spherical, with a tiny depression in the centre. The lateral plateau's articular surfaces are irregular, and it is bigger than the medial one. The lateral and medial plateaus appear convex and concave, respectively, in the sagittal plane. Because the lateral plateau is often more visible due to its elevated position relative to the medial plateau, this information is essential when examining lateral X-rays of the knee joint. Consequently, neither plateau significantly adds to knee stability.

According to Bohler, the tibial plateau descends posteroinferiorly at an angle of 51 degrees from the horizontal, and the plane of its articular surface creates an angle of 76 ± 3.6 degrees with the tibial crest. When screwing the proximal tibia region from the anterior to the posterior side, this is an important factor to take into account. Different damage patterns are caused by the articular surfaces' special qualities. Axial force transmission makes the medial tibial plateau, which is convex toward the tibial side, susceptible to split fractures in a mediolateral orientation. However, the lateral tibial plateau, which is convex toward the femoral side, frequently experiences multifragmentary joint depression and joint expansion under axial pressure. Additionally, because the medial portion of the knee experiences higher physiological stress, the trabecular bone on the medial plateau is stronger. Because of this, lateral tibial plateau fractures occur more frequently than medial ones. Surgeons must investigate potential severe trauma and associated neurovascular injury while treating medial plateau fractures.



Tibial plateau – anterior view
lateral surface - convex
medial surface - concave



Tibial plateau – Medial View.
In lateral radiography, high convex surface overrides the concave medial surface.

Fig.1: anatomy of tibia

The anterior and posterior tibial spines are located on the non-articular part of the plateau surface. Directly behind the medially positioned anterior tibial spine is where the ACL attaches. The posterior cruciate ligament attaches to the posterior intercondylar area, which extends onto the posterior side of the metaphysis. To properly restore the anatomical width of the proximal section of the tibia, the intercondylar eminence width must be rebuilt. The patellar tendon attaches to the tibial tubercle, which is situated around 2 cm below the anterior joint line and above the anterolateral tibial crest. Gerdy's tubercle, a protrusion along the lateral flare of the tibia where the iliotibial band inserts, indicates anterolateral approach to the proximal tibia. The fibular head, which is seen at the posterolateral part of the tibial condyle, is connected to the fibular collateral ligament and the biceps tendon [15].

Patella

The patella is a triangular sesamoid bone that is situated between the patellar tendon and the quadriceps in the extensor mechanism. The smaller distal part is called the apex, and the bigger proximal part is called the base.

EXTRA ARTICULAR STRUCTURES

Ligamentous and musculotendinous units make up the extra-articular structures.

Musculotendinous units:

"These are made up of

i) Anteriorly	- Quadriceps femoris
ii) Posteriorly	- Gastrocnemius
	- Popliteus
iii) Medially	- Semimembranosus
	- Semitentendinosus
	- Gracilis
	- Sartorius
iv) Laterally	- Bicep femoris
	- Iliotibial band" [16]

Ligamentous Structures:

The capsule is a sheath of fibrous tissue that envelops the medial, lateral, and posterior parts of the joint and extends anteriorly from the patella and patellar tendon. Its bony attachments are located close to the articular surface. On the medial side, the menisci are securely attached, whereas on the lateral side, they are less firmly attached.

Medial capsule is more well-defined and distinct compared to lateral capsule. Medial and lateral extensions of quadriceps muscle, as well as the capsular structures, serve as the main stabilizers anterior to the joint's transverse axis. Iliotibial band, which is situated posteriorly to the transverse axis, the popliteus muscle, medial and lateral hamstring muscles, and collateral ligaments all support the capsule.

On the rear portion of medial aspect of tibial metaphysis, beneath the pes anserinus tendons, tibial collateral ligament inserts 7 to 10 cm past the joint line. It is a long, moderately narrow, and well-defined structure that is superficially located over the medial capsule. In order to provide stability against valgus stress, it is essential. Lateral collateral ligament is attached to lateral femoral epicondyle proximally and fibular head distally. When the knee is extended, this ligament plays a crucial role in supporting it against varus stress. The lateral collateral ligament's ability to stabilize against varus forces decreases with knee flexion [16].

INTRAARTICULAR STRUCTURES:

stability in the sagittal plane is provided by the cruciate ligaments and menisci, which are intra-articular structures. Although they are intra-capsular, the two cruciate ligaments, anterior and posterior, are located extra-synovially [16].

Anterior Cruciate Ligament:

Bundles of fibres that are taut at different knee flexion and extension angles make up the anterior cruciate ligament. The ACL measures an average of 3.8 cm in length and 1.1 cm in breadth. It is situated in front of the anterior tibial spine at its tibial connection. The ACL acts as the primary stabilizer to prevent the tibia from moving anteriorly.

Posterior Cruciate Ligament:

The main stabilizing factor against posterior tibial displacement with respect to the femur is the posterior cruciate. In the coronal plane, it runs medially and obliquely upward to its attachment on the femur, whereas in the sagittal plane, it is almost vertical. With a length of 3.8 cm and a breadth of about 1.3 cm, the PCL is smaller and more durable than the ACL

Menisci

These are semicircular, wedge-shaped fibrocartilaginous structures that are situated between the tibial and femoral condyles. There are two of them: medial and lateral. Because they shield articular cartilage from up to 60% of the force encountered, the menisci are crucial for load distribution. These components are linked to the tibia by the meniscotibial ligaments. These structures should be located and horizontally incised through submeniscal exposure in order to surgically see the joint.

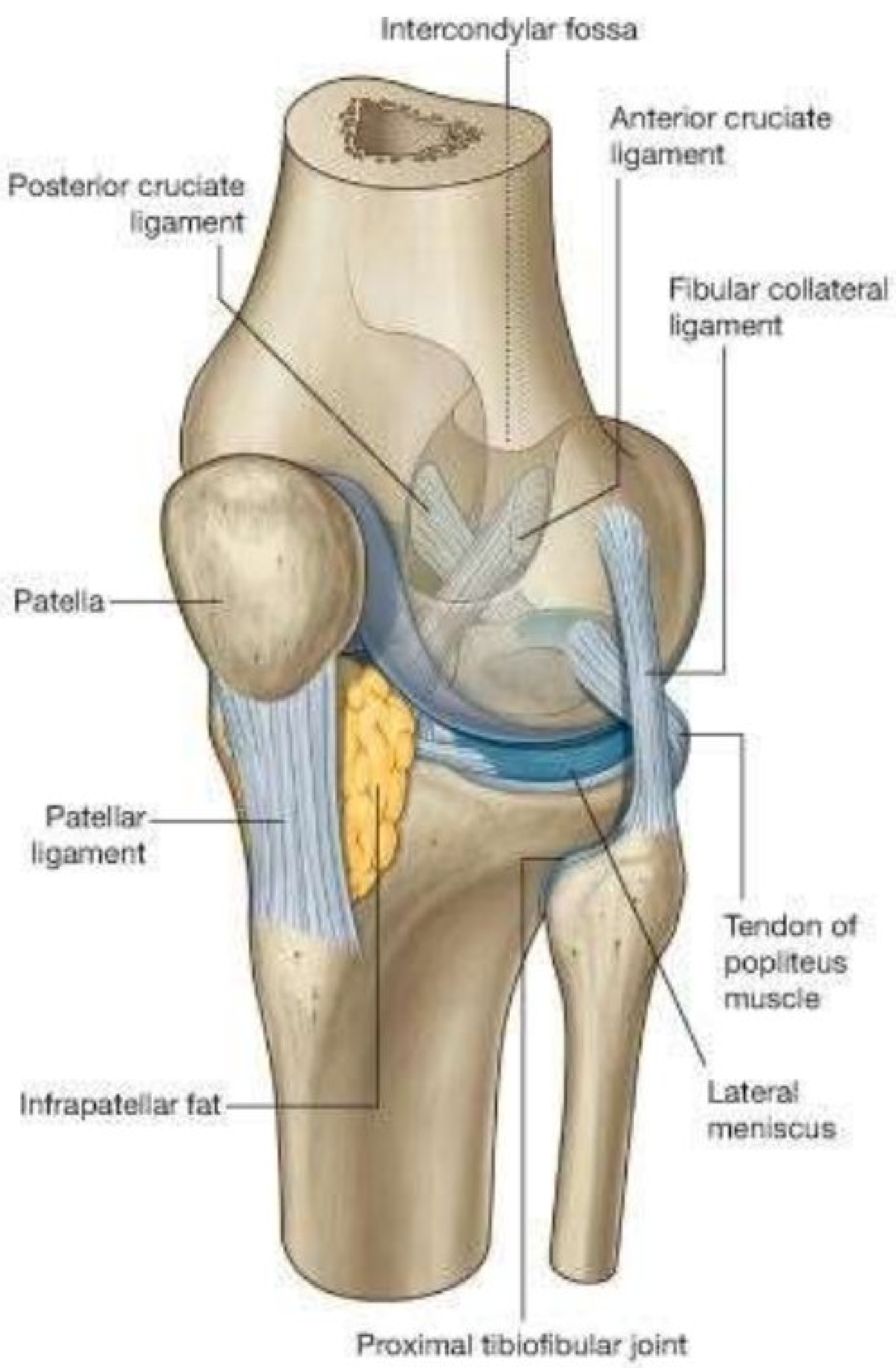


Fig.2.: Knee joint after removal of joint capsule

Fig.3: Flexed knee – viewed from front

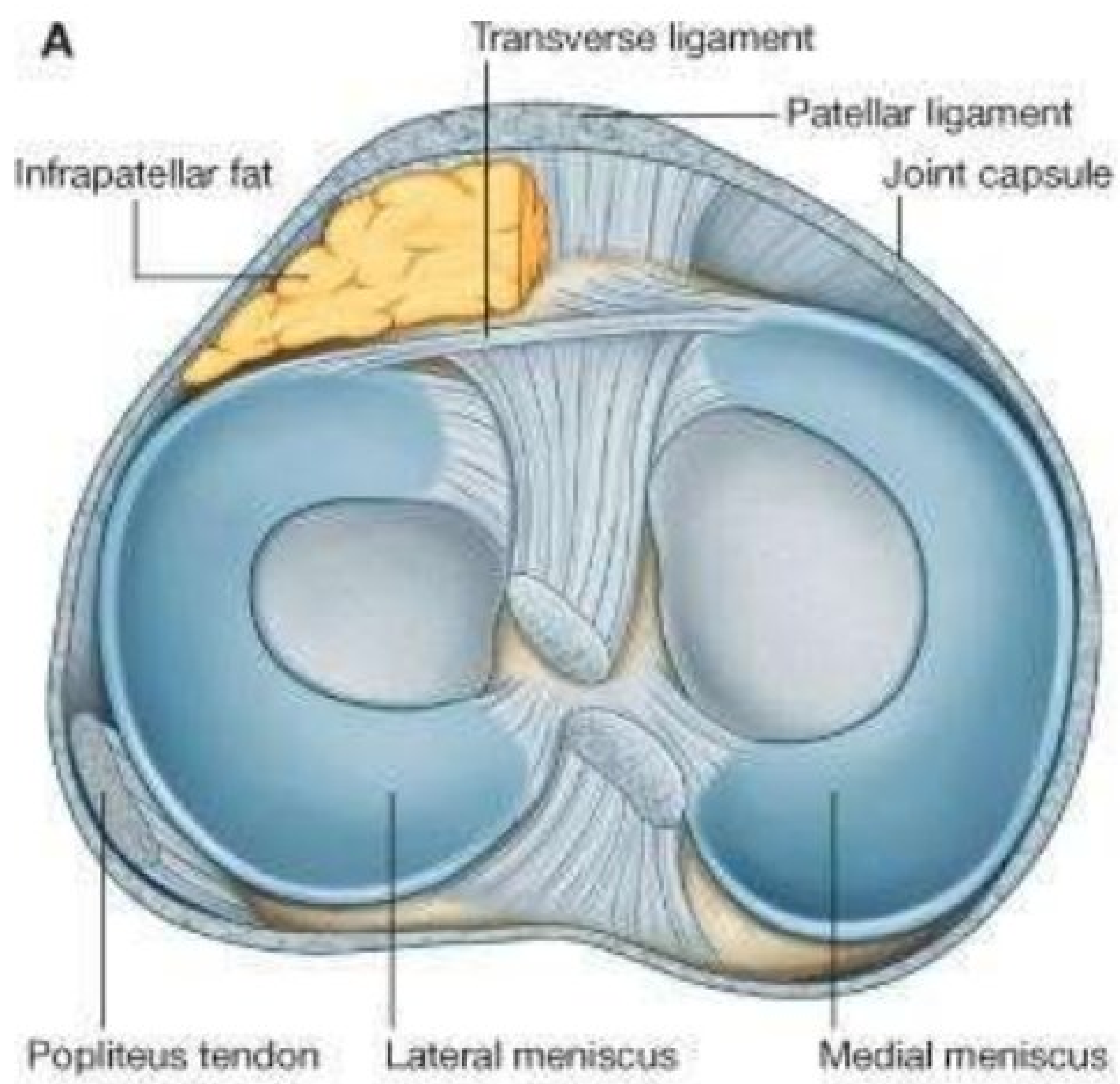


Fig.4: Articular surface of tibia – viewed from above

Definition

The literature has documented knee joint fractures involving the proximal tibial articular surface, either with or without extension into the metaphysis, since the early 1800s. 27 For fractures involving the lateral tibial plateau, Cotton and Berg (1929) used the phrases bumper and fender fracture. Until the early 1950s, cast immobilization was the nonoperative treatment for these fractures. Surgeons began using open reduction and internal fixation (ORIF) as a therapeutic technique after the introduction of AO principles for fracture fixation and encouragement of early outcomes of operative treatment. Except for some minimally displaced fracture forms, surgical treatment of tibial plateau fractures has evolved into the current standard of care throughout time.

Currently, tibial plateau fractures can be effectively treated using screws, plates, external fixators, and nails. From slightly displaced articular injuries that mend predictably with nonoperative treatment to high-energy comminuted fractures that provide numerous issues to the treating orthopaedic surgeon, these fractures span a broad spectrum of severity. Patients with these fractures should receive extra care during evaluation, which includes taking a thorough medical history to identify the mechanism of injury.

To rule out soft tissue damage, detect open fractures and imminent compartment syndrome, and evaluate the injured extremity's neurovascular state, a thorough physical examination should be conducted. In order to outline the fracture pattern and create a surgical plan, adequate and relevant imaging is necessary. This includes x-rays, computed tomographic (CT) scans (including three-dimensional [3D] reconstructions, if available), and magnetic resonance imaging (MRI), if necessary. A stable articular reduction and proper limb alignment with early range of motion (ROM) are prerequisites for treatment ideas. Treatment for severe injuries, which significantly affect patients' quality of life, has been transformed by newer surgical procedures [16].

Epidemiology

About 1% to 2% of all long bone fractures are tibial plateau fractures. 28,100 such other periarticular injuries such distal radius or proximal humerus fractures, these injuries have a bimodal age distribution. Due to high-energy mechanisms of injury, such as car crashes, falls from a height, sports-related injuries, etc., comminuted fractures are more common in younger people. They are also more common in men, with young adult men with a mean age of 43 years accounting for 70% of these cases.

According to reports, between 16% and 40% of patients hospitalized to a trauma center with multiple traumas had a tibial plateau fracture. 36 When elderly people suffer unicondylar or bicondylar tibial plateau fractures, low-energy falls are typically the most common cause of injury.

According to a recent retrospective assessment of tibial plateau fractures, the most frequent mechanisms of injury were low-energy falls (22%) and pedestrians struck by a motorized vehicle (30%).

According to Kugelman et al. the number of patients with low-energy injuries is rising in tandem with the older population's improved survival in recent years. Because of the delicate nature of the epidermis and the possibility of failure due to low bone quality, these fractures provide serious treatment challenges [17].

A B

Fig.5: The range of injuries associated with tibial plateau fractures is depicted in these two pictures.

A: A 37-year-old man who fell after missing a step suffered a low-energy lateral plateau fracture that was managed nonoperatively.

B: A 42-year-old male who suffered a high-energy bicondylar tibial plateau fracture in a car accident was treated with an external fixator at first, and then bicondylar plating was used for definitive fixation.

MECHANISM OF INJURY

The energy related to the injury and the force applied to the proximal tibia both affect the fracture pattern. Axial loads usually cause more serious injury patterns.

Simple falls in older people often cause fractures, and these osteopenic bones often have split depressions of the lateral condyle. In younger people, proximal tibial fractures are usually caused by high-energy events, which frequently result in split and rim avulsion fractures in addition to ligament damage.

Split depression, split fractures and lateral plateau depression are often the result of a combination of valgus and axial compression. There are many valgus forces in the knee. An undamaged MCL acts as a hinge for lateral condyle fractures, according to cadaveric studies. Internal rotation, varus posture, and knee flexion are the main causes of posteromedial shearing fractures of the medial plateau.

In tibial plateau fractures, which frequently happen while the leg is in a weight-bearing position, axial loads typically contribute to the deforming force. Energy of the injury increases with increasing axial load, leading to more severe fractures. When the axial load is the main contributor to the deforming force, bicondylar fractures happen.

Metaphyseal fractures, which involve a combination of axial pressures and bending stresses, are caused by direct impacts and bumper injuries. In these situations, intra-articular fracture extension is seen and the tibial shaft separates from the condyles. This type of injury has a high rate of sequelae, such as compartment syndrome, open fractures, vascular injuries, and significant soft tissue damage [18].

According to research, the medial plateau usually exhibits characteristic fracture patterns, such as posteromedial shear fracture, but lateral tibial plateau is more likely to fracture with fragmentation and joint enlargement. Based on the joint's anatomical features, attempts have been made to elucidate this. The femoral condyle revolves around a fixed center of flexion, and the medial joint surface is convex toward the tibial side. Tibial tray may be disrupted by axial force from the femur to the tibial condyle. The resulting stress vector primarily points posteriorly due to the tibial plateau's posterior slope, resulting in a posterior split fragment. The lateral compartment's anatomical shape also curves in the direction of the femur, and the joint's centre of rotation is inconsistent. The axis of rotation moves to the back edge of the tibia during flexion. Axial loads are transmitted, creating an impression akin to pushing into an eggshell. This means that the more flexed the knee, the deeper the joint depression. Furthermore, coronal joint surface increases as result of curved tibial compartment flattening, thereby expanding the compartment [18].

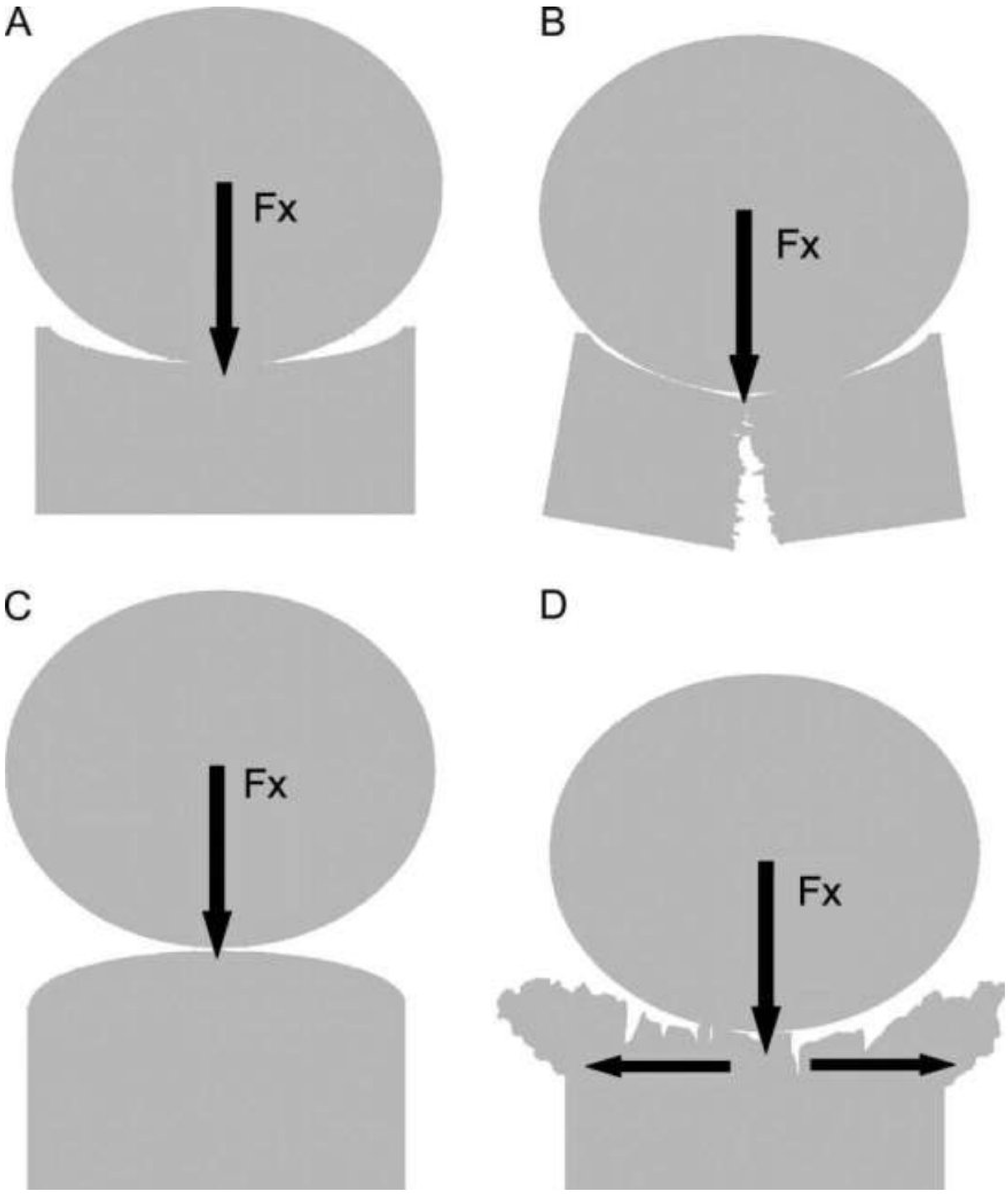


Fig.6: Fracture mechanics

A: As the knee's medial compartment is convex toward the tibia, axial loads cause pieces of the coronal plane to separate (B).

C: As the lateral compartment is convex toward the femur, axial stresses result in joint enlargement and comminution (D).

TYPES OF ACCIDENTS

When the knee is injured by one of several different processes, different patterns of tibial plateau fractures occur. Simple falls most frequently result in lateral- or less frequently, medial-side fracture patterns in middle-aged or older patients. The most frequent fractures of the lateral plateau are split depression fractures. In elderly patients, insufficiency fractures may occur and go undetected on conventional radiographs when the bone is extremely osteopenic. Split fractures or rim avulsion fractures linked to knee ligament injuries might result from higher-energy injuries sustained by younger patients during sports or other comparable mechanisms. More severe patterns, which may encompass both condyles and have a high risk of accompanying neurovascular injuries, compartment syndrome, and communicating open wounds, are frequently produced by motor vehicle accidents, falls from heights, and struck-pedestrian injuries [19].

Forces Causing Injury

The fracture pattern is determined by the type, direction, and magnitude of forces that cause injury to the knee. The fracture is more serious and the pieces are more displaced and comminuted the more energy the proximal tibia absorbs. Both the applied forces and the bone's condition contribute to the energy of fracture.

In general, axial loading forces release more energy and do so more quickly than angular forces. Split depression fractures with a combination of both forces, local compression fractures with axial forces, and conventional split fractures with pure valgus forces can all be created in cadavers.

The lateral femoral condyle is hinged by the intact medial collateral ligament (MCL), which is necessary for the lateral plateau to fracture. Due to the knee's natural 5-to-7-degree valgus alignment and its tendency to be struck from the lateral side, the proximal tibia is most likely to experience a valgus force. The lateral tibial plateau is directly struck by the lateral femoral condyle, causing a valgus force that stresses it to failure. Lateral-side depression, split depression, or less frequently, lateral split or entire lateral condyle fractures (the traditional "bumper fracture"), are caused by a combination of valgus and axial compression. Elderly individuals with osteopenic bone have a higher component of compression with a less noticeable split fragment, while younger patients with healthy bone typically have split fractures with less depression. At least a tiny portion of a split fracture and a depression at the fracture's periphery are most frequently seen in lateral fracture patterns [20].

The medial plateau fails as a result of varus injuries, which are less frequent than lateral-side fractures. The entire medial plateau may be affected by these injuries, and in certain situations, the fracture-shearing plane may reach far into the lateral plateau. In other instances, smaller areas of the medial plateau are affected by the fracture. A common medial-side pattern is a posteromedial shearing fracture of the medial plateau, which can occur as an isolated split fracture or as part of the bicondylar fracture pattern in up to one-third of cases.

The mechanism has been defined as internal rotation of the medial femoral condyle, varus, and knee flexion.

Since tibial plateau fractures usually happen when the leg is bearing weight, axial load is usually a part of the force that causes the injury. In general, the energy at failure and the severity of the fracture pattern increases with the axial load component. When axial load dominates, bicondylar patterns are produced; the severity of these patterns varies according to the magnitude of the axial forces. A medial plateau fracture or fracture-dislocation can occasionally result from an axial force shearing the medial tibial condyle in a patient with valgus knee.

The metaphyseal region experiences a different kind of tibial plateau fracture pattern due to direct trauma and/or a combination of axial load and bending forces. With proximal expansions of fracture lines into the plateau, these are typical bumper injuries or other crushes, direct strikes, or other processes where the tibial shaft is severed from the condyles. These severe injuries have a high risk of consequences both because of the anatomic location of the damage and the high degree of energy transfer. This process is linked to compartment syndrome, trifurcation injury, severe closed soft tissue injury, and open fractures.

Additionally, the surgeon should distinguish between rim avulsion fractures, which are linked to knee dislocations and may be a sign of an unstable injury, and split fractures, which are caused by a shearing force. Another subset of these injuries, known as varus hyperextension injuries, was recently described by Firoozabadi et al[21] These injuries are linked to anterior cortical compression and posterior cortex tension failure with varus deformity in the coronal plan.

INJURIES ASSOCIATED WITH TIBIAL PLATEAU FRACTURES

Injuries are common in patients with tibial plateau fractures. These could include additional ipsilateral or contralateral skeletal injuries as well as damage to other systems that could affect the treatment of the plateau fracture. 13 out of 41 patients with bicondylar tibial plateau fractures also had additional significant skeletal injuries, and it was discovered that these injuries had an impact on the patients' functional result.

In a different investigation, MRI was used to detect or confirm knee dislocation occurrences in 46% of Schatzker type IV patterns. Additionally, a high incidence of ligament injury was shown by Schatzker type IV, V, and VI patterns. There is a significant risk of compartment syndrome and a low risk of vascular damage with high-energy tibial plateau fractures.

Tibial plateau fractures also have typical local soft tissue injuries that are crucial to diagnose since they may influence fracture care and prognosis. Valgus stresses can cause lateral plateau fractures, which are linked to MCL damage. However, the lack of osseous support resulting from the depression of the lateral plateau articular surface is frequently linked to valgus instability on clinical examination.

Therefore, it is crucial to perform a clinical assessment of the knee following the reduction and stabilization of the depressed articular surface. According to one mechanical investigation, a lateral plateau fracture could only occur if the MCL was intact and serving as a pivot point for the lateral femoral condyle

Additionally, there are often accompanied intra-articular soft tissue injuries to the menisci and cruciate ligaments. These injuries contribute to the treatment of fractures of the tibial plateau. Certain tibial plateau margin peripheral fractures are almost always indicative of cruciate ligament injury, hence it is appropriate to treat the ligament damage in addition to the plateau fracture in these injured knees. These peripheral fractures include fractures of the semimembranosus tendon insertion site, anteromedial tibial border, reverse Segond fracture, and Segond fracture [22].

SIGNS AND SYMPTOMS OF TIBIAL PLATEAU FRACTURES

The mechanism of damage should guide the appropriate level of awareness for related injuries and offers hints about the fracture pattern. Low-energy impacts from falls and twisting accidents are usually the cause of split lateral plateau fractures. There is virtually little chance of compartment syndrome or related neurovascular damage. However, patients who sustain injuries from motor vehicle accidents, pedestrian strikes, or falls from a height are more likely to have tibial plateau fracture patterns, which increase the likelihood of these related injuries that require immediate medical attention.

While the history is important, the fracture pattern is what determines the risks for complications and guides treatment decisions. The clinician should be aware that the mechanism of injury alone may be misleading, as relatively high-energy fractures can occur when the history suggests more benign mechanisms. It is important to ask about pertinent patient history, such as any form of tobacco use, diabetes, vascular disease, cancers, nutritional problems, renal diseases, and the use of medications such as chronic steroids, chemotherapeutic agents, antiseizure medications, or immunotherapeutic agents, among others, as these medications have a negative impact on bone quality and hinder wound healing.

Lastly, to create a strong surgical plan, it is important to establish the patient's degree of activity, employment status, and mental health. In order to detect related injuries and consequences, plan for surgical treatment, and choose the best time for interventions, a physical examination of the knee and leg is essential. A physical examination of the damaged leg is necessary to detect any connecting open wounds that may be present in tibial plateau fractures. A comprehensive neurovascular examination is crucial for all wounded limbs, but it's more crucial for individuals with specific fracture patterns. Among these injuries, fracture-dislocations and metaphyseal–diaphyseal dissociation patterns are most vulnerable to vascular or neurological damage. There is a significant chance of compartment syndrome with several tibial plateau fracture types [23].

This is particularly true for fractures of the medial tibial condyle, which are basically variations of a dislocated knee. These injuries can have a variety of origins, including compartment syndrome. The most common causes are direct muscle injury and contusion, but it can also result from muscular ischemia brought on by vascular blockage (intimal damage and subsequent thrombosis) or secondary hemorrhage from artery shearing. Serial examinations should be performed to assess the lower leg compartments for indications of compartment syndrome. Measuring compartment pressures is recommended for patients who are not responding, and the presence of the well-known symptoms, such as tense compartments and pain with passive stretching, should increase the suspicion of an associated compartment syndrome.

It is possible to execute fasciotomy without taking pressure readings if the diagnosis is evident from the physical examination. Compartment pressure measurements taken at presentation may be beneficial for patients with high-energy fracture patterns, those who are difficult to examine, and those who are unable to provide a history. Depending on the clinical findings and the results of the initial measurement, these measurements may need to be repeated.

A comprehensive vascular evaluation with documentation of an ankle-brachial index (ABI) (normal ≥ 0.9) is recommended for high-energy accidents. An injured lower extremity's Doppler-assisted systolic pressure is compared to that of an intact extremity, ideally one of the upper limbs. The ratio of the blood pressure in the upper arm (brachium) to the blood pressure at the ankle is known as the ABI. A vascular consult is recommended and additional vascular workup, including a CT arteriogram, may be required if the ABI is less than 0.9. Due to the possibility of compartment syndrome in the initial days following injury (or surgery), it is recommended that patients with tibial plateau fractures and intact arteries undergo a series of clinical examinations that focus on swelling, motor function, sensation, and stretch pain. During the first day or two following injury, a neurologic examination that evaluates sensation and voluntary motor function is crucial as a baseline and needs to be performed on a regular basis. It is necessary to record cutaneous sensation to the tibial, superficial peroneal, saphenous, and sural nerves.

Assessing for knee valgus instability in cases with lateral tibial plateau fractures may help determine whether surgery is necessary. [8] As previously stated, instability is most likely the result of fracture displacement and will not go away unless the fracture is reduced. However, the utility of this assessment is limited because it is frequently difficult to evaluate the knee for coronal instability due to pain from the injury. The soft tissue envelope surrounding the knee needs to be closely inspected in all patients, especially if an open reduction is planned. This assessment will determine the sort of surgical approach and, in certain cases, the timing of the procedure.

Examining the soft tissues is crucial because surgical procedures for high-energy tibial plateau fractures have a considerable risk of soft tissue complications. The degree of edema, any obvious contusions, and the size, type, and position of fracture blisters are all significant characteristics of the soft tissues. Normal skin wrinkling (wrinkle sign positive) indicates that the edema has subsided [24].

CLASSIFICATION

The fracture pattern determines the course of treatment, the likelihood of complications, and, to a certain degree, the outcome for the patient. Grouping comparable injuries together and keeping distinct injuries apart are crucial since different fracture patterns call for quite different treatment approaches. In this manner, fracture patterns can be used to match treatments in order to maximize results. Reliability, reproducibility, inclusiveness, mutual exclusion, logic, and clinical utility are all desirable qualities in a categorization system. The Schatzker classification and the OTA/AO classification system are currently the most often used categorization schemes in clinical practice. The OTA/AO categorization system is more thorough and frequently used in scientific publications, therefore it should be thoroughly examined even though the Schatzker system is simpler to memorize. These two classification systems, which are based on AP radiographs, do not take into account posterior shear fracture patterns and bicondylar sagittal and/or coronal plane fracture lines, which are crucial for proper surgical planning. The entire course of treatment and the outcome of surgery may suffer if these trends are not recognized.

"Tibial plateau fractures can be categorized using a variety of techniques.

1. Schatzker classification
2. Hohl and Moore classification
3. AO/OTA classification
4. Three column classification" [25]

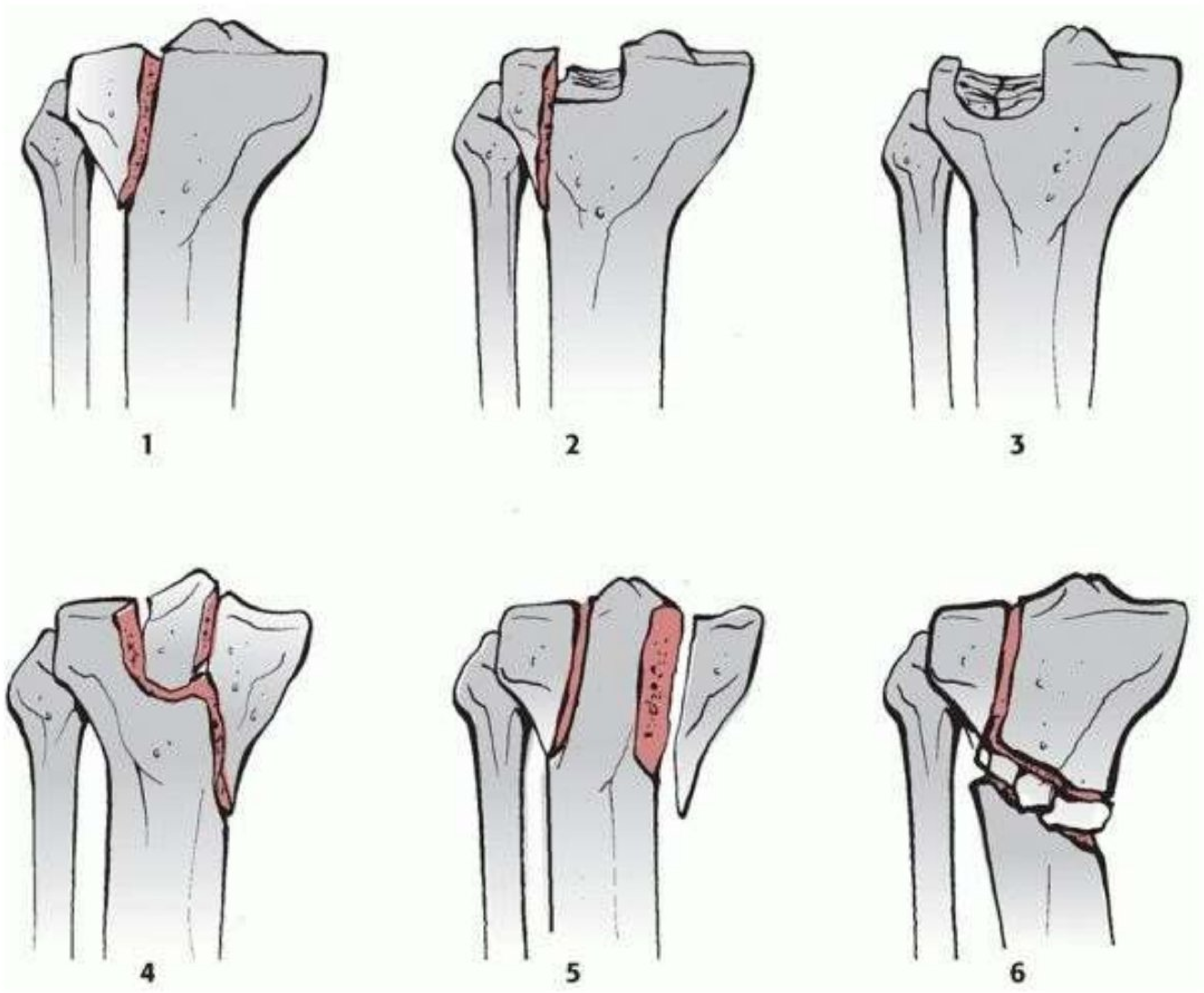
1. “Schatzker classification

Schatzker et al.,118 in 1979, published their data on 94 fractures of the lateral tibial plateau, over 8 years from 1968 to 1975. The Schatzker classification has been one of the most commonly used classification systems for tibial plateau fractures ever since.

Most practitioners are familiar with this system, which is the most often used one. It includes six types, each requiring different treatment approaches, making it quite beneficial.

- Type I - pure split: This involves a non-comminuted wedge-shaped fragment and is frequently observed in younger individuals with healthy bones.
- Type II - split with depression: This type features a wedge on the lateral side accompanied by a depression of the articular surface.
- Type III - pure central depression: Lateral cortex is left intact, but articular surface is forced into the plateau. Patients who have osteoporotic bones are more likely to sustain these fractures.
- Type IV - fractures of the medial condyle: These fractures may be complicated and depressed, frequently angulating into varus, or they may appear as a single wedge.
- Type V - bicondylar fractures: The metaphysis and diaphysis remain continuous despite the separation of both tibial plateaus.
- Type VI - Bicondylar tibial plateau fracture with separation of the diaphysis and metaphysis.” [26]

Fig.7:Schatzker classification



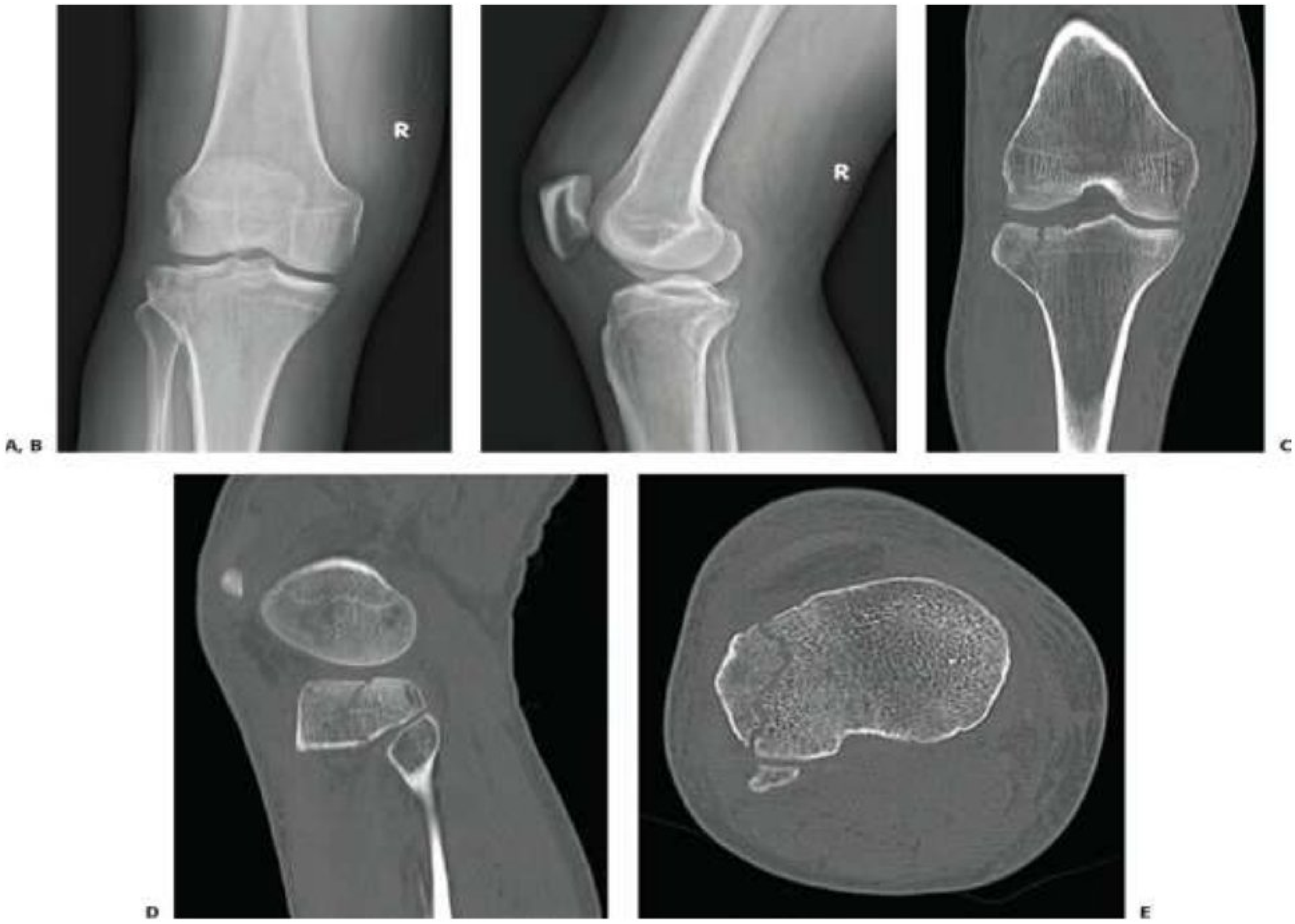


Fig.8: Schatzker type I. Split type of lateral tibial plateau fracture seen evident on x-rays (**A**, **B**) and CT scans (**C**–**E**).

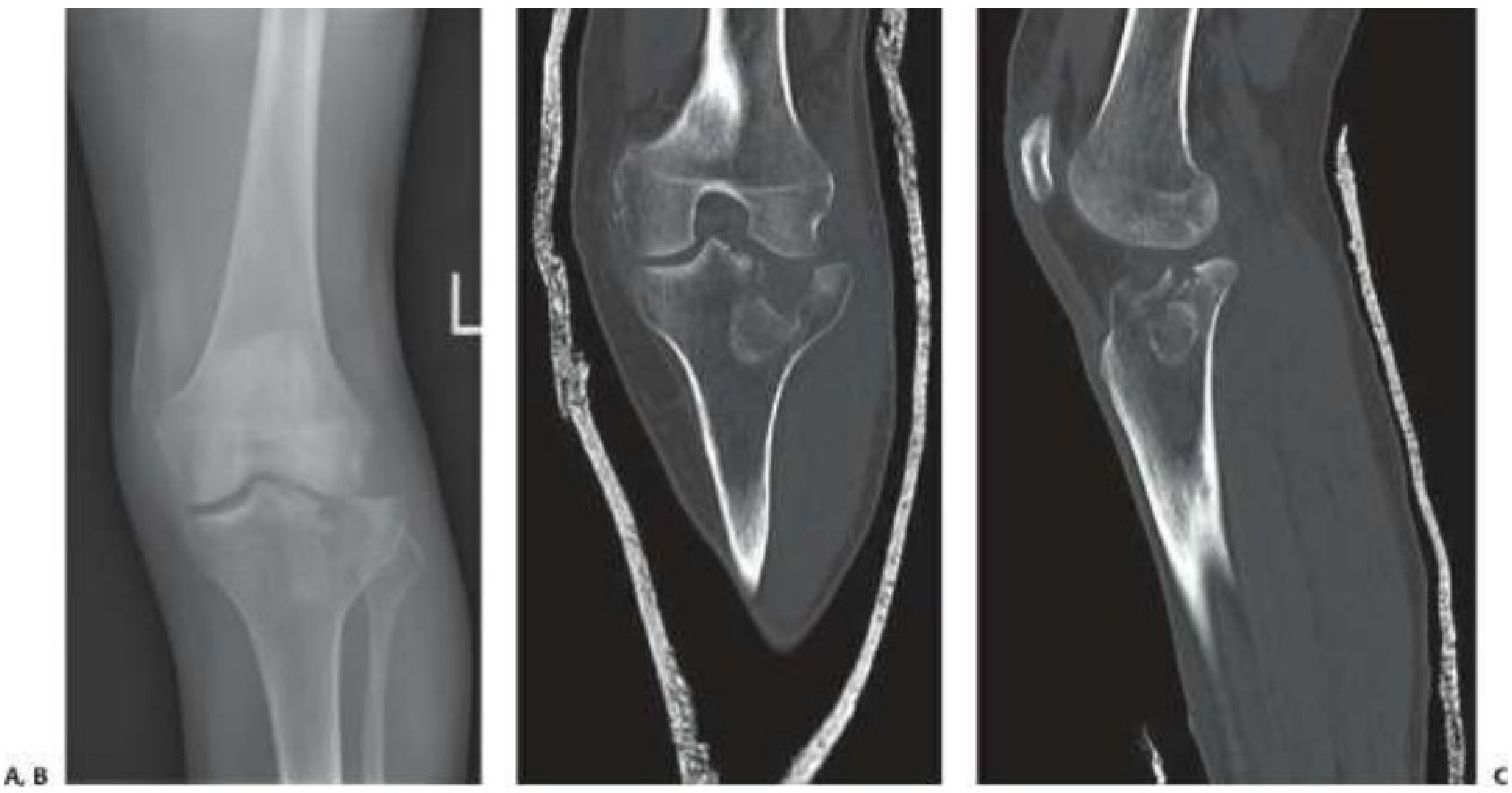


Fig.9: Schatzker type II. Split plus depression of lateral tibial plateau evident on x-ray (**A**) and CT imaging (**B**, **C**).

Fig.10: Schatzker type III pure depression type lateral tibial fracture evident on CT imaging.

Fig.11: Schatzker type IV medial plateau fracture seen on x-rays (**A**, **B**) and CT scans (**C–E**).

Fig.12: Schatzker type V fracture of the medial and lateral tibial plateau evident on an AP x-ray.

Fig.13: Schatzker type VI fracture of the medial and lateral tibial plateau with meta diaphyseal disruption evident on AP (**A**) and lateral (**B**) x-rays.

2. “Hohl and Moore classification

Given their correlation with an increased incidence of ligament, meniscal, and neurovascular injuries, Hohl and Moore developed a classification system for fracture dislocations.

- Type I - coronal split fracture: From a lateral view, this typically affects the medial condyle and occasionally extends to the lateral side.
- Type II - entire condyle fractureAs an illustration, consider a fracture-dislocation of the lateral or medial condyle. It differs from Schatzker types I and IV because the fracture line crosses into the contralateral compartment beneath the intercondylar eminence.
- Type III rim avulsion fracture: High valgus/varus pressures primarily induce the ligamentous and capsular attachments to avulsion from the corresponding plateau's edge on the lateral plateau.
- Type IV rim compression fracture: The comparable femoral condyle compresses the plateau rim when the other side collateral ligament ruptures.
- Type V four-part fracture: These injuries, which are highly unstable, include separation of the intercondylar eminence, avulsion of both collateral ligaments, and a bicondylar fracture. In about half of cases, neurovascular injury occurs.

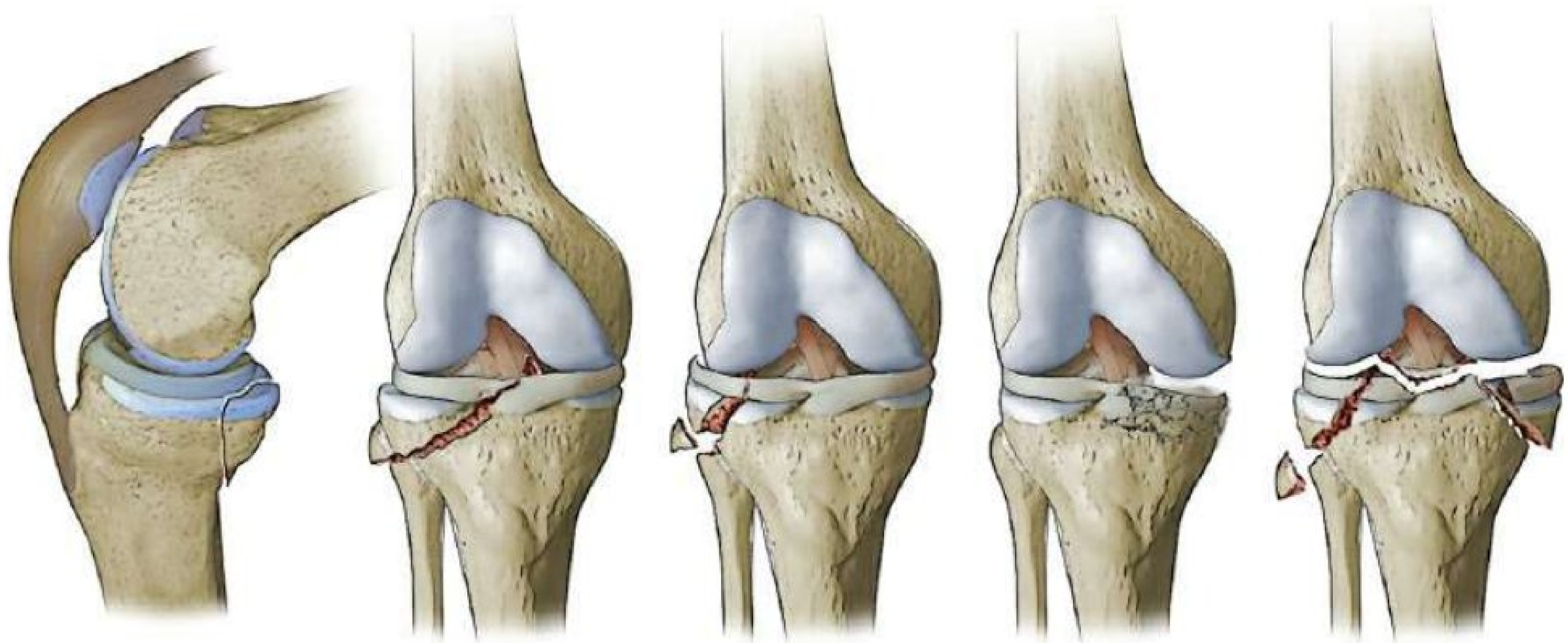


Fig.14: Hohl and Moore's classification of tibial plateau fractures. Type I: coronal split. Type II: entire condyle. Type III: rim avulsion. Type IV: rim compression. Type V: four-part." [27]

3. AO/OTA classification

The AO/OTA method indicates that number 41 corresponds to the proximal tibia. One can categorize these fractures as totally articular, partly articular, or extraarticular.

- "Type A: extraarticular, indicating that the tibial plateau is not affected
- Type B: partial articular
  - ✓ B1 - Simple articular split
  - ✓ B2 - Split depression
  - ✓ B3 - Comminuted split depression
- Type C: complete articular
  - ✓ C1 - Noncomminuted total articular fractures
  - ✓ C2 - Metaphyseal comminution paired with simple articular fracture lines
  - ✓ C3 - Total comminuted articular fractures that also involve the articular surface." [28]

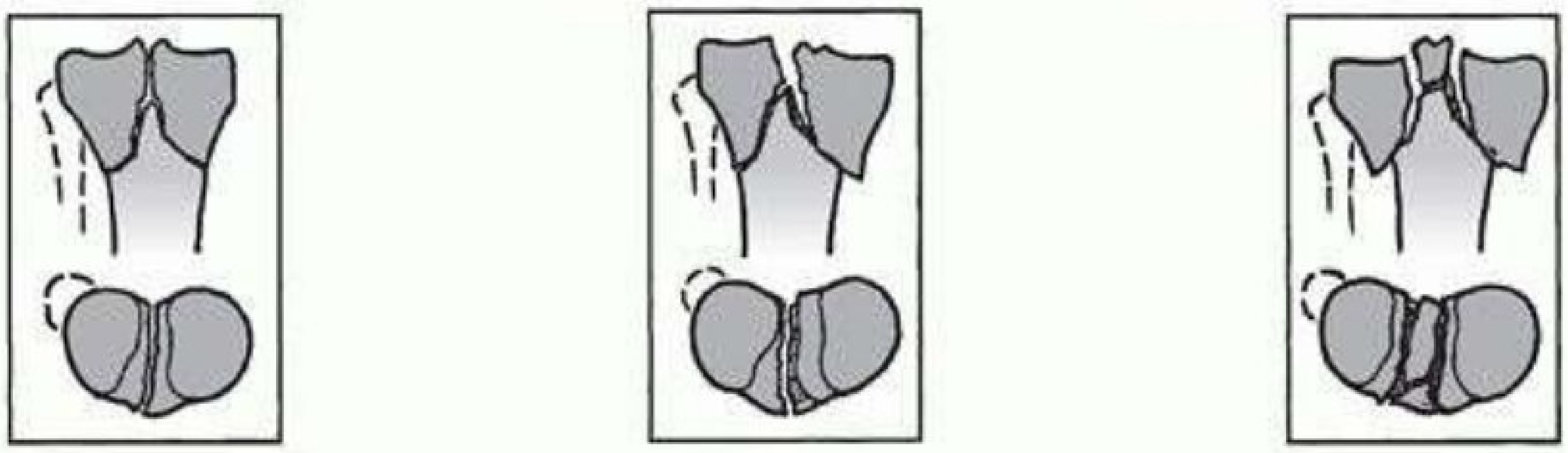
Fig.15: AO/OTA CLASSIFICATION – 41-C

Tibia/fibula, proximal, complete articular, simple articular, simple metaphysis (41-C1)

(1) intact anterior tibial tubercle and intercondylar eminence
(2) anterior tibial tubercle involved
(3) intercondylar eminence involved

1. Slight displacement (41-C1.1)
2. 1 condyle displaced (41-C1.2)
3. Both condyles displaced (41-C1.3)

C1



Tibia/fibula, proximal, complete articular, articular simple, metaphysis multifragmentary (41-C2)

1. Intact wedge (41-C2.1)
(1) lateral
(2) medial

2. Fragmented wedge (41-C2.2)
(1) lateral
(2) medial

3. Complex (41-C2.3)

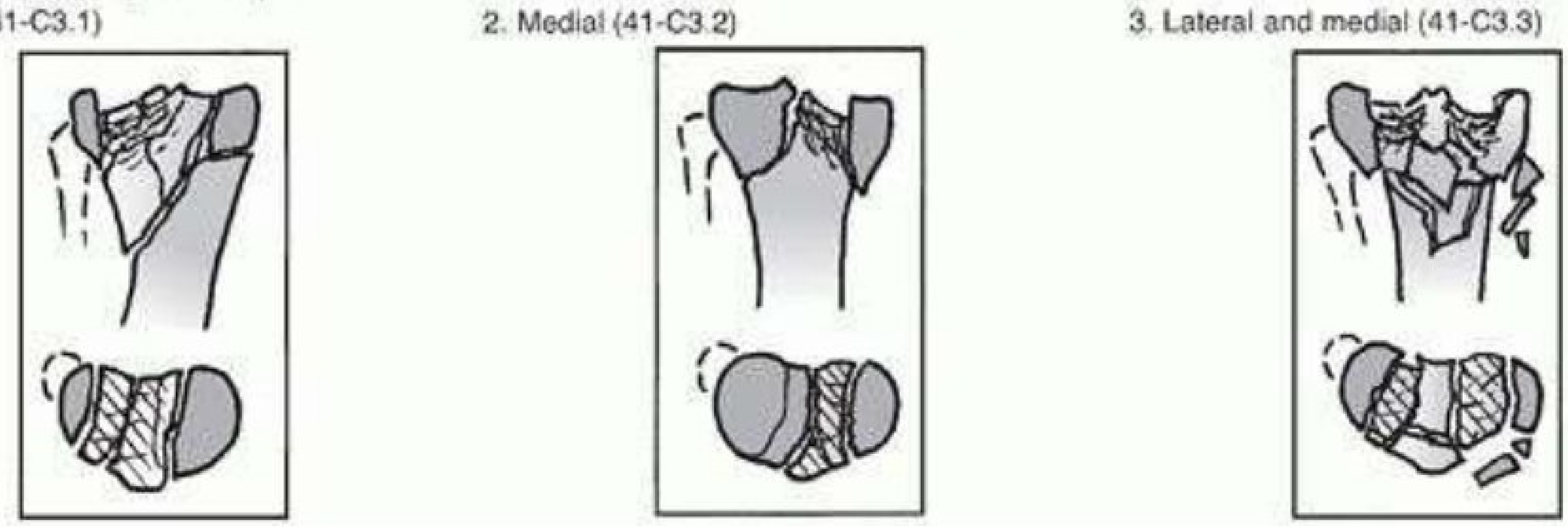
C2

Tibia/fibula, proximal, complete articular, articular multifragmentary (41-C3)

(1) metaphyseal simple
(2) metaphyseal lateral wedge
(3) metaphyseal medial wedge
(4) metaphyseal complex
(5) metaphysio-diaphyseal complex

1. Lateral (41-C3.1)
2. Medial (41-C3.2)
3. Lateral and medial (41-C3.3)

C3



4) Luo three-column classification

"A three-dimensional view of the tibial plateau was used in the implementation of the Luo Three-Column Classification in 2010, which makes it useful for characterizing intricate multiplanar tibial plateau fractures. Tibial plateau fractures have been classified using conventional two-dimensional methods like Moore and Schatzker based on plain radiographs, but Luo employs axial CT scans. The three crossing lines that separate the medial, lateral, and posterior columns of the tibial plateau and merge in the middle of the two tibial spines are how Luo describes it. The lateral line runs from the midway to just in front of the fibular head, the medial line runs from the midpoint to the posteromedial ridge, and the anterior line runs from the centre of the plateau to the tibial tuberosity.

The four categories of fractures are one-, two-, three-, and zero-column fractures. Pure depression fractures (Schatzker III) are considered zero column fractures because a column is only considered fractured when a cortical split is present. Using this classification approach helps with preoperative planning, particularly with regard to posterior participation, which has been shown to be more important than previously believed. A poor diagnosis may cause functional instability and misalignment." [29]

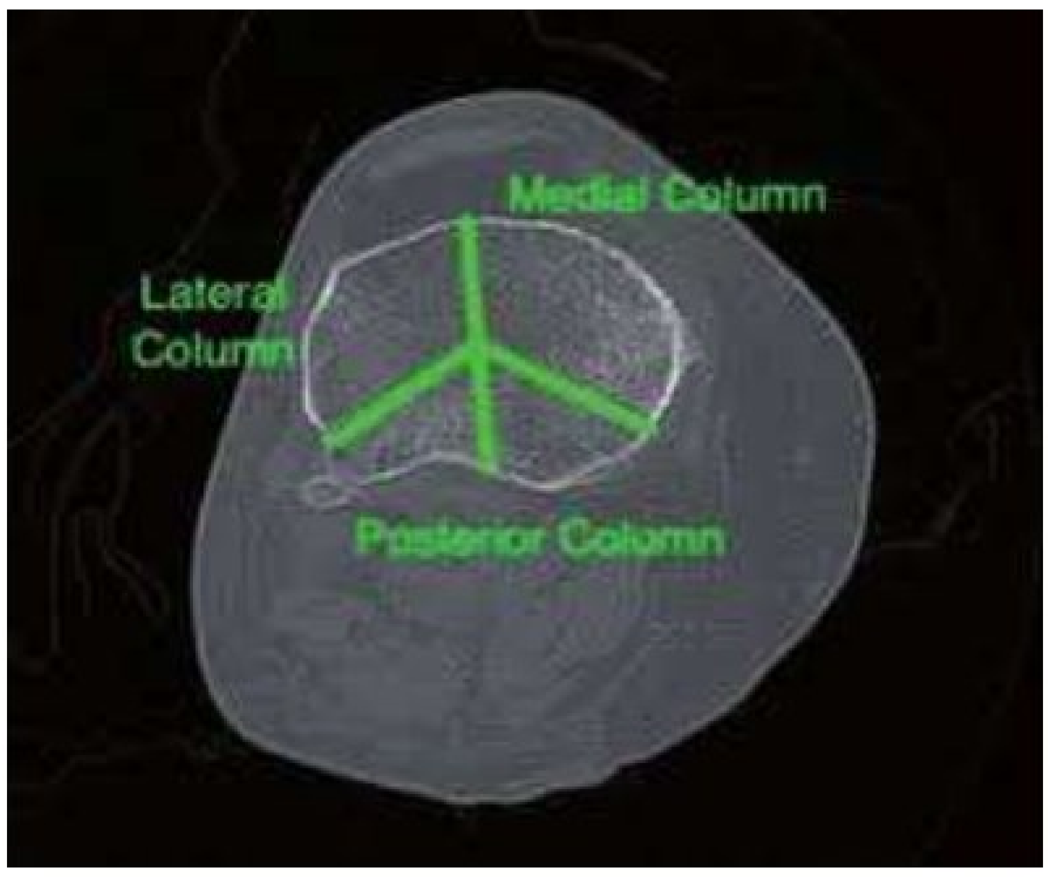


Fig.16: CT image axial section of proximal tibia showing Luo three column classification

Table 1: Three-Column and Schatzker Classifications for Tibial Plateau Fractures

Three-Column Classification	Schatzker Classification	Description
One column	Type I	Pure cleavage fracture of the lateral tibial plateau
One column	Type II	Cleavage combined with depression of the lateral tibial plateau
One column posterior	Not included	Posterior column fragment, without involvement of the anteromedial or anterolateral columns
Zero column	Type IIIA	Pure lateral depression of the lateral tibial plateau
Zero column	Type IIIB	Pure central depression of the lateral tibial plateau
Two column medial and posterior columns	Type IV	Medial tibial plateau fracture with a separate split or depressed component
Two column lateral and posterior columns	NA	Lateral tibial plateau fracture with a separate split or depressed component
Three column	Type V	Wedge fracture of the lateral and medial tibial plateau
Three column	Type VI	Variable bicondylar fracture pattern, with transverse subcondylar fracture and dissociation of the metaphysis from the diaphysis
Three column (posterior column component)	NA	Separate fragments in each of the three columns; posterior column components are not described in the Schatzker classification system

Sources.—References 1, 2, and 4.
Note.—NA = not applicable.

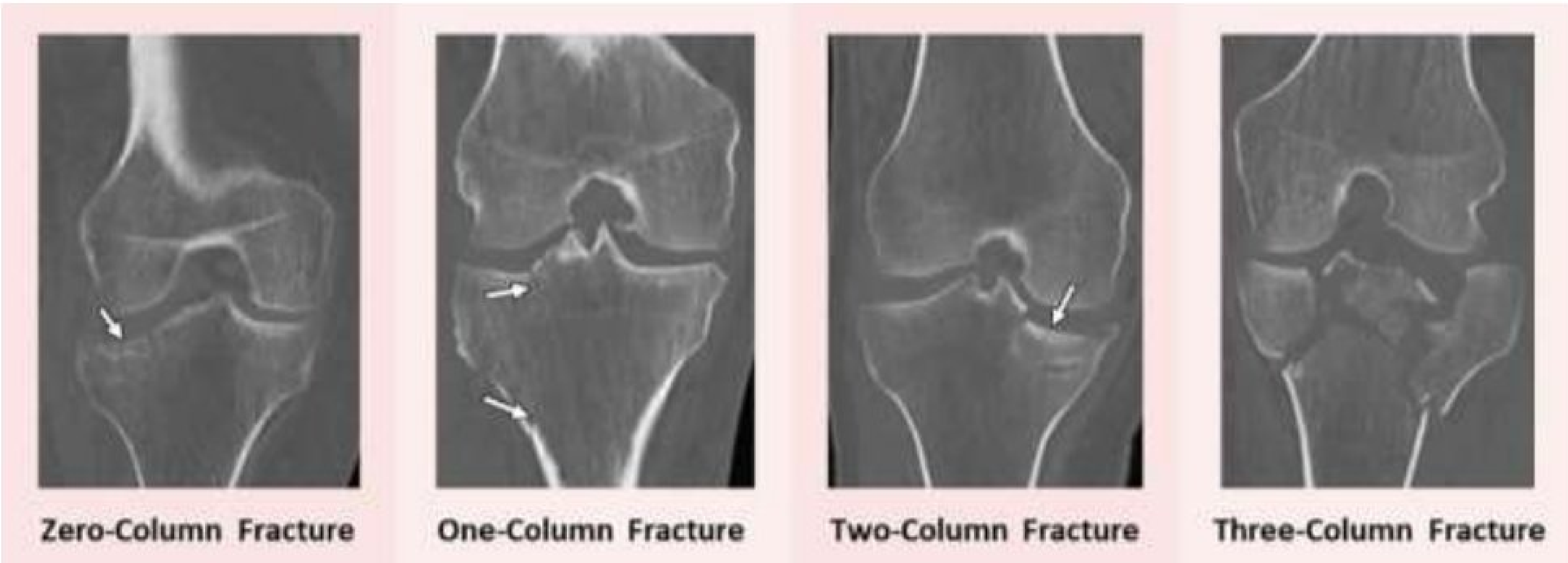


Fig. 17: Three column and schatzker classification relation

DIAGNOSIS

History

A thorough history, which included mechanism of damage, was taken. Among other things, soft tissue damage, compartment syndrome, and neurovascular impairment are associated with high-energy injuries. Treatment choices are influenced by patient's general health as well as functional and financial factors. We regularly look into any linked injuries and ask about any symptoms associated with head, stomach, or chest injuries because of the severity of the impact.

Examination

A comprehensive clinical assessment was carried out to ascertain the condition of neurovascular and soft tissue function.

Abrasions, severe bruising, skin darkening, haemorrhagic or clear blisters, and external wounds that potentially expose the fracture to the environment were all examined as part of the soft tissue assessment. When there was significant soft tissue damage, surgery was postponed until the tissue swelling subsided. If the ankle-brachial pressure index was less than 0.9, arteriography was performed. The Lachman test was used to evaluate for ligamentous injuries since they are indicative of high-energy trauma.

Radiography

To assess the fracture pattern, standard lateral and anteroposterior radiographs were performed.

A 10-degree caudal tilt image, as opposed to a standard anteroposterior view, provides important information on articular surface depression and splitting as well as a profile of fracture in tibial plateau's anteroposterior plane. It is easier to see the fracture lines when the leg is seen obliquely in both internal and exterior rotations. The most accurate radiographs describing the fracture pattern were those obtained when the leg was being manually tractioned. Traction reduces overlap and aids in the restoration of the limb's gross structure.

Computed Tomography

Recently, CT scans have been used into the evaluation procedure for fractures of the tibial plateau. They provide the most precise study of displacement, comminution, and depression of the articular surface. Three-dimensional reconstructions have proven effective in guiding treatment strategies. Accurately determining the severity of fractures and enabling preoperative planning, categorization, and fixation schemes are made possible by CT scans, which greatly assist the surgeon in treating these intricate injuries.

Magnetic Resonance Imaging

When assessing the severity of soft tissue injuries, MRI is helpful, especially when it comes to the state of the menisci and cruciate ligaments. With the exception of stress fractures that might not be evident on routine radiographs, it is less useful than CT at examining fracture lines. Although this is still debatable, MRI may be a part of standard investigations if surgeons want to treat the soft tissue injury along with bone injury.

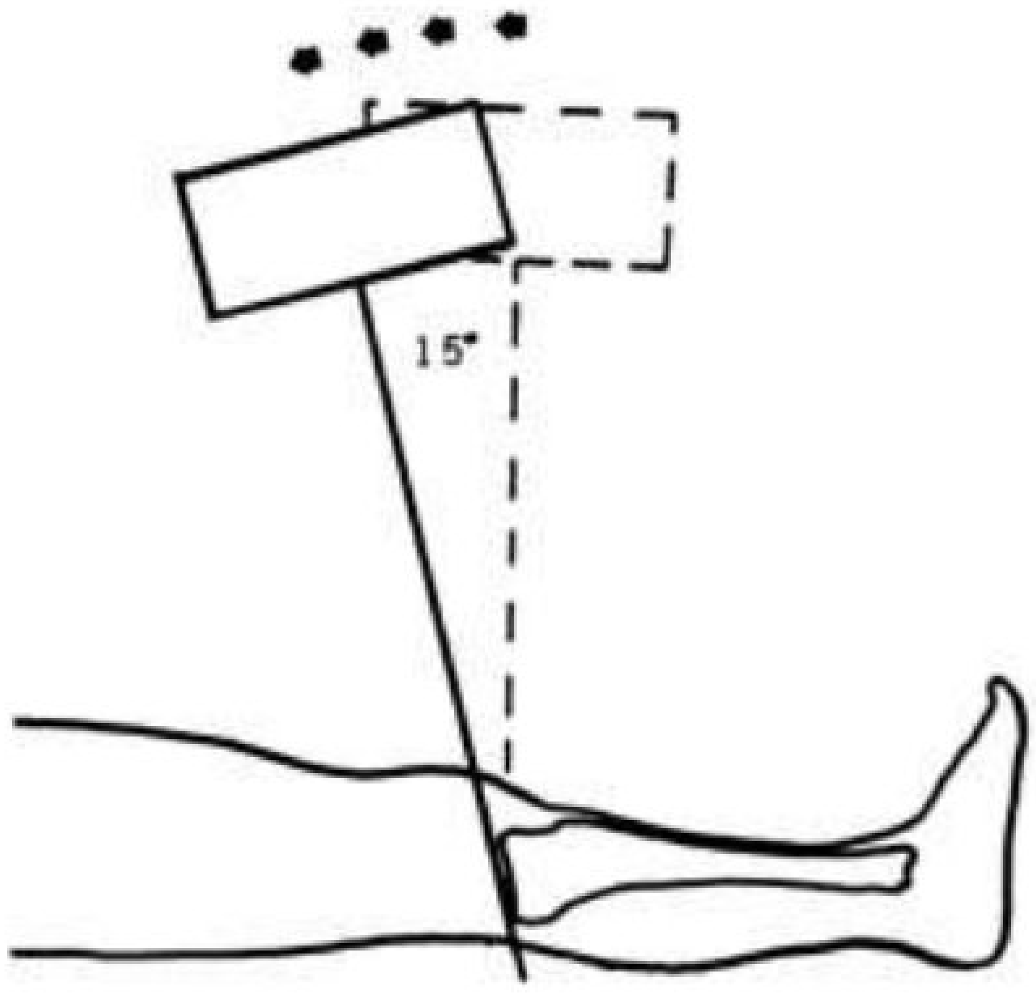
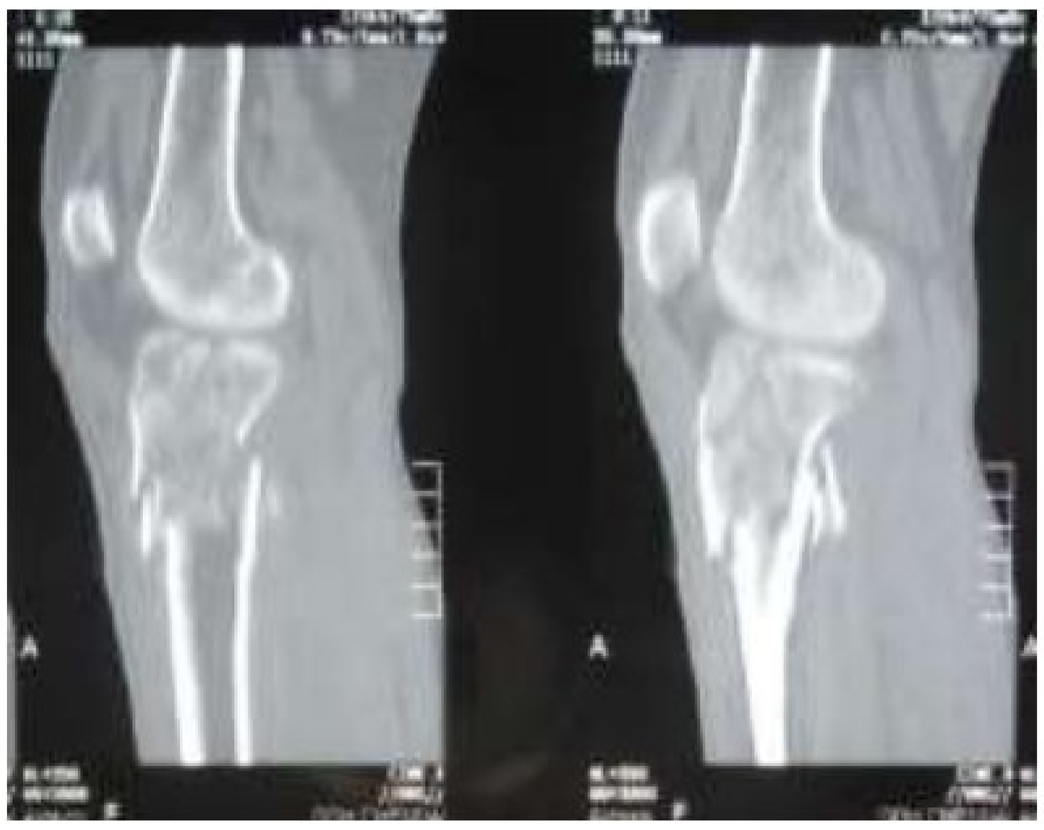


Fig.18: Tibial plateau: Technique and x ray picture



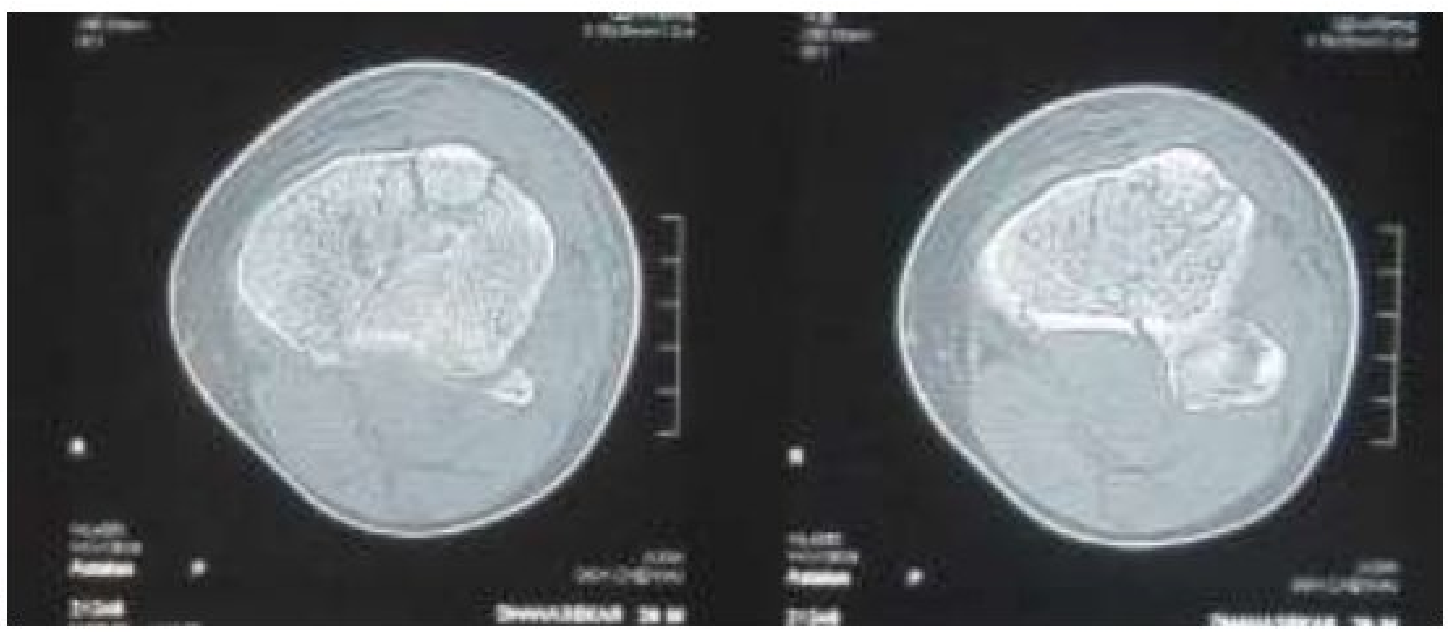


Fig.19: CT images: posteromedial fracture fragment

Outcome Assessment Metrics

Numerous outcome measures, including generic health status measures like the Short-Form 36 (SF-36) and SMFA, have been reported for patients with tibial plateau fractures. The Hospital for Special Surgery (HSS) Knee Score, Oxford Knee Score, WOMAC, Rasmussen score, KOOS, and Lysholm score are other disease-specific patient-reported outcome tools that have been used. Unfortunately, the ideal knee score for patient follow-up studies for tibial plateau fractures is still up for debate, and the variety of scores utilized makes it challenging to draw useful comparisons between research.

Furthermore, no study offers a sufficiently wide patient distribution to support a normative score distribution. Because of this, it is impossible to predict the predicted score at a specific moment following a plateau fracture in a patient who is following a normal course. Secondary outcomes such articular reduction, residual pain, knee range of motion, patient satisfaction, return to work or sport, and length of hospital stay were also included in the majority of papers. Usually, adverse outcomes such nerve damage, deep infection, compartment syndrome, and the necessity for reoperation were described [30].

PRINCIPLES OF TREATMENT

NON-OPERATIVE TREATMENT

In carefully chosen cases of tibial plateau fractures, non-operative therapy can be used successfully with positive results.

Typical signs include:

- ✓ Fractures that should mend without causing major deformity
- ✓ High-risk elderly patients for surgery
- ✓ Coexisting illnesses that increase the risk of surgery

Mild to severe articular depression (up to 10 mm) in isolated lateral condyle fractures is expected to heal properly and without deformity. However, bigger articular depressions or related split and displaced pieces usually heal with a valgus alignment, which increases the risk of osteoarthritis because of uneven joint loading. Because the fracture pattern is more oblique in the coronal plane, isolated medial condyle fractures, particularly those with only minor displacement, are more likely to heal in varus malalignment. For all medial condyle fractures, anatomical reduction is therefore recommended. In light of this, it is often inappropriate to treat bicondylar fractures in young, active individuals without surgery because the expected functional results may be below par [31].

Indications

- ✓ Fractures that are not displaced or only slightly displaced
- ✓ On clinical examination, there are minor lateral plateau depressions that are neither deformed nor unstable.
- ✓ Serious medical conditions that make surgery impossible
- ✓ Older adults with low functional needs who can accept minor abnormalities

Relative Contraindications

- ✓ Unstable knee
- ✓ Greater displacement in areas with readily foreseeable deformities
- ✓ injuries to the displaced medial side

Nonoperative treatment is recommended in specific fracture configurations, even though surgical treatment is more frequently used for tibial plateau fractures. Nonoperative treatment of undisplaced or partial fractures can be effective. Patients who appear late, for whom surgery is not recommended because of several medical comorbidities, or who are at high risk of anaesthesia-related morbidity and death may also be candidates for nonsurgical therapy. Small to moderate articular displacements are tolerated by the proximal tibial articular surface, and nonoperative treatment of appropriately chosen fractures yields consistently good results in spite of articular abnormalities.

It is quite uncommon for posttraumatic arthritis to become incapacitating over time. Regarding the nonoperative management of tibial plateau fractures, there are no established protocols. A closed reduction of a displaced proximal tibia fracture for definitive nonoperative therapy is uncommon in contemporary practice and is difficult for many displaced fractures. Predicting whether a deformity will persist after therapy is crucial when choosing patients for nonoperative treatment. An angular malalignment following a tibial plateau fracture will result in increased strain on the articular cartilage of the damaged condyle, and it is not well tolerated.

Furthermore, misalignment can affect one's appearance, raise the risk of knee instability, impair balance, and result in falls. The patient's age, activity level, overall health, clinical assessment of limb alignment, and a thorough examination of the available imaging for bone quality, fracture type, direction of initial displacement, degree of articular comminution, width of the tibial plateau, and degree of articular depression are all important factors in predicting further displacement. Articular depression is associated with the chance of deformity development. It is not a 1:1 relationship, though. Stable knees with favorable clinical results can be achieved with localized depressions of at least 10 mm. Generally speaking, split depression fracture patterns and fractures involving significant portions of the lateral tibial plateau are likely to result in valgus malalignment.

Certain Schatzker type II lateral tibial plateaus can also be treated nonoperatively with little chance of worsening, particularly if the fractured plateau is not very large. Because medial plateau fractures are more likely to heal when the lower limb's weight-bearing axis crosses slightly medial to the midline, one must be more careful when treating them nonoperatively. Varus deformity may result from medial plateau subsidence or collapse. The literature has a strong bias in Favor of developing new methods and investigating novel strategies for treating these injuries surgically [31].

Techniques

Bracing

The damaged side of the joint can be unloaded with cast bracing. In the past, they were frequently employed to support the damaged joint while allowing for some joint motion. Cast braces are not widely used at the moment. This extra protection is not necessary for tibial plateau fractures that are naturally stable or surgically stabilized; instead, a lighter, detachable brace is recommended. The majority of surgeons choose early mobilization with a hinged brace, which permits joint motion and offers some coronal support, even though damaged knees with tibial plateau fractures can withstand up to six weeks of cast immobilization before becoming more rigid.

Weight-Bearing Guidelines

The majority of individuals with tibial plateau fractures that are treated nonoperatively should be kept off their feet for the first few weeks following their injury. Depending on the fracture pattern, nonweight bearing is usually required for 4 to 8 weeks.

Outcomes

Data about the effectiveness and functional effects of nonoperative therapy are scarce. Nonoperative treatment of tibial plateau fractures has shown excellent results. The majority of the information comes from older series, while there has been some recent research that concentrate on nonoperative treatment. When compared to those treated nonoperatively in modern treatment, the earlier series can be regarded as the worst case because the indications for treating plateau fractures nonoperatively have significantly decreased [31].

OPERATIVE TREATMENT

Indications:

- ✓ Bicondylar fractures,
- ✓ Valgus or varus instability exceeding 10 degrees within a knee movement arc of 0 to 90 degrees;
- ✓ lateral condyle split fractures
- ✓ concomitant metaphysiodiaphyseal dissociations
- ✓ displaced fractures of the medial condyle; and
- ✓ Open fractures,
- ✓ compartment syndrome, or related arterial injuries
- ✓ articular depression affecting more than half of the articular surface

Anatomical alignment, stiff fixation, appropriate mechanical and anatomical limb alignment, and early joint mobilization are all advantages of surgical intervention.

There are proponents of both internal and external fixation, thus the choice is between the two.

Approaches:

- ✓ Anterolateral
- ✓ Posteromedial
- ✓ Combined approach
- ✓ Anteromedial
- ✓ Posterior

Plates and screws:

Locking compression plates, T buttress plates and L buttress plates, are among the plates that are available for the proximal tibia. There are several precontoured plates available that are easy to use.

The anterolateral region of the proximal tibia is usually where plates are placed in the tibial plateau. In split and depression fractures of the lateral plateau, this plate serves as a buttress to support the tibia's delicate lateral cortex. Because locking plates are robust implants with stronger screws that can tolerate the deforming stresses connected to high-energy bicondylar fractures, their use in the lateral column has increased recently.

Lateral plates also feature many parallel screw grooves close to the joint surface, making it easier to implant multiple screws—often called "rafting screws"—near the articular surface. The most common implants used to fix tibial plateau fractures are plates and screws. Precontoured periarticular plates and locking plates have recently been created by all major manufacturers, giving patients a variety of plate options. Lag screws are the most basic implants used to treat tibial plateau fractures. They can be used alone or in combination with other fixation devices to compress simple fracture lines. The most popular screws for compression are partially threaded ones, and 6.5-mm screws are good for large plateau fracture lines, while smaller screws might still be effective.

Depending on the fracture pattern and their anatomical location, plates have a variety of uses. Anterolateral proximal tibia plates are frequently utilized as buttresses and to replace the injured lateral cortex that results from lateral split depression plateau fractures. Because these plates are precontoured for this anatomical area, it is considerably simpler to get a precise fit when buttressing the lateral tibial condyle.

The 4.5-mm implants that were once widely used have mostly been replaced by 3.5-mm implants and screws, which are now the most popular size. Because 3.5-mm implants are smaller and easier to insert into the bone, more screws can be positioned near the articular surface to support fewer fragments. To support the smaller articular surface and lessen the likelihood of postoperative settling, 3.5-mm screws can be positioned parallel and near the articular surface thanks to many holes in the plate's head. This method is known as "rafting screws" [32].

Bicondylar and Schatzker type VI fractures require lateral plates that can withstand bending, rotation, and axial forces. In order to withstand these mechanical forces, locking screws to the plate has been a significant advancement, and these implants are today highly common. Because these patterns must withstand significant deforming stresses, plate structures for them may be larger (4.5 mm, for example) than those used for unicondylar fractures. They must stop bending forces from causing a varus deformity from their lateral position. They have reduced the requirement for definitive external fixation and twin plates by preventing varus collapse, although they are typically regarded as inadequate in supporting an unstable medial column.

The mechanical purpose of posteromedial plates differs from that of anterolateral plates. To withstand shearing forces in this region, the plate must act as an antiglide device. Once more, the most popular implants are 3.5 mm, and a number of manufacturers are starting to offer particularly shaped plates. with this region, the precise location of screws is less significant than the plate's position with respect to the fracture's apex. The plate will be tightly apposed in this crucial region if a screw is positioned close to the fracture's apex.

The purpose of posteromedial plates is to counteract shearing pressures on the posteromedial fragment by acting antiglidely, preventing varus collapse.

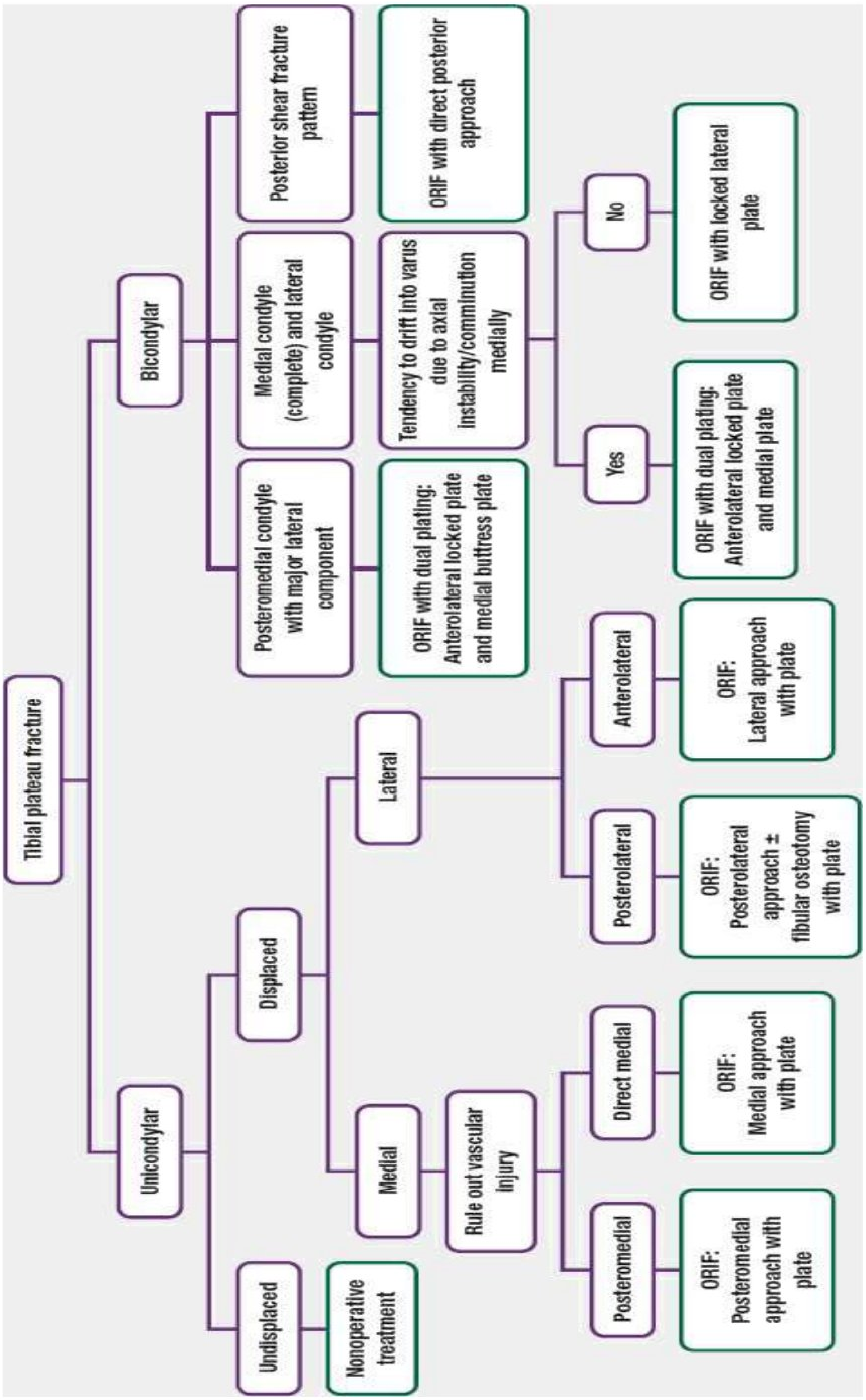


Fig.20: Approach to proximal tibia plating

External fixators:

Temporary external fixation is put across the knee joint to maintain limb length and restore limb alignment. This facilitates the healing of soft tissues prior to the application of permanent internal fixation.

If there is significant soft tissue damage if the surgeon so chooses, external fixators may be utilized as a last resort for high-energy bicondylar fractures. If applied correctly and with sufficient stability, definitive external fixation may produce results comparable to internal fixation in high-energy injury instances. Joint-sparing and hybrid fixators are beneficial in this situation.

Principles of External Fixation

Over the past ten years, there has been a significant shift in the application of external fixation for tibial plateau fractures. The amount of external fixation required for the final treatment of shaft-dissociated and bicondylar patterns has dramatically decreased with the introduction of locking plates placed by restricted techniques. In order to visualize the fragments for articular restoration, standard treatment usually involves open reduction. However, this procedure necessitates significant soft tissue dissection, which may harm the local vascularity and increase the risk of infection and wound breakdown. But these days, external fixation—which involves spreading the knee—is widely utilized as a short-term remedy. During soft tissue recovery, this method aligns the fracture and restores length before internal fixation is used as a final treatment.

Depending on the surgeon's preference, definitive external fixation may still be used in complex tibial plateau fractures or in situations involving substantial soft tissue damage where internal fixation is not seen to be safe even after a wait. Limited-access internal fixation combined with a tiny wire exterior fixator offers stability comparable to ORIF but with fewer issues. With minimal soft tissue damage, a tiny wire fixator can be utilized to compress over the fracture site at the articular and metaphyseal segments. Once the reduction is applied, it can be adjusted with the fixator to retain the proper reduction.

Additionally, very early in the postoperative period, patients treated with a thin wire fixator are typically permitted to bear their own weight as tolerated.

Principles of Void Filling

Reducing depressed tibial plateau articular fragments, usually of the lateral plateau, results in voids or empty spaces in the bone beneath the reduced fragments more often than with most other fracture patterns. After the articular fragments are decreased, the injury compresses the cancellous trabeculae, causing a loss of material. Despite internal fixation, there is a greater chance that the reduced articular fragments will redisplace because these voids function as a region that lacks support. The goal of lateral plateau fracture surgery has been to reduce this risk by filling metaphyseal voids to improve stability and stop redisplacement. Allografts, autologous bone grafting, and the use of synthetic bone replacements are available methods for void-filling.

The usage of autograft has been declining because of its poor mechanical qualities, donor site morbidity, and limited supply. Minor complications like superficial infections, superficial seromas, and minor hematomas have been linked to autologous bone graft harvesting. Major complications include vascular injuries, deep infections at the donor site, neurologic injuries, iliac wing fractures, herniation of abdominal contents through massive bone graft donor sites, and deep hematoma formation that necessitates surgery or transfusion. Autograft's handling characteristics are comparable to those of allograft, although donor site morbidity is absent. [33].

The use of allografts has been linked to a potential danger of infection transmission. Additionally, a competent bone banking system must be accessible, however this may not be the case everywhere. In mechanical and clinical trials, researchers have evaluated a range of commercially available graft alternatives. Although the best material is yet unknown, this is an area where practices are evolving. New techniques to sustain the reduced articular surface are crucial because subsidence following surgically decreasing and repairing lateral plateau fractures is a serious issue. The majority of recent research has concentrated on phase-changing cements, which have been demonstrated to have mechanical qualities superior to those of autologous and allograft bone grafts, rather than comparable. Calcium phosphate (Ca-P) cement was noticeably firmer in compression than cancellous bone in a split depression fracture model in cadavers.

Principles of Postoperative Care

The ideal postoperative regimen should expedite recovery and return to function, reduce problems and loss of fracture reduction, and maximize knee motion. To lessen the likelihood of shifting the reduced fracture, a period of nonweight bearing or low weight bearing is required. Most surgeons will not advance weight bearing until sometime in this range since it likely takes 6 to 12 weeks for there to be any discernible gain in resistance to displacement from fracture healing, depending on the fracture pattern and fixation strength. Given that knees immobilized for more than two weeks tended to be stiff, Gausewitz and Hohl thought that early motion was far more crucial following surgical therapy. Nowadays, surgeons try to mend fractures so that the patient can move around during the first few weeks of healing, often using a hinged brace.

Tibial Plateau Fractures:

“COMMON ADVERSE OUTCOMES AND COMPLICATIONS

- Loss of reduction
- Wound breakdown and infection
- Septic arthritis after external fixation
- Knee stiffness
- Prominent or painful hardware
- Nonunion or delayed union / malunion
- Posttraumatic arthritis
- Compartment syndrome” [34]

MATERIALS AND METHODS

SOURCE OF DATA:

- "Patients admitted in Department of Orthopaedics in B.L.D.E. (DEEMED TO BE UNIVERSITY), Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura" with the diagnosis of proximal tibia fractures.
- The patients will be informed about the study in all respects and informed written consent would be obtained.
- The period of study will be from 1st April 2023 to 1st December 2024.

DESIGN OF STUDY: Prospective study.

METHOD OF COLLECTION OF DATA:

- "Patients admitted in Department of orthopaedics in B.L.D.E (DEEMED TO BE UNIVERSITY), Shri B. M. Patil's Medical College, Hospital and Research centre," with diagnosis of proximal tibia fracture Schatzker type-V and type-VI.
  - by clinical examination.
  - history taking
  - Diagnosis- Clinical and Radiological

INCLUSION CRITERIA

- Over eighteen years of age.
- Schatzker classification of tibial plateau fracture type-v and type-vi.
- Closed fractures and Gustilo Anderson type-I.
- Fractures with trauma less than 3 weeks.

EXCLUSION CRITERIA

- Patients with pathological fracture.
- Compound fractures and Gustilo Anderson >type-II and type-III.
- Fractures with neurovascular deficits.
- Ipsilateral fractures of lower limb.

SAMPLE SIZE CALCULATION:

As per the study done by Shrestha DK and et al assessed "the functional outcome of bicolumnar dual plating for bicondylar fractures of tibial plateau". By above considerations average incidence of tibial plateau fractures constitutes about 1.2% of all the fractures. Considering the confidence limit of these studies to be 95% with 5% level of significance and margin of error 0.05. The sample size computed using the formula

Sample size (n) = $(Z^2 * p * (1-p)) / d^2$

Where,

z is the z score = 1.96

d is the margin of error = 0.05

n is the population size

p is the population proportion =0.012

The estimated sample size of this study is **31**.

STATISTICAL ANALYSIS:

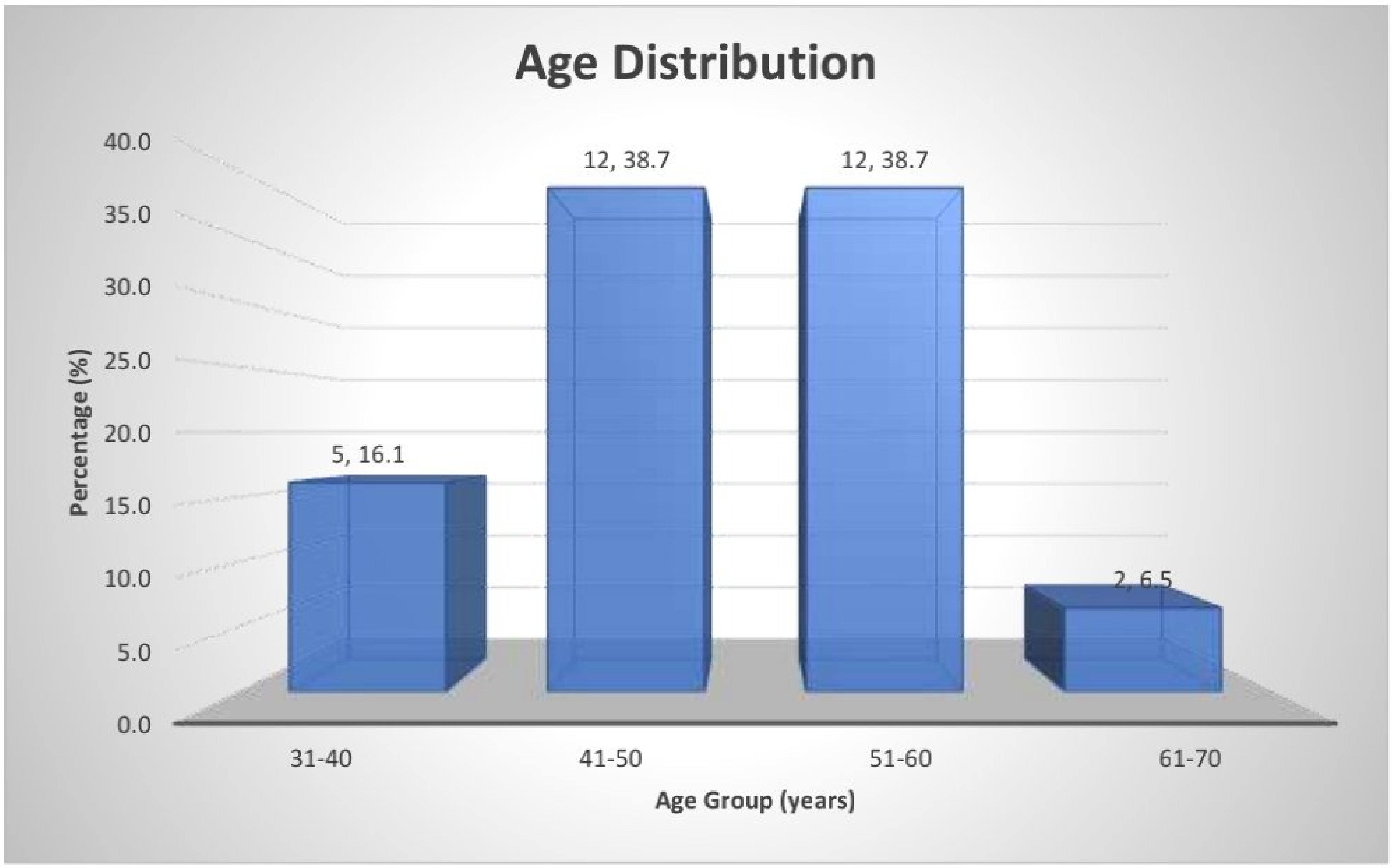
- Following data entry into a Microsoft Excel spreadsheet, statistical analysis is performed using statistical software for the social sciences (SPSS) (Version 27).
- The results are shown using diagrams, counts, percentages, mean, and standard deviation (SD).
- The two groups' normally distributed continuous variables will be compared using an independent samples test.
- The Mann-Whitney U test will be used for variables that don't have a normal distribution.
- The two groups' categorical variables are compared using either the Chi-square test or the precise Fisher's test.
- An ANOVA will be performed if there are more than two groups, and a Kruskal-Wallis H test will be used for data that do not have a normal distribution. A statistically significant p-value is one that is less than 0.05. Two-tailed tests will be used to assess all statistics.
- Our research included thirty-one patients who fulfilled the study's requirements.

Age Distribution:

In our study, patients aged from 31 to 70 years were included.

Age group	Frequency	Percentage
31-40	5	16.1
41-50	12	38.7
51-60	12	38.7
61-70	2	6.5

Table.1. Age distribution

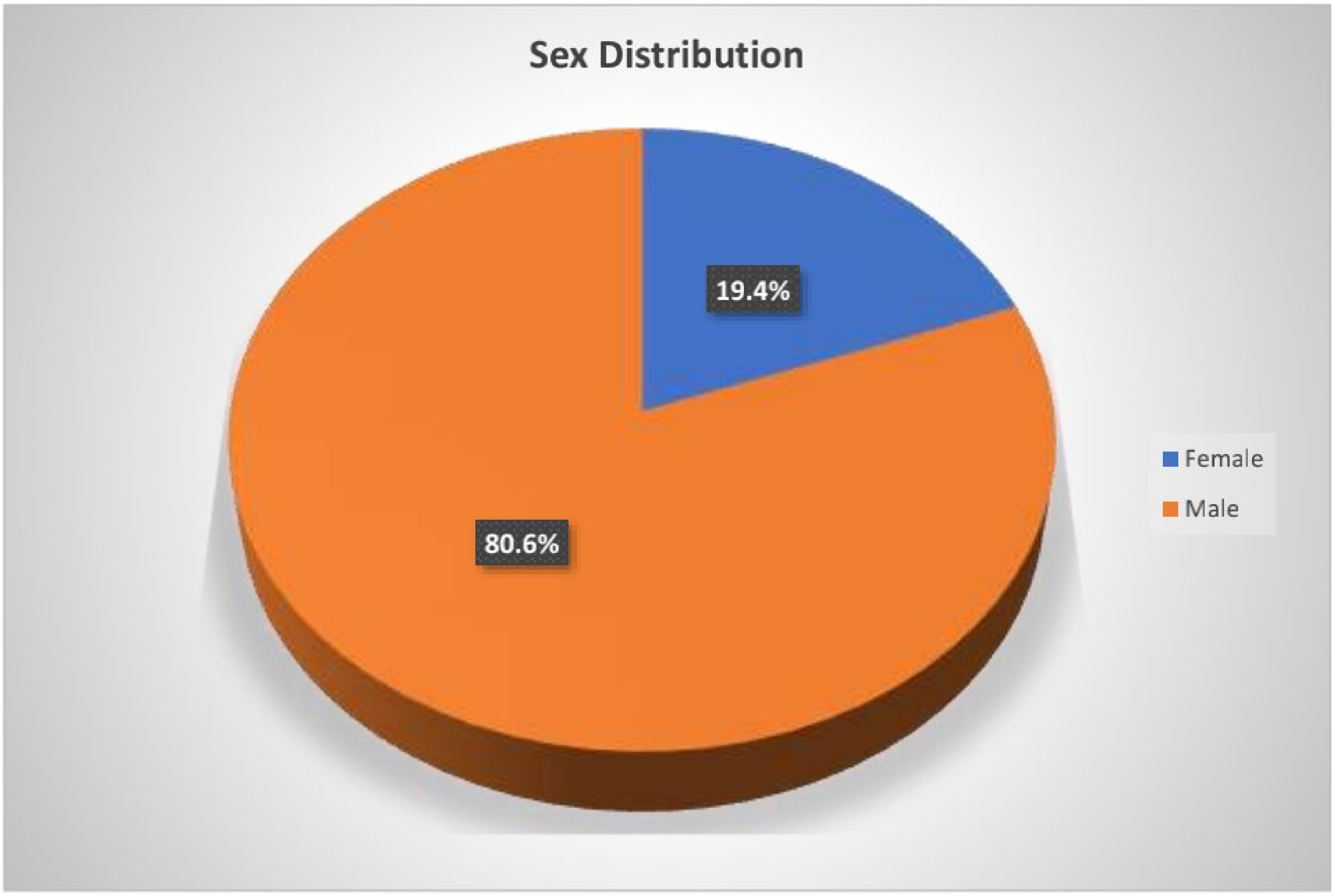


Sex Distribution:

In our study, females were 19.4% and males were 80.6%

Fracture type	Frequency	Percentage
Female	6	19.4
Male	25	80.6

Table.2. Sex distribution

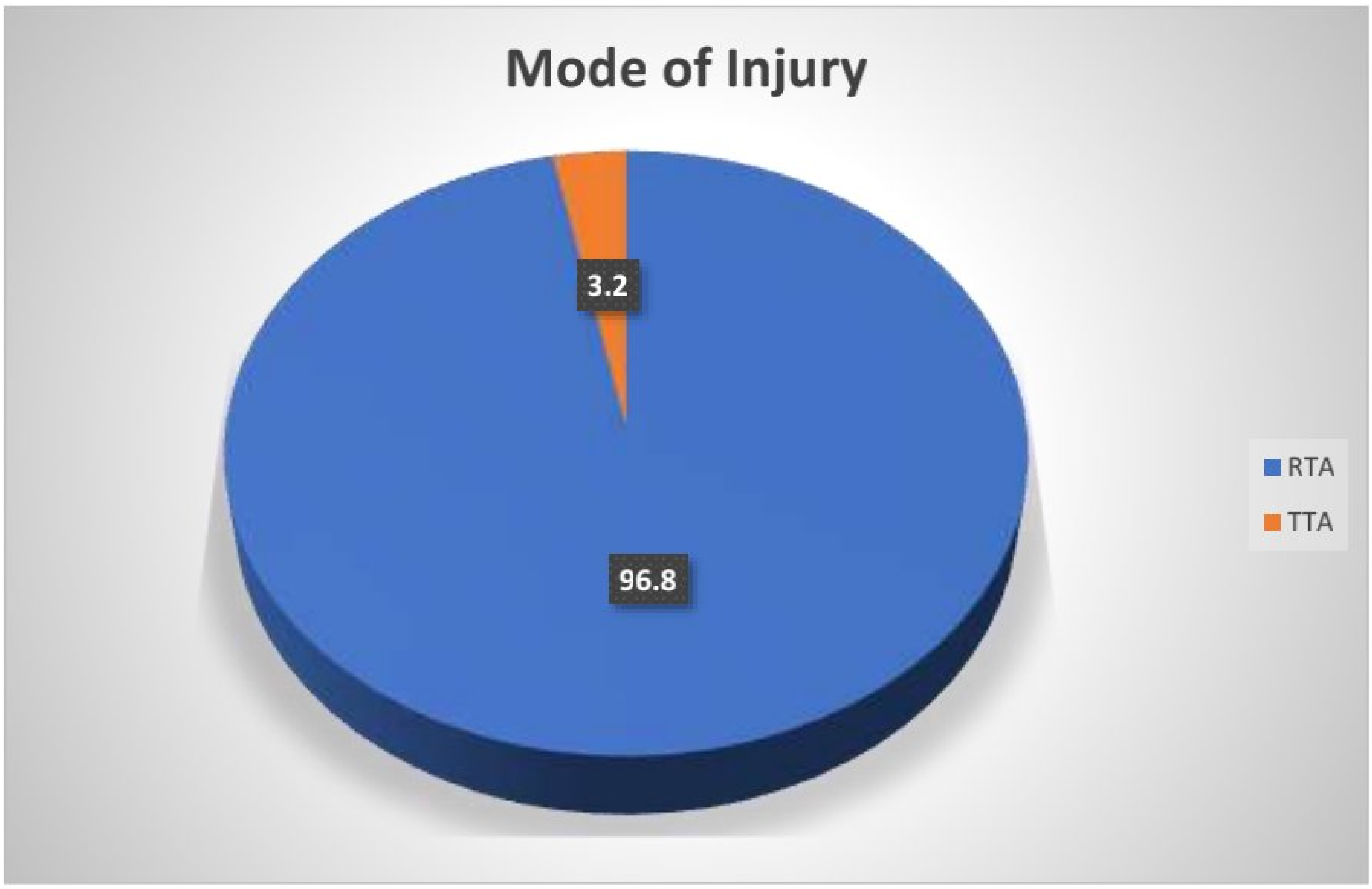


Mode of injury:

A total of 30 patients were injured due to a road traffic accident, while one patient experienced an injury from a train traffic accident.

Mode of injury	Frequency	Percentage
Road traffic Accident	30	96.8
Train Traffic Accident	1	3.2

Table.3. Mode of injury

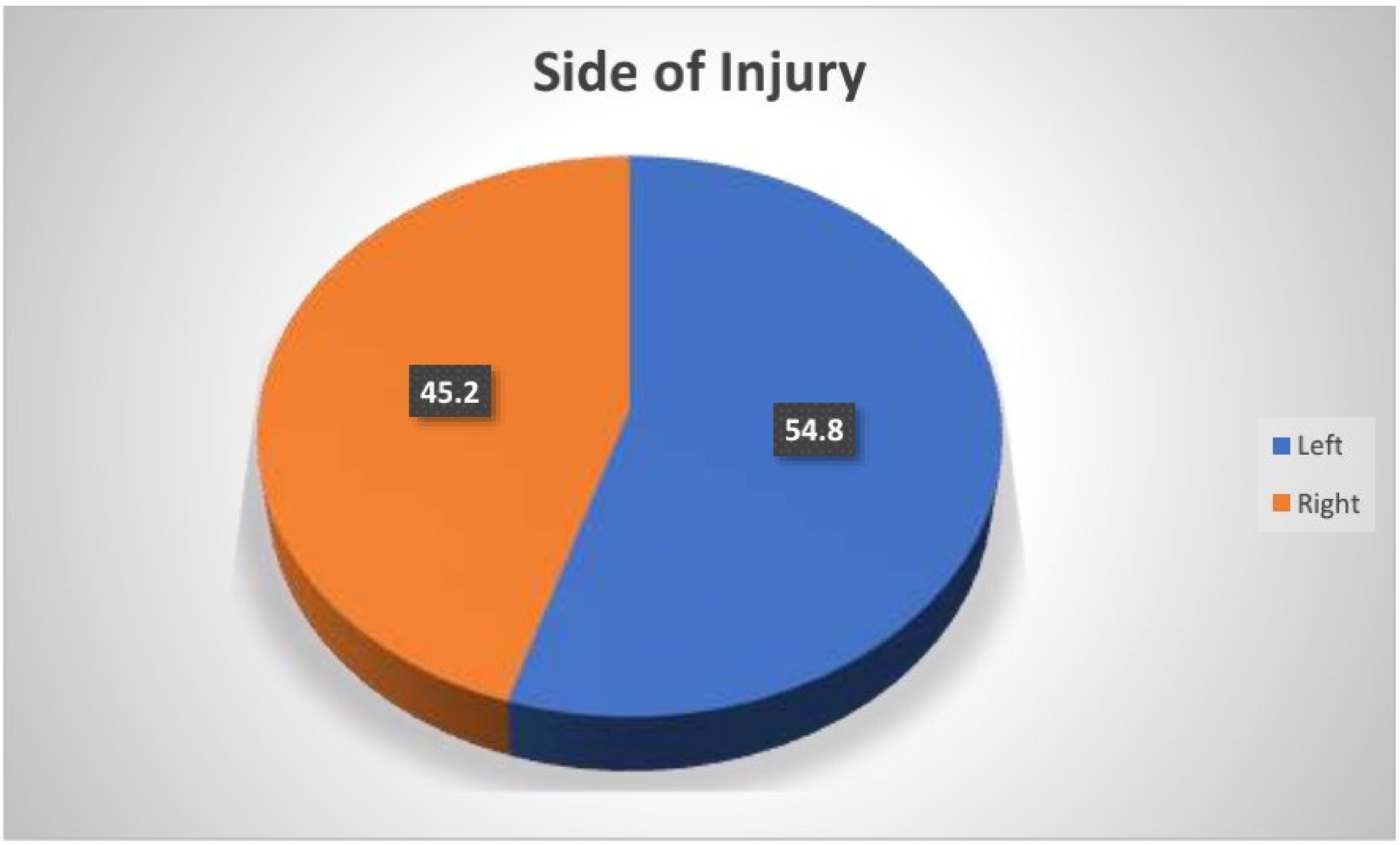


Side of injury:

We found that the right side was injured in 14 individuals while the left side was injured in 17.

	Frequency	Percentage
Left	17	54.8
Right	14	45.2

Table.4. side of injury

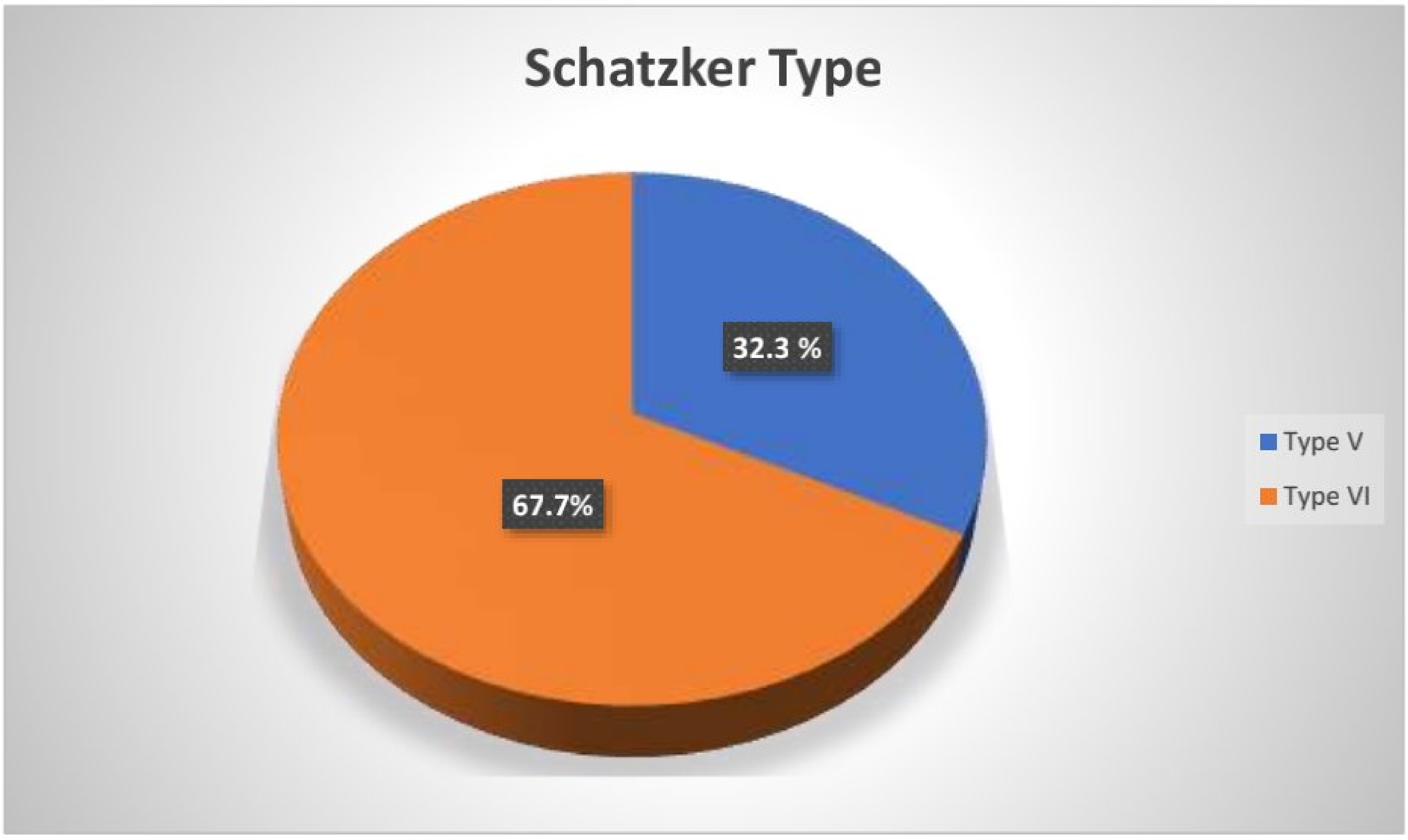


Fracture types:

According to our results, 21 patients were categorized as Schatzker type VI and 10 patients as Schatzker type V.

Type of Fracture	Frequency	Percentage
V	10	32.3
VI	21	67.7

Table.5. Fracture type

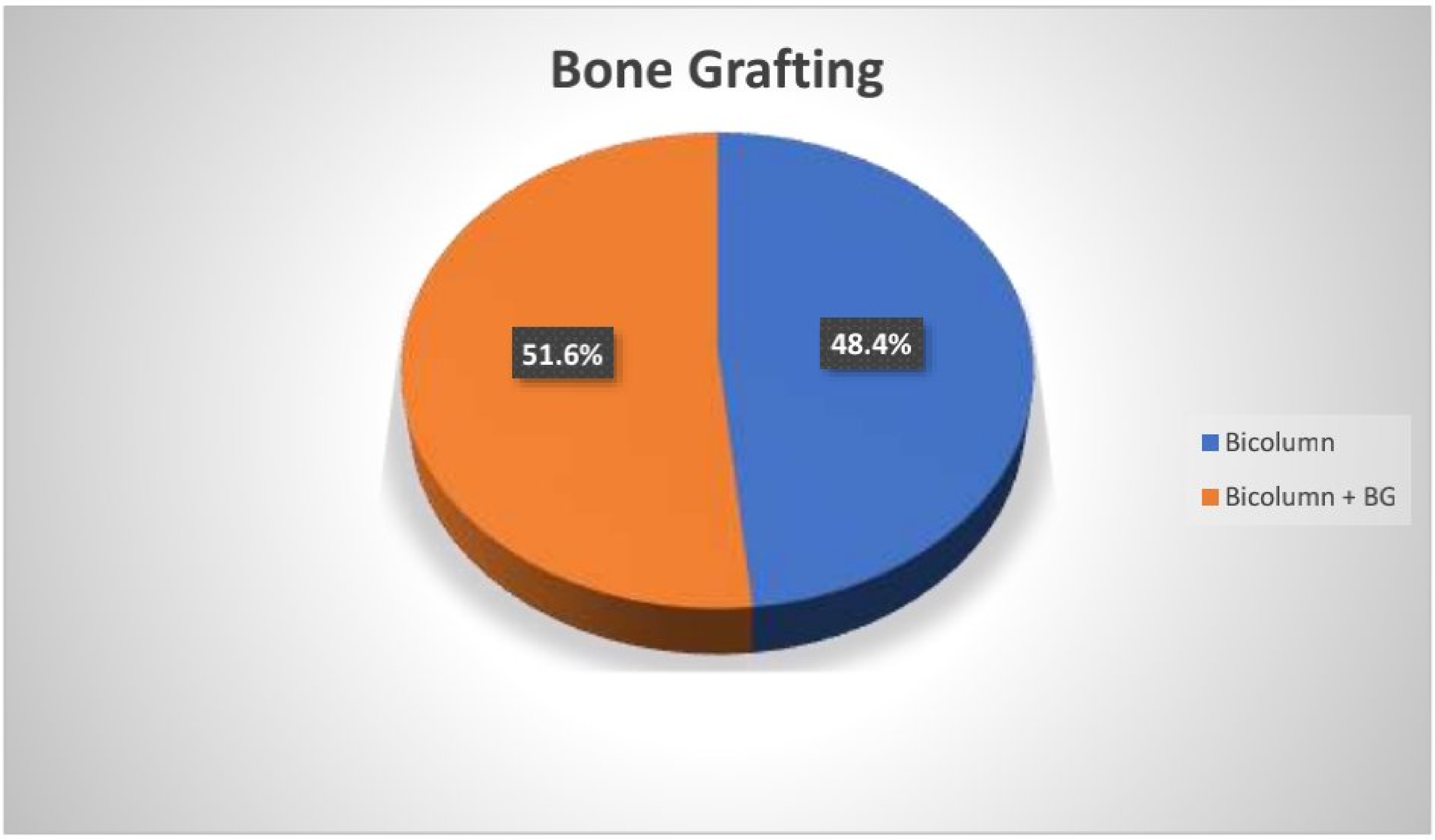


Procedure done:

In our study, Bicolumn was done in 15 patients and Bicolumn + Bone grafting was done in 16 patients

Procedure type	Number	Percentage
Bicolumn	15	48.4
Bicolumn + Bone grafting	16	51.6

Table.6. type of procedure



Time to surgery:

The average time between day of injury and surgery in our study was 11.06 days, with a range of 3 to 20 days.

Associated Injuries:

Of the 31 patients, seven had associated injuries such as

1. Shaft of femur fracture
2. Both bone leg fracture
3. Distal end of radius fracture
4. Malleolar fracture
5. Clavicle fracture

MANAGEMENT PROTOCOL

Preoperative management

The patients were given enough injectable analgesia when they arrived at the emergency room. Following the temporary stabilization of the damaged limb with a Thomas splint, patients were taken for X-ray imaging. A number of views were acquired, including lateral, right, left, and anterior perspectives. Traction was given manually when necessary. Regular CT scans were performed to assess the fracture geometry in three dimensions. Every patient was put under skeletal traction with weight application and calcaneal pin traction. It was advised to foment with ice for the first two days. We kept a careful eye on the skin surrounding the fracture. Blisters or significant soft tissue edema were not scheduled for surgery until the "wrinkle sign" appeared.

Dual Plating for Bicondylar or Metaphyseal–Diaphyseal Dissociation Tibial Plateau Fractures

Depending on the features of the medial-side injury, the fracture in certain bicondylar patterns is best treated on two sides. When the medial condyle is comminuted, greatly displaced, or a comparatively substantial portion, a medial plate is indicated. It can be necessary to use a posteromedial plate to repair the medial condyle independently if it splits coronally, resulting in a posteromedial fragment. These features of the medial-side injury have a major role in the decision between dual plates and a lateral locking plate alone. The precise fracture pattern needs to be carefully evaluated, and choosing the right option is difficult when it comes to traditional classification divisions or subcategories.

Preoperative Planning

"PREOPERATIVE PLANNING CHECKLIST

- OR table- Radiolucent table
- Position/positioning aids- Supine
- Fluoroscopy location -C-arm enters from the same side if beginning medial, then opposite side during lateral plate placement
- Ensure that the C-arm can "turn" underneath the table for lateral imaging
- Equipment -Reduction clamps, femoral distractor, external fixator
- Tourniquet -Can be prepped out (optional)
- Implants Plates—anatomic lateral and medial plates, 3.5- and 2.7-mm buttress plates, screws, bone void filler"

Positioning

The hip is nudged to neutral extremity rotation, the leg is raised on a radiolucent platform, and the patient is placed supine on a radiolucent table. If the injury is on the medial side, the leg is brought to a figure-of-four position at the beginning of the treatment.

Surgical Approach

Combined Anterior and Posteromedial Approaches

These are dual plating's mainstay methods. Anterolateral and posteromedial techniques, as previously mentioned, are commonly used in combination to treat condyle fractures. Compared to extensile anterior methods, dual techniques strip fewer soft tissue attachments but allow access to difficult bicondylar fractures. The posteromedial part of the method requires the leg to externally rotate while the patient is in a supine position. There is no problem with small skin bridges because the anterolateral and posteromedial incisions are almost 180 degrees apart. The amount of soft tissue dissection needed is reduced since direct access to each injured condyle is achieved in order to decrease the fracture and install implants.

Surgical procedure

Every patient was administered Inj. Cefoperazone + sulbactam 1.5 g IV as standard prophylaxis prior to surgery.

To help with flexion, a folded pillow was placed behind the patient's knee while they were in a supine posture. When needed, outside fixators were used. A coronal fracture of the medial condyle usually extends in a mediolateral direction because of the unique architecture of the injury. Consequently, the primary fragment is usually dislocated posteriorly, prompting the reduction process to begin with medial condyle.

About 2 cm posterior to tibial shaft's posteromedial border, first incision was made. The pes anserinus was retracted forward, and the fascia over the gastrocnemius was cut. Through a submeniscal arthrotomy, the intra-articular fracture dislocation was apparent. It is possible to identify the posteromedial wedge fragment by raising medial head of gastrocnemius away from tibia. In order to maximize view of the posterior portion of the tibia and facilitate reduction, the affected fragment was mobilized utilizing flexion and external rotation. This configuration involved shaping and screwing a 3.5-mm dynamic compression plate into the distal portion. Following knee extension, the 3.5-mm plate was used as a dorsal buttress to minimize the posteromedial fragment, which was then secured with compression screws in a postero-anterior manner.

A lazy S incision that extended about 2 cm laterally to the tibial crest and was centered above the Gerdy tubercle was used to access the lateral fracture. Evaluation of the intra-articular injury was made possible by a submeniscal arthrotomy with the knee internally rotated and flexed in a varus. The articular surface's depression was lifted and the fracture was aligned after the fracture was mobilized with a chisel and immediately diminished under ocular observation. An autograft was then used to fill the resulting subchondral or metaphyseal defect. The tibia's transverse diameter was managed with a large compression clamp and fluoroscopy. The lateral compartment was stabilized using a buttress plate or lateral compression plate. Unlike the posteroanterior screw orientation in the medial compartment, this orientation permits the screws to be positioned at a biomechanically advantageous 90-degree angle, ensuring that the screws used for medial fixation did not obstruct the reduction of the lateral side.

Fifteen patients received lateral locking plates, and sixteen patients received buttress plates. Autologous bone grafts from the iliac crest were used in sixteen patients.

Postoperative protocol

Patients were treated with well-padded dressings after surgery. Above knee slab was applied for immobilization. On the second postoperative day, the drain was taken out. Five days of antibiotic therapy were given. As soon as patients could tolerate movement, knee mobilization was started, and by ten days after surgery, all patients had 90 degrees of active knee flexion. On the twelfth postoperative day, the sutures were taken out. Patients were discharged, instructed to walk with crutches without bearing weight.

Follow up

In the outpatient department, radiography was used to evaluate patients at two weeks, six weeks, three months, and six months. Partial weight-bearing was started eight weeks after fracture union was observed. It was only permitted to support its entire weight following a solid fracture union. The average follow-up length for our patients was 22.74 weeks, with a range of 20 to 26 weeks.

Assessment

The functional outcome evaluation was done by **modified Rasmussen's scoring** system.

Subjective	Points
A. Subjective complaints	
a. Pain	
No pain	6
Occasional pain	5
Constant pain after activity	4
Significant rest pain	0
b. Walking capacity	
Normal walking capacity (in relation to age)	6
Walking outdoors for at least 1 h	4
Short walks outdoors for >15 min	2
Walking indoors only	1
Wheel-chair/bedridden	0
B. Clinical signs	
a. Extension	
Normal	6
Lack of extension (0–10°)	4
Lack of extension > 10°	2
b. Total range of motion	
≥140°	6
≥120°	5
≥90°	4
≥60°	2
≥30°	0
c. Stability	
Normal stability in extension and 20° of flexion	6
Abnormal instability 20° of flexion	5
Instability in extension < 10°	4
Instability in extension > 10°	2
Maximum	30
Excellent	27–30
Good	20–26
Fair	10–19
Poor	<10

INTRAOPERATIVE PICTURES

Fig.21: Posteromedial

Fig.22: medial T buttress plate posteromedial fragment.

Fig.23: Lateral column L buttress plate

Fig.24: Incisions closed with drain in situ

Fig.25: Intraoperative fluoroscopy

RADIOLOGICAL ASSESSMENT

For evaluation, we took into account two radiological factors.

Assessment of post operative X rays as follows:

1. Assessment of articular incongruity: By measuring degree of step off (depth of depression) in AP radiographs. Malreduction was defined as intraarticular step-off of at least 3 mm measured on scaled radiographs.
2. Assessment of alignment of the proximal tibia: We defined alignment of the proximal tibia by measuring the medial proximal tibial angle (MPTA) in the coronal plane and posterior proximal tibial angle (PPTA) in the sagittal plane These angles were measured according to Freedman and Johnson. **MPTA** is the medial angle between the tangential line and Anatomical axis of the tibia in AP radiographs. (normal range: 82°-92°). **PPTA** is the angle between the tangential line of medial plateau and the perpendicular line of the anterior tibial cortex on lateral radiographs. (normal range:4°-14°).

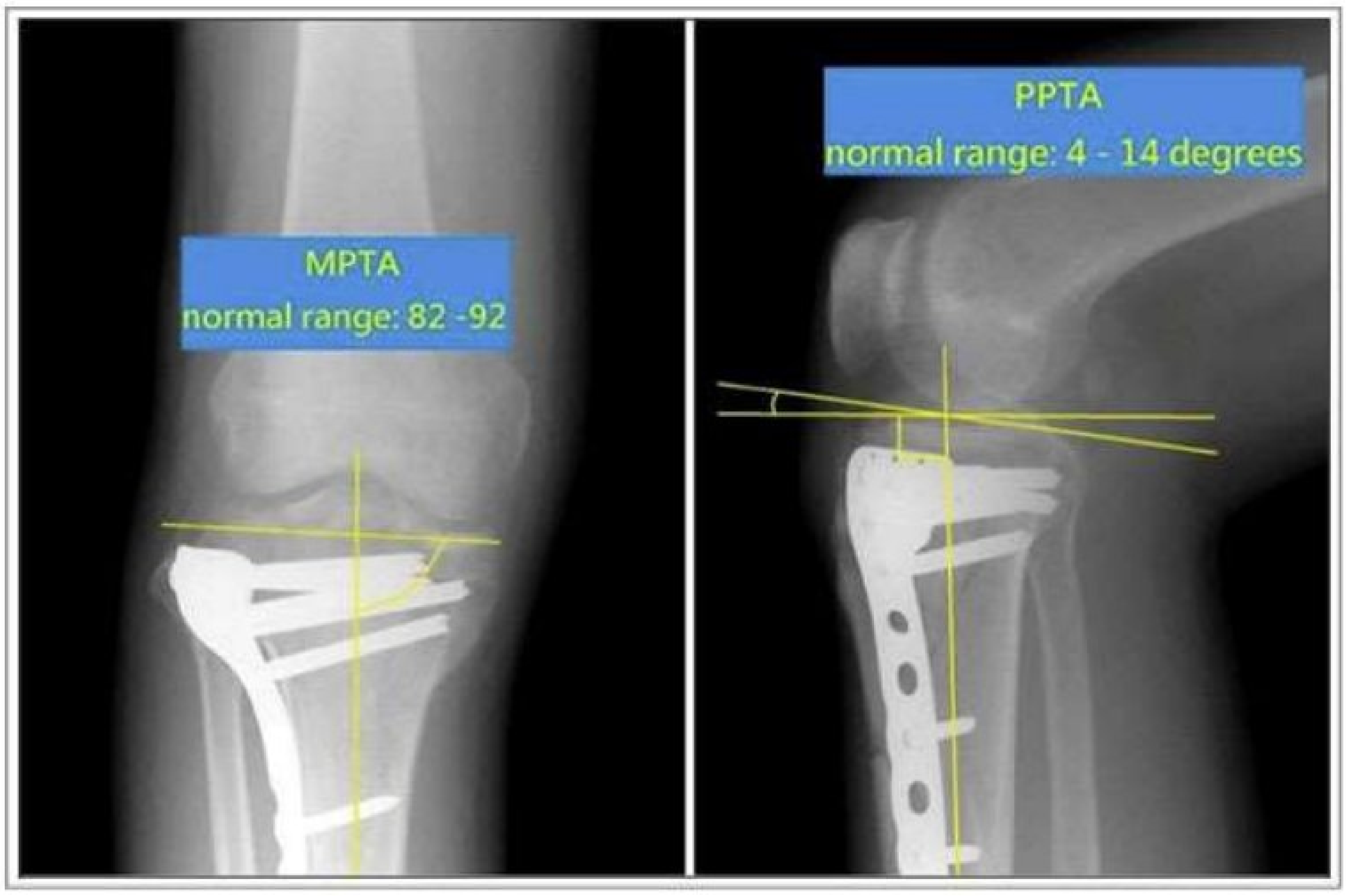


Figure.26: Radiographic measurement of MPTA and PPTA and normal reference range

OBSERVATION AND RESULTS

- In our analysis, the incidence was higher among men than women (a ratio of 4.16:1).
- In all instances, except one involving a train traffic accident, road traffic accidents were the cause, which explains high-energy nature of injury.
- The incidence observed is 45.2% on right and 54.8% on left side.
- Frequency in group aged over 40 years was 83.9% out of 31 cases.
- Every patient who participated in our study experienced significant energy injuries from automobile accidents. None had suffered minor trauma-related injuries. Low-energy injuries are likely to cause complicated tibial plateau fractures in elderly people with osteoporotic bones. But in our series, we haven't encountered any such cases.
- Ten patients (32.3%) had Schatzker type V fractures out of 31 cases, whereas all other patients had Schatzker type VI fractures.
- All 24 patients had solitary tibial plateau fractures, while seven patients had associated injuries.
- All patients received routine surgery, which included anterolateral and posteromedial incisions.
- Fifteen patients received lateral locking compression plates, whereas sixteen patients received lateral buttress plates.
- Following articular surface elevation, 16 patients (51.6%) underwent bone transplantation to close the metaphyseal defect.
- The average time required for union was 13.7 weeks, with a range of 11 to 16 weeks.
- The average medial proximal tibial angle (MPTA) was 86.4 degrees, with a range of 83 to 88 degrees.

- An articular step-off of more than 2 mm was present in four of the patients (range: 3–5 mm).
- Eight cases of sporadic pain, one case of chronic pain, five cases of superficial infection, and six cases of knee stiffness were reported.

COMPLICATIONS

1. Five of the individuals in our group had knee stiffness. Two patients' knee range of motion (ROM) was between 10 and 80 degrees of flexion, two patients' ROM was between 0 and 90 degrees, and one patient's ROM was between 10 and 90 degrees. The main cause of the stiffness was found to be poor adherence to physical treatment.
2. During the postoperative period, five patients developed superficial wound infections. All infections were effectively resolved through prompt debridement, wound dressing, and appropriate antibiotic treatment, leading to excellent functional outcomes for the patients.
3. Occasional pain was reported by eight out of thirty-one patients. This pain did not hinder the patients' activities, and eight patients achieved a good functional score.
4. Chronic Knee Pain was reported by one out of 31 patients, who had a fair functional score.

RESULT ANALYSIS

The modified Rasmussen's scale, a clinical grading system that the surgeon filled out, was used for functional analysis.

<u>According to lateral column implant</u>

Fifteen patients received lateral locking compression plates, whereas sixteen patients received lateral buttress plates. Every patient also had medial plating, medial buttress plates in all cases.

Results in LCP group:

Based on the modified Rasmussen score, seven of 15 patients received an exceptional score, seven received a good score while one had fair score. 25.47 was the mean score.

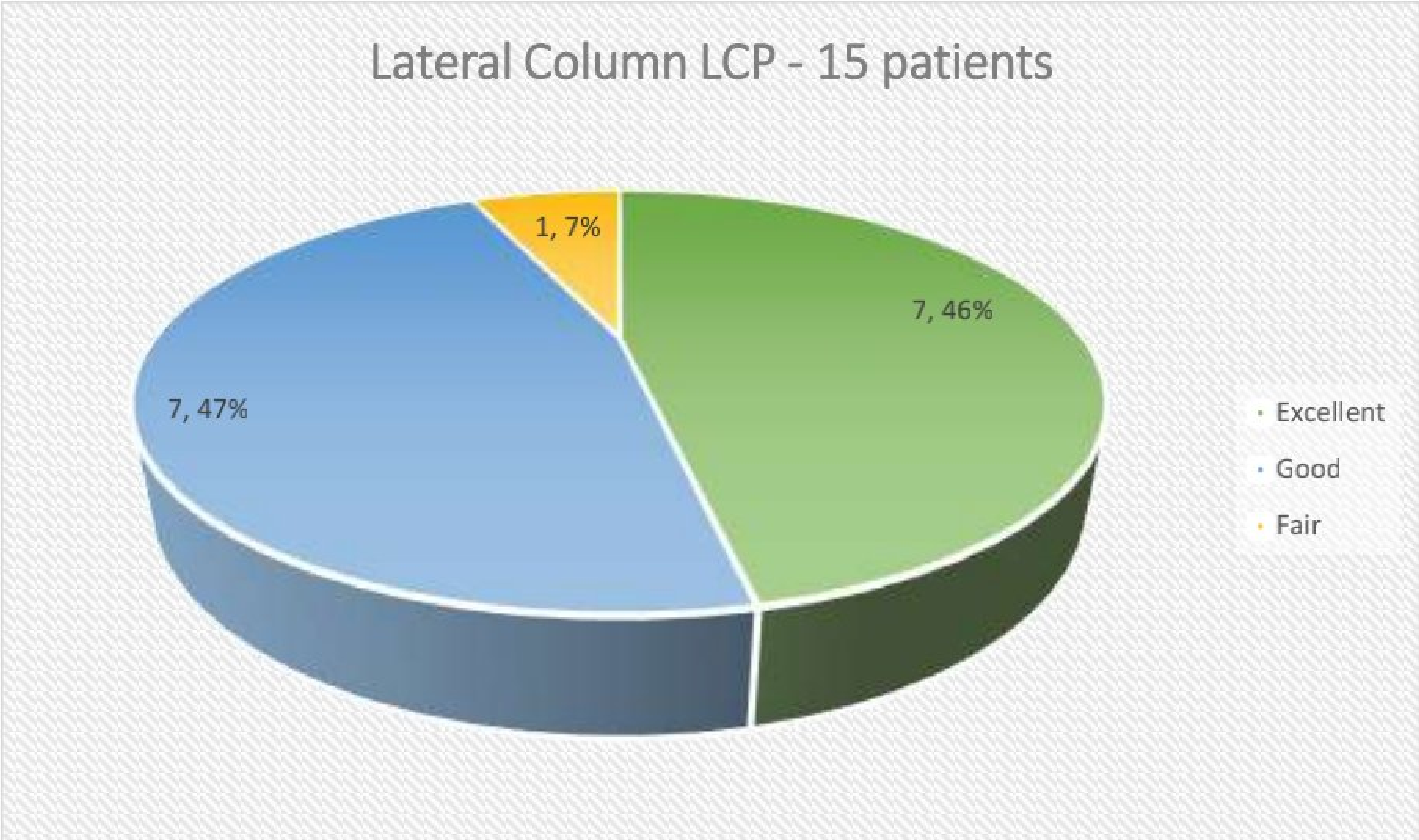
Results in Buttress plate group:

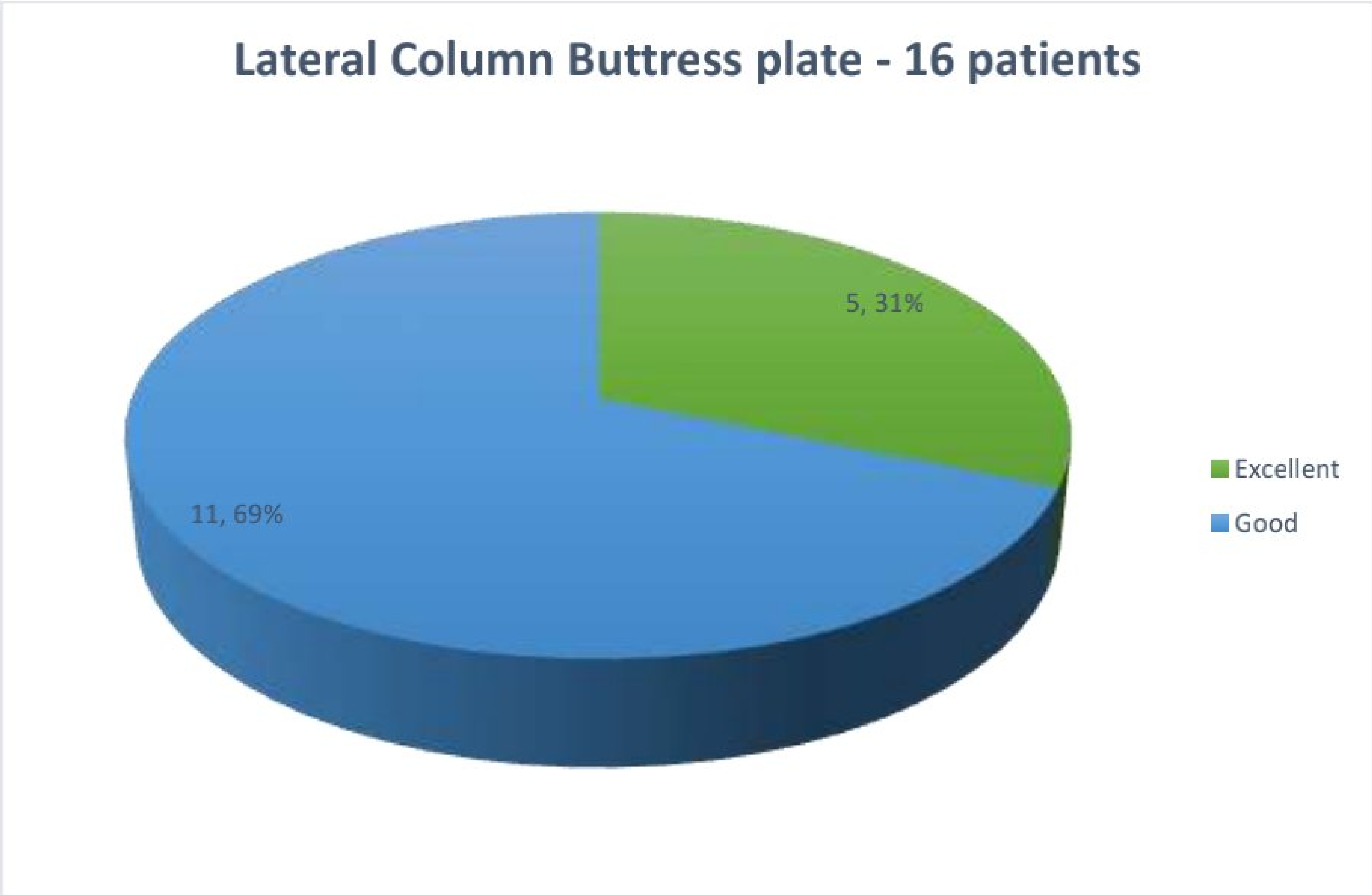
Based on the modified Rasmussen score, five of 16 patients received an exceptional score while 11 had good results. A mean score of 25.50 was obtained.

SI. No.	Lateral column implant	No. of Patients	Average Modified Rasmussens score	Grading			
				Excellent	Good	Fair	Poor
1	LCP	15	25.47	7	7	1	-
2	Buttress plate	16	25.5	5	11	-	-

Table.7: Results based on lateral column implants

Pearson Chi-Square value and p value for lateral column implants and function outcome (modified Rasmussens score) was found to be 2.192 and 0.334 respectively, which has statistically no significant association.



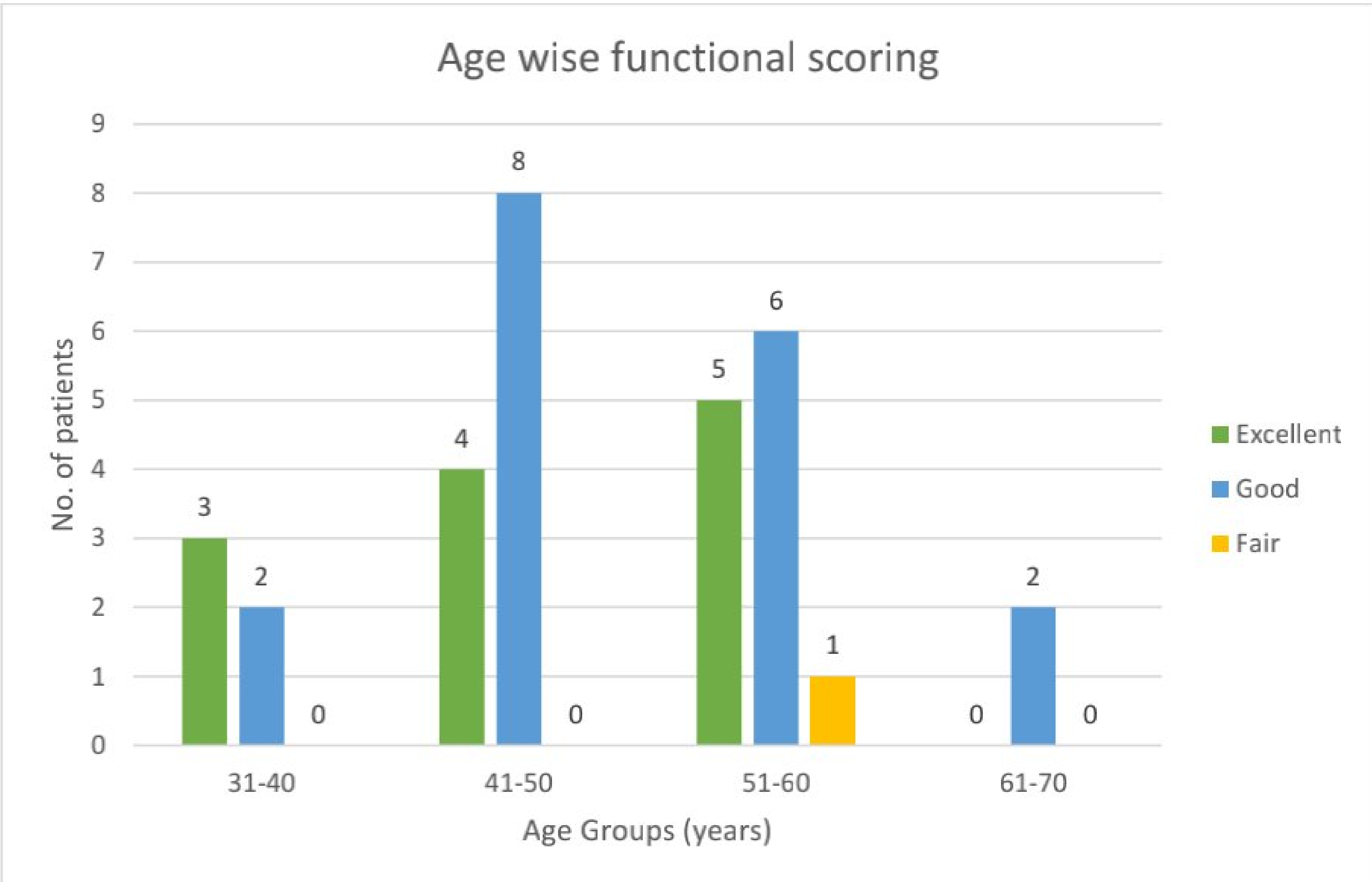


According to age group distribution

Twelve of the thirty-one individuals in our study had an exceptional functional score, eighteen had a good functional score, and one had a fair functional score according to our study.

SI. No.	Age group	Number of patients	Average Modified Rasmussens score	Grading			
				Excellent	Good	Fair	Poor
1	31-40	5	26.60	3	2	0	-
2	41-50	12	25.58	4	8	0	-
3	51-60	12	25.25	5	6	1	-
4	61-70	2	23.50	0	2	0	-

Table.8: Results based on age distribution



Radiological analysis

After surgery, varus/valgus malunion was evaluated using the medial proximal tibial angle (MPTA) and posterior proximal tibial angle (PPTA). The average MPTA in our series was 87.51 degrees, with a range of 85.21 to 90.11 degrees. The average PPTA in our series was 8.1 degrees, with a range of 6.66 to 10.11 degrees. Thus, we discovered that following bicolumn fixation, the proximal tibial joint maintains its natural position.

Less than or equal to 2 mm was maintained as the acceptable criterion for arterial stepoff measurement. In our series, 27 instances had an acceptable outcome of less than or equal to 2 mm stepoff, while 4 cases had articular stepoff greater than 2 mm (range 3 to 5 mm).

DISCUSSION

For orthopaedic surgeons, tibial plateau fractures pose a serious difficulty. Complex proximal tibial fractures reported by healthcare practitioners are becoming more common as a result of an increase in traffic accidents and the high-energy injuries they cause. Furthermore, even low-energy events, such as falls at home, can cause complicated tibial plateau fractures in older persons with osteoporotic bones. Finding the best treatment is complicated, and achieving a painless mobile joint requires extensive technical knowledge and surgical skills.[37]

Due mostly to subpar surgical methods employed in the past, bicolumn fixation for complicated tibial plateau fractures was initially viewed with suspicion. The orthopaedic community became cautious about bicolumn fixation because of high likelihood of wound complications and infections associated with the practice of using a single midline incision combined with forceful soft tissue manipulation. With the introduction of locking plates, the focus shifted to isolated lateral plating with locking compression plates. Screws fed through the locking plate stabilized the medial fragment.

Numerous publications emphasized this technique's exceptional functional results, but later on, many patients' varus collapse raised concerns. According to analyses, this issue was exacerbated by the frequent occurrence of posteromedial fracture fragment in some cases, as well as by insufficient stability when a lateral plate was the only stabilizing device utilized. The present twin incision bicolumn plating technique for complicated proximal tibial fractures is the result of this insight. A major challenge for orthopaedic surgeons is tibial plateau fractures. Complex proximal tibial fractures reported by healthcare practitioners are becoming more common as a result of an increase in traffic accidents and the high-energy injuries they cause.

Furthermore, even low-energy events, such as falls at home, can cause complicated tibial plateau fractures in older persons with osteoporotic bones. It can be challenging to determine the optimum course of action, and obtaining a movable joint without discomfort necessitates a high level of technical expertise and surgical proficiency.

In our research, the male-to-female ratio was 4.16:1, with males being more prevalent. This could be attributed to males leading a more active lifestyle and having a greater likelihood of being involved in road traffic accidents. This finding aligns with the study by Shrestha D K et al. [9], which included 32 patients (twenty-four males and eight females). Road traffic incidents were identified as the cause of injury for 30 patients, while one case was attributed to a train accident. The side-specific distribution of incidences was almost balanced.

Locking plates or buttress plates were used for lateral plating. Seven patients had good results, seven had excellent results, and one was categorized as fair in the locking compression plate group. Eleven patients obtained good functional scores, while five patients in the buttress plate group reported excellent functional scores. Multiple reports indicate that locking plates yield better results in proximal tibial fractures. Significant advancement has occurred in design of locking plates and pre-contoured plates. However, our data shows comparable outcome for the buttress plate and locking plate groups. This could be because early mobilization leads to better functional outcomes and medial buttressing increases stability. There aren't many studies in the literature that contrast buttress plates and lateral column locking plates in bicolumn fixation; this could be a topic for future investigation. A longer follow-up could possibly change the results because our study is only short-term.

16 out of 31 patients (51.6%) underwent bone grafting, mostly to correct metaphysis abnormalities following the elevation of depressed lateral articular surface fragments. With a range of 11 to 16 weeks, the average period before union was 13.74 weeks. Given how quickly metaphyseal fractures usually mend without grafting, bone transplantation did not seem to speed up the healing process.

Physiotherapy was used to treat six individuals who had tight knees and no more than 90 degrees of movement. Five patients had superficial wound infections, which were treated with debridement, frequent dressing changes, and the right medications. Each of the three impacted instances recovered well.

Analgesics and local heat therapy were used conservatively to treat the eight patients who occasionally experienced pain while doing activities like ascending stairs. Out of the 31 patients, only one had a fair outcome, 18 had good functional outcomes, and 12 had exceptional functional outcomes.

The patient with a fair grade (patient 4) had chronic knee pain as a result of improperly placing the medial plate, which did not support the posteromedial fracture fragment; however, she declined to undergo another procedure. Three patients in our study had ipsilateral clavicle fractures, one had an ipsilateral distal end of radius fracture, one had contralateral lateral malleolus fractures, one had a contralateral distal radius fracture, one patient had a contralateral both bone leg fracture with a contralateral shaft of femur. Totally only seven patients had associated injuries.

In every instance in our investigation, radiographic evaluations verified the maintenance of normal proximal tibial knee joint alignment. The average medial proximal tibial angle in our series is 87.51 degrees, with a range of 85.21 to 90.11 degrees. The normative value is 87 ± 5 degrees. This further supports the enhanced stability afforded by bicolumn plating in bicondylar tibial plateau fractures, thereby preventing late varus collapse, often seen with isolated lateral plating. This represents an improvement compared to Shrestha D K et al. [9], who reported a case of varus collapse (10 degrees) after a fall from bed that did not require surgical intervention.

In our study, 27 out of 31 patients had accurate articular reconstruction (articular step-off ≤ 2 mm), indicating an 81% accuracy rate. This result is similar to that of Eggli et al. [1], who found that 85% of the 14 patients in their group had correct articular reconstruction. The ratio of men to women in our study was 4.16:1, with men predominating. This could be attributed to males leading a more active lifestyle and having a greater likelihood of being involved in road traffic accidents. This finding aligns with the study by Shrestha D K et al., which included 32 patients (24 males and 8 females). Road traffic incidents were identified as the cause of injury for 30 patients, while one case was attributed to a train accident. The side-specific distribution of incidences was almost balanced.

CONCLUSION

Our research leads us to the conclusion that

- For bicondylar tibial plateau fractures, bicolumn plating with dual incision has a very low rate of wound complications and an excellent to good functional outcome.
- This approach allows for early joint mobilization, which improves the eventual range of motion of the knee.
- Posteromedial plating protects patients with posteromedial fracture patterns from late varus collapse.
- Patients in good soft tissue condition benefit most from anatomical joint reduction and internal fixation; in closed injuries with healthy soft tissue cover, this surgery shouldn't be postponed because of potential wound problems.
- For bicondylar fractures, the functional result after medial plating is not much changed by the use of a locking plate or a buttress plate in the lateral column. It will take more research to validate this conclusion.

CASE ILLUSTRATIONS

Case 1

Name	: Shrishail
Age/Sex	: 57/M
Mode of Injury	: RTA
Side injured	: Right
Schatzker type	: Type VI
Time Interval between injury and surgery	: 3 days
Procedure	: ORIF with lateral and medial buttress plate
Post-op period	: Superficial infection, treated with antibiotics
Knee mobilization	: 2 days
Partial weight bearing	:12 weeks
Full weight bearing	:18 weeks
At follow-up	: 26 weeks
Modified Rasmussens Score	: 26
MPTA	: 86.81 degrees
PPTA	: 7.55 degrees
Articular step off	: < 2 mm

Preoperative imaging

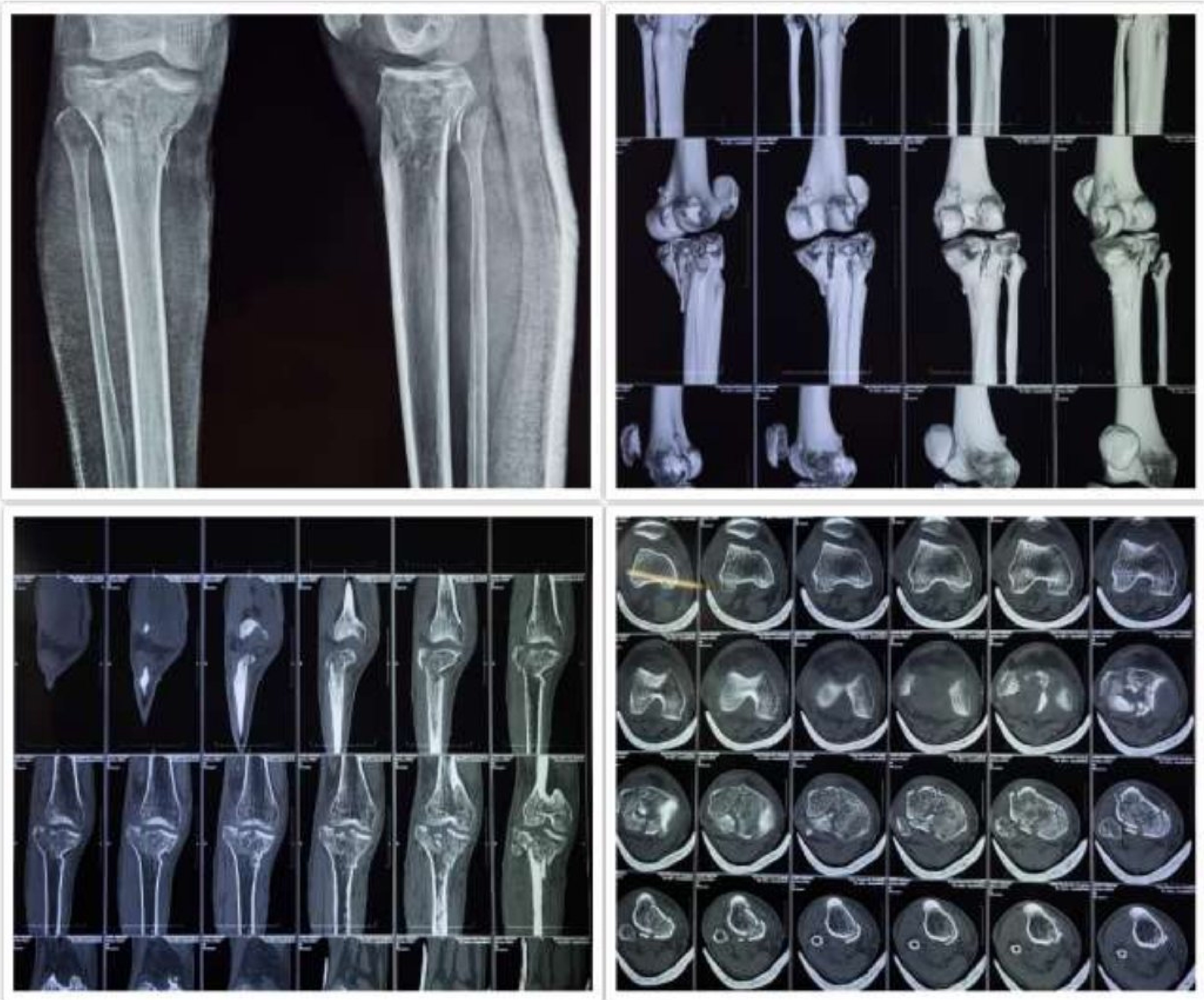
Immediate postoperative

26 weeks follow up

Case 2

Name	: Suresh
Age/Sex	: 35/M
Mode of Injury	: RTA
Side injured	: Left
Schatzker type	: Type V
Time Interval between injury and surgery	: 3 days
Procedure	: ORIF with lateral LCP and medial buttress plate
Post-op period	: occasional pain
Knee mobilization	: 3 days
Partial weight bearing	:14 weeks
Full weight bearing	: 20 weeks
At follow-up	: 22 weeks
Modified Rasmussens Score	: 86
MPTA	: 87.33 degrees
PPTA	: 7.22
Articular stepoff	: < 2 mm

Preoperative imaging



Intraoperative c arm pictures

Immediate postoperative

22 weeks follow up

Case 3

Name	: Kallapa
Age/Sex	: 55/M
Mode of Injury	: RTA
Side injured	: Right
Schatzker type	: Type VI
Time Interval between injury and surgery	: 20 days
Procedure	: ORIF with lateral LCP and medial buttress plate
Post-op period	: Uneventful
Knee mobilization	: 2 days
Partial weight bearing	:12 weeks
Full weight bearing	:18 weeks
At follow-up	: 24 weeks
Modified rasmussens criteria	: 27
MPTA	: 87.31 degrees
PPTA	: 8.34 degrees
Articular stepoff	: < 2 mm

Preoperative imaging

Immediate postoperative 25 weeks follow up

Case 4

Name	: Bheemana
Age/Sex	: 52/M
Mode of Injury	: RTA
Side injured	: Right
Schatzker type	: Type V
Time Interval between injury and surgery	: 5 days
Procedure	: ORIF with lateral LCP plate and medial buttress plate
Post-op period	:Superficial infection treated with antibiotics
Knee mobilization	: 2 days
Partial weight bearing	: 13 weeks
Full weight bearing	: 17 weeks
At follow-up	: 21 weeks
Modified Rasmussens score	: 25
MPTA	: 86.66 degrees
PPTA	: 7.83 degrees
Articular stepoff	: < 2 mm

Preoperative imaging

Immediate postoperative

21 weeks follow up

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ANNEXURE –I

SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA - 586103

PROFORMA

CASE NO. :

NAME :

AGE/SEX :

I P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized lymphadenopathy:	present/absent
Built:	poor/moderate/well
Nourishment:	poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Right/ Left leg

Gait:

Attitude:

Inspection:

a) Attitude/ deformity

b) Abnormal swelling

- Site
- Size
- Shape

- Extent

c) Skin

Palpation:

a) Local tenderness

b) Bony irregularity

c) Abnormal movement

d) Crepitus

e) Swelling

Movements:	Right	Left
KNEE JOINT		
Flexion		
Extension		
Abduction		
Adduction		
Internal rotation		
External rotation		

ANNEXURE –II

B.L.D.E. (DEEMED TO BE UNIVERSITY) SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTER, VIJAYAPURA-586103

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/ RESEARCH

I, the undersigned, _______________, S/O D/O W/O ________________, aged ____years, ordinarily resident of ____________ do hereby state/declare that **Dr. AJAYGURU SENTHURVELAN** of Shri. B. M. Patil Medical College Hospital and Research Centre has examined me thoroughly on ______________ at ______________ (place) and it has been explained to me in my own language that I am suffering from ________________ disease (condition) and this disease/condition mimic following diseases. Further **Dr. AJAYGURU SENTHURVELAN** informed me that he/she is conducting dissertation/research titled "**TO STUDY THE FUNCTIONAL OUTCOMES OF BICOLUMNAR PLATING IN SCHATZKER TYPE-V AND TYPE-VI FRACTURES OF PROXIMAL TIBIA**" under the guidance of Dr Ashok Nayak. requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

The Doctor has also informed me that during the conduct of this procedure like adverse results may be encountered. Among the above complications, most of them are treatable but are not anticipated; hence there is a chance of aggravation of my condition. In rare circumstances, it may prove fatal despite the anticipated diagnosis and best treatment made available. Further

Doctor has informed me that my participation in this study help in the evaluation of the results of the study, which is a useful reference to the treatment of other similar cases soon, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than my legal hirer or me except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on the information given by me, I can ask for any clarification during the course of treatment/study related to diagnosis, the procedure of treatment, result of treatment, or prognosis. I have been instructed that I can withdraw from my participation in this study at any time if I want, or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt ____________________________ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of the patient:

Signature of Doctor:

Witness: 1.

2.

Date:

Place:

ANNEXURE -III

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

Azadi Ka Amrit Mahotsav

BLDE (DU)/IEC/ 972/2022-23 10/4/2023

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Saturday, 18th March, 2023 at 11.30 a.m. in the CAL Laboratory, Dept. of Pharmacology,** scrutinizes the Synopsis/ Research Projects of Post Graduate Student / Under Graduate Student /Faculty members of this University /Ph.D. Student College from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "TO STUDY THE FUNCTIONAL OUTCOMES OF *BICOLUMNAR PLATING IN* SCHATZKER TYPE-V AND TYPE-VI FRACTURES OF *PROXIMAL TIBIA.*"

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR.AJAYGURU SENTHURVELAN

NAME OF THE GUIDE: DR. ASHOK NAYAK, PROFESSOR,
DEPT. OF ORTHOPAEDICS

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA
Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA
MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

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MASTER CHART

Sl.No	Name	Age	Sex	IP no	Mode of injury	Side injured	Associated injuries	Time delay before surgery	Schatzker type	Procedure	Lateral column implant	MPTA	PPTA	Mod. Rasmussens score post operative	Time to union (weeks)	Follow up (weeks)	Complications
1	Hanamanth	58	M	55390	RTA	Left		3 days	VI	Bicolumn	Buttress plate	86.55	8.88	25	15	20	Knee stiffness
2	Shrishail	57	M	56415	RTA	Right		6 days	VI	Bicolumn	Buttress plate	86.81	7.55	26	12	26	Superficial infection
3	Suresh	35	M	65815	RTA	Left		7 days	V	Bicolumn	LCP	87.22	7.33	26	14	22	Occasional pain
4	Rekha	51	F	57392	TTA	Left	# SOF right, BB leg # rt	10 days	V	Bicolumn + BG	LCP	85.21	6.66	19	16	26	Chronic Knee Pain
5	Sharanappa	55	M	9573	RTA	Left	# Clavicle lt	12 days	VI	Bicolumn + BG	LCP	87.33	8.26	27	13	24	
6	Goudappa	63	M	15100	RTA	Right		20 days	VI	Bicolumn + BG	Buttress plate	88.22	7.99	26	13	21	Occasional pain
7	Santhosh	60	M	27539	RTA	Right		17 days	VI	Bicolumn	Buttress plate	86.66	7.11	22	14	20	Knee stiffness
8	Mohammad	45	M	56943	RTA	Left		12 days	V	Bicolumn	Buttress plate	86.99	7.63	24	16	22	Superficial infection
9	Shankarappa	42	M	47812	RTA	Right		10 days	VI	Bicolumn	Buttress plate	89.69	9.11	27	12	24	
10	Laxmibai	50	F	50178	RTA	Left	# Distal radius rt	16 days	V	Bicolumn + BG	LCP	86.67	7.43	25	14	25	Occasional pain
11	Bourawwa	56	F	30145	RTA	Right		10 days	VI	Bicolumn	LCP	86.22	9.78	27	13	21	
12	Chandrashekar	47	M	88396	RTA	Right		5 days	V	Bicolumn + BG	Buttress plate	89.11	9.55	28	12	22	
13	Rihana	67	F	61853	RTA	Right	# lat. malleolus lt	19 days	VI	Bicolumn	LCP	85.71	7.11	21	14	23	Occasional pain
14	Hamu	46	M	84738	RTA	Right		20 days	V	Bicolumn	LCP	87.77	8.11	27	11	25	
15	Yamnappa	40	M	93296	RTA	Left		10 days	VI	Bicolumn + BG	Buttress plate	88.88	8.53	27	13	20	
16	Rohit	32	M	107958	RTA	Left		8 days	VI	Bicolumn + BG	LCP	90.11	9.99	29	12	21	
17	Shivakumar	45	M	107668	RTA	Left		6 days	VI	Bicolumn + BG	LCP	89.99	10.11	29	14	24	
18	Kallappa	55	M	109229	RTA	Right		9 days	VI	Bicolumn + BG	LCP	87.31	8.34	27	14	24	
19	Bheemanna	52	M	30554	RTA	Right		11 days	V	Bicolumn + BG	LCP	86.66	7.83	25	16	21	Superficial infection
20	Shivu	58	M	42890	RTA	Left		9 days	VI	Bicolumn + BG	Buttress plate	89.67	8.22	28	15	20	
21	Bheemanagowda	45	M	67992	RTA	Left		10 days	VI	Bicolumn + BG	Buttress plate	88.37	7.81	26	14	23	Occasional pain
22	Iranna	59	M	55390	RTA	Left		3 days	VI	Bicolumn	Buttress plate	87.99	7.33	26	15	20	Knee stiffness
23	Somanath	46	M	56415	RTA	Right		6 days	V	Bicolumn	Buttress plate	86.34	7.21	25	12	26	Superficial infection
24	Iranna	49	M	65815	RTA	Left		7 days	VI	Bicolumn	LCP	87.32	8.01	26	14	22	Occasional pain
25	Gangamma	50	F	57392	RTA	Left	Left clavicle fracture	10 days	VI	Bicolumn + BG	LCP	86.21	7.02	22	16	25	Knee stiffness
26	Abishek	40	M	9573	RTA	Left	# Clavicle lt	12 days	VI	Bicolumn + BG	LCP	89.99	9.22	28	13	24	
27	Raju	45	M	15100	RTA	Right		20 days	V	Bicolumn + BG	Buttress plate	85.51	7.99	23	13	21	Occasional pain
28	Laxman	34	M	27539	RTA	Right		17 days	VI	Bicolumn	Buttress plate	85.37	7.36	23	14	20	Knee stiffness
29	Venkatesh	49	M	56943	RTA	Left		12 days	VI	Bicolumn	Buttress plate	87.64	7.98	25	16	26	Superficial infection
30	Salim	60	M	47812	RTA	Right		10 days	V	Bicolumn	Buttress plate	88.31	9.44	27	12	24	
31	Fareedha	57	F	50178	RTA	Left	# Distal radius lt	16 days	VI	Bicolumn + BG	LCP	86.98	7.22	24	14	23	Occasional pain

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