Swanirman Sunirmit Publications of Research Volume 4, Issue 2-Jun 2024 | [2024-25]
ISSN [Online]: 2583-2654

Comprehensive Rehabilitation of a Severe Tibia Fracture Using ORIF and Intensive Physiotherapy: A Detailed Case Report

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I. INTRODUCTION

Tibial plateau fractures are peri-articular knee fractures of the proximal tibia. The presentation is dependent on the mechanism of injury. The tibial plateau is the bony platform of the distal half of the knee joint, and is made up of a medial and lateral condyle separated by the intercondylar eminence. The presentation of tibial plateau fractures can vary greatly as a result of the bimodal mechanism of injury and patient characteristics. The patient should be assessed for life- and limb-threatening injuries in accordance with British Orthopaedic Association Standards of Trauma guidelines. Imaging is undertaken to understand configuration of the fracture, which is classified by the Schatzker classification. Definitive management of the fracture depends on the severity, ranging from conservative to surgical management. Surgery is required for more severe tibial plateau fractures to restore articular congruity, mechanical alignment, ligamentous stability and to permit early mobilisation. (Rudran et al. 2020)

Tibial plateau fractures account for 1% of all fractures, and typically occur either as a fragility fracture or secondary to a high-energy impact. These latter injuries are associated with extensive soft tissue injury, life- and limb-threatening complications and long-term sequelae. (Rudran et al. 2020)

Fractures involving the tibial head can result from multidirectional forces (medial, lateral, or axial). Forces directed medially (valgus force moment) are often classic “bumper fractures” (motor vehicle vs. pedestrian accidents). More complex mechanisms involve combinations of two, axial as well as varus or valgus, forces. In most cases, both shearing and compressive forces are applied to the underlying tibial plateau via the femoral condyle (either medially or laterally). (Gahr, P. Et al. 2023)

II. CLASSIFICATION

The classification of proximal tibial fractures has changed over the years. Schatzker et al. (1979) proposed a morphological system based on anteroposterior radiographs. distinguishing six types of fractures ranging from simple split fractures to complex fractures (Figure 1)

Comminuted fractures of the tibia, particularly those classified as Stage 6 according to the AO/OTA classification system, are rare and present significant challenges in terms of management and rehabilitation.

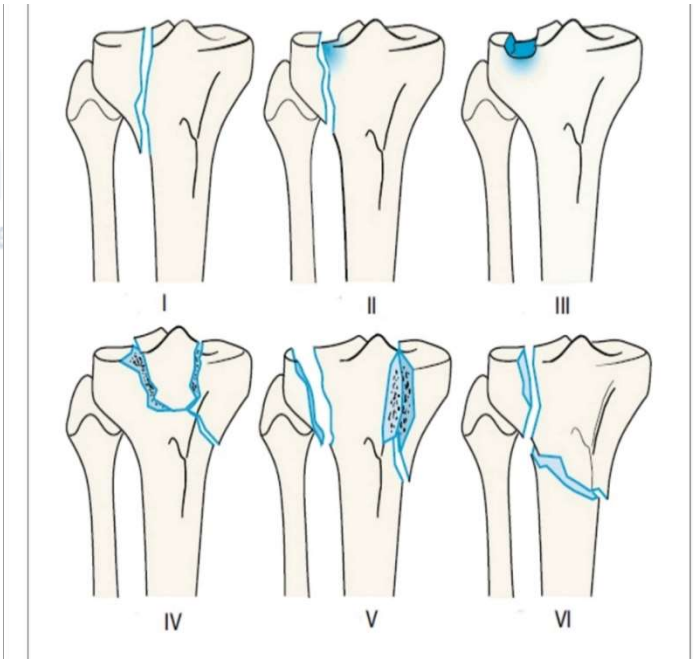


Fig 1: Schatzker’s classification of proximal tibia fractures. (I) Wedge-shaped pure cleavage fracture of the lateral tibial plateau. (II) Splitting and depression of the lateral tibial plateau. (III) Pure depression of the lateral tibial plateau; Schatzker IIIa: with lateral depression; Schatzker IIIb: with central depression. (IV) Medial tibial plateau fracture with a split or depressed component. (V) Wedge fracture of both lateral and medial tibial

ISSN [Online]: 2583-2654

plateau. (VI) Transverse tibial metadiaphyseal fracture, along with any type of tibial plateau fracture (metaphyseal-diaphyseal discontinuity). (From Springer Science +Business Media. Müller-Mai CM, Ekkernkamp A. Frakturen. Klassifikation und Behandlungsoptionen. Berlin Heidelberg New York: Springer-Verlag (2010). 453 p.)

III. DEMOGRAPHIC PROFILE

This case report presents the management and rehabilitation of a 24 year old male patient with a Stage 6 comminuted tibia fracture following a high-velocity motor vehicle accident.

IV. CHIEF COMPLAINT

The patient presented with severe pain and inability to bear weight on the right lower limb following the traumatic incident.

V. PRESENT HISTORY

The patient was involved in a high-velocity motor vehicle accident, resulting in direct trauma to the right lower limb and a comminuted fracture of the tibia.

VI. MECHANISM OF INJURY

The incident occurred when the patient accidentally collided with another car, resulting in a high-intensity lateral blow. This impact caused the patient to fall from the vehicle. During the fall, the patient's right leg became entrapped in the scooter, subjecting the tibia to a significant torsional force. Consequently, the patient sustained a severe comminuted fracture of the right tibia.

VII. INVESTIGATION

Diagnostic investigations included X-rays and computed tomography (CT) scans to assess the extent and severity of the fracture.

Conventional radiology (x-ray) of the knee joint and proximal lower leg in anterior-posterior and lateral planes, usually allows immediate evaluation of the underlying fracture type. Nevertheless, computed tomography provides the most detailed illustration of the fracture in all dimensions and therefore should be used in more complex fractures.

Fig 2 : X-Ray - AP and lateral view showing Tibia Plateau comminuted fracture

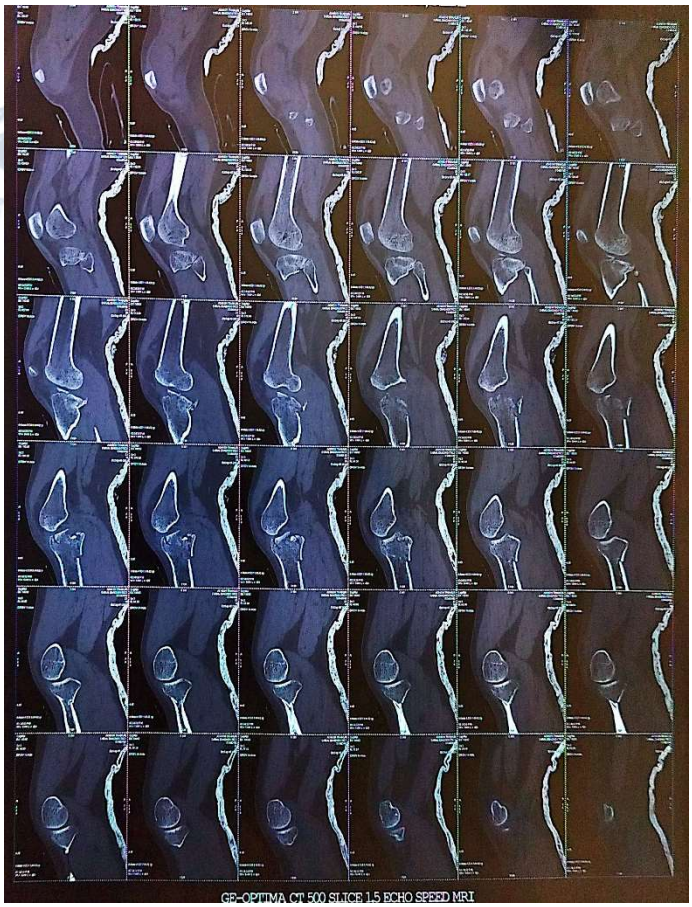
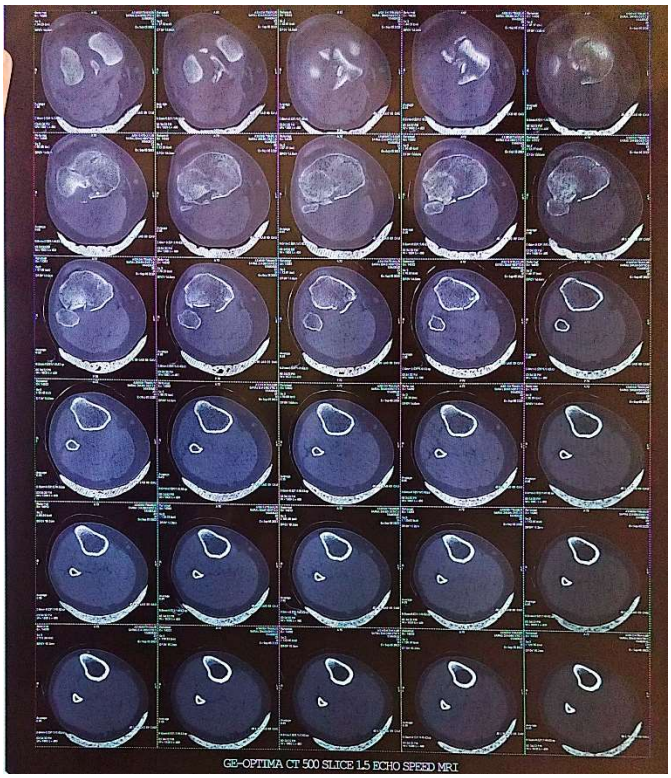


Fig 3: A- Sagittal view CT scan films showing Tibia Plateau comminuted fracture

ISSN [Online]: 2583-2654



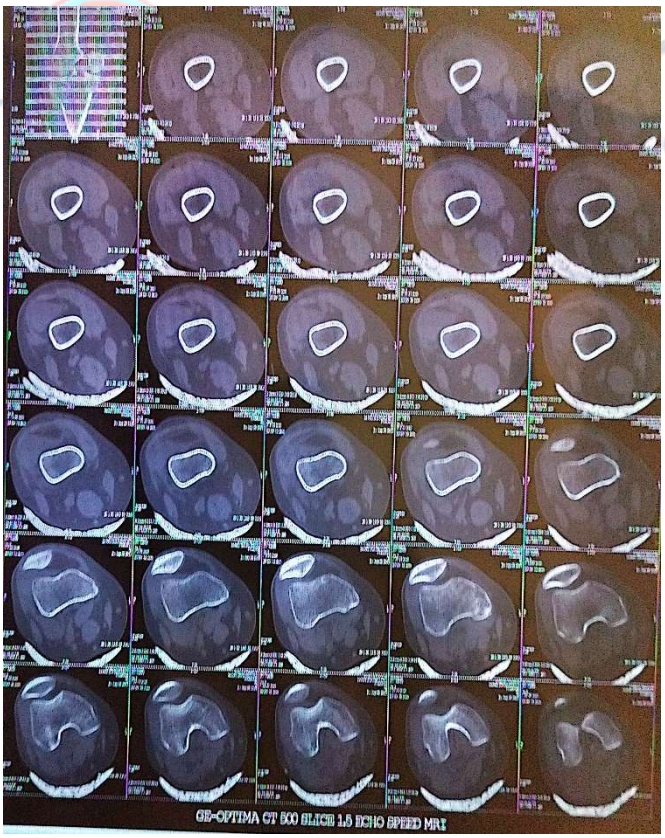


Fig 3: B & C - Axial view CT scan films showing Tibia Plateau comminuted fracture

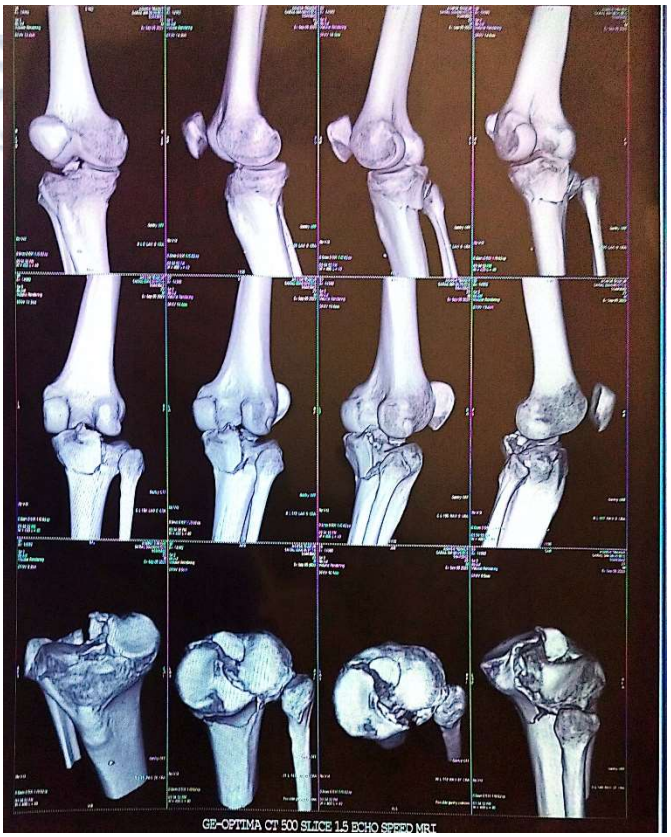


Fig 3: D- Coronal view, E - 3D CT scan : CT scan films showing Tibia Plateau comminuted fracture

ISSN [Online]: 2583-2654

VIII. SURGERY

Raj, M. Et. Al. (2021) explained High-energy bicondylar tibial plateau fractures (Schatzker type V and VI) are unstable intraarticular fractures that have consistently posed a challenge for surgeons. The goals of surgical treatment for these fractures include achieving anatomic reduction of the fracture fragments, maintaining articular congruity, preserving the surrounding soft tissues, and preventing complications, especially infection and malalignment. Schatzker type V and VI fractures necessitate the reduction and stabilization of both the medial and lateral condyles of the tibia. The dual plate technique, which secures both medial and lateral columns, provides mechanical stability through sufficient fixation. Studies have shown that dual plate fixation offers superior biomechanical strength and a lower subsidence rate compared to a single lateral locking plate.

In this case emergency surgical intervention was performed, involving open reduction and internal fixation (ORIF) of the comminuted tibia fracture using 2 titanium plates and 14 screws to stabilize the bone fragments and restore anatomical alignment.

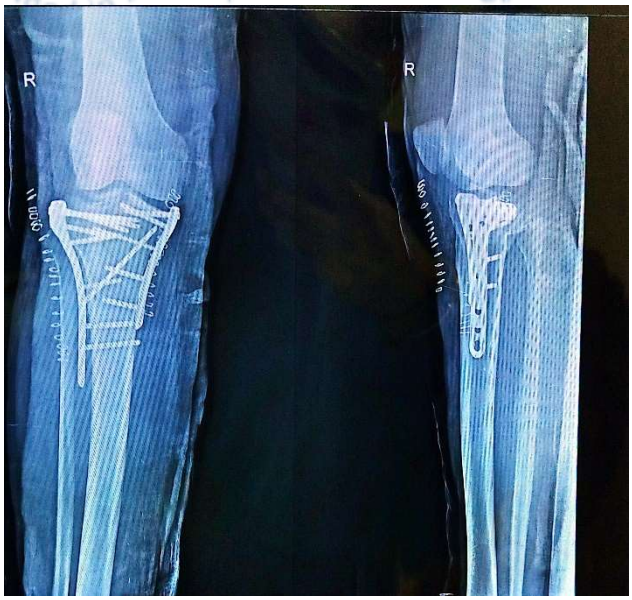


Fig 4 : X-ray AP and lateral view showing how 14 screws and plates were used in the ORIF surgery of this patient to repair the Tibia Plateau comminuted fracture

IX. RISK OF COMPLICATIONS

Compartment syndrome following tibial plateau fracture has been described, solely as case reports, as a relatively rare complication. In a retrospective analysis of Chang and colleagues, the overall incidence of compartment syndrome was 10.3% (Chang YH, et al. 2000) High-energy trauma (Schatzker's type IV, V, and VI) was associated with a higher incidence of compartment syndrome (30.4% in type VI).

Other complications include risk of DVT, Pulmonary embolism, infections, failure of fixation, pseudolaxity of knee joint, painful post traumatic osteoarthritis, etc (Gahr, P. Et al. 2023)

In this case the complications were prevented through early mobilization, regular physiotherapy even during the cast, applying a holistic approach, maintaining posture correction to prevent limping, and regular follow ups for the red flags.

X. PHYSIOTHERAPY ASSESSMENT

1. Pain history: The patient's pain history was thoroughly assessed throughout the rehabilitation period. During the initial phase (0-8 weeks), the patient experienced a dull ache in the lower limbs accompanied by cramping pain in the lower back. From 8-16 weeks, the pain evolved into a sharp and severe sensation in the knee, particularly upon movement.

2. Observation - A comprehensive observation of the patient revealed several key findings:

A. Built: The patient has an endomorphic body type.
B. Posture*:*

- Forward head
- Rounded shoulders
- Hip hike on Right side
- Compensatory side bending of trunk towards Right side
- Increased thoracic kyphosis
- Inverted ankles in cast (due to malpositioning during the application of the cast)

ISSN [Online]: 2583-2654

C. Scar: Healthy healing surgical scar on Right knee with no sign of infection

3. Examination

A detailed examination of the patient identified significant muscle tightness in various areas. The assessment revealed tightness in the pectorals, right side obliques, quadriceps, tensor fasciae latae (TFL), piriformis, hamstrings, adductors, and right ankle inverters.

Further examination of Range of motion and manual muscle testing was also done during all the different phases of the rehabilitation to adjust the rehabilitation protocol and redefine the goals at the different stages according to the patient's need. The improvement of the range of motion and muscle strength is demonstrated in the figure 5 and 6.

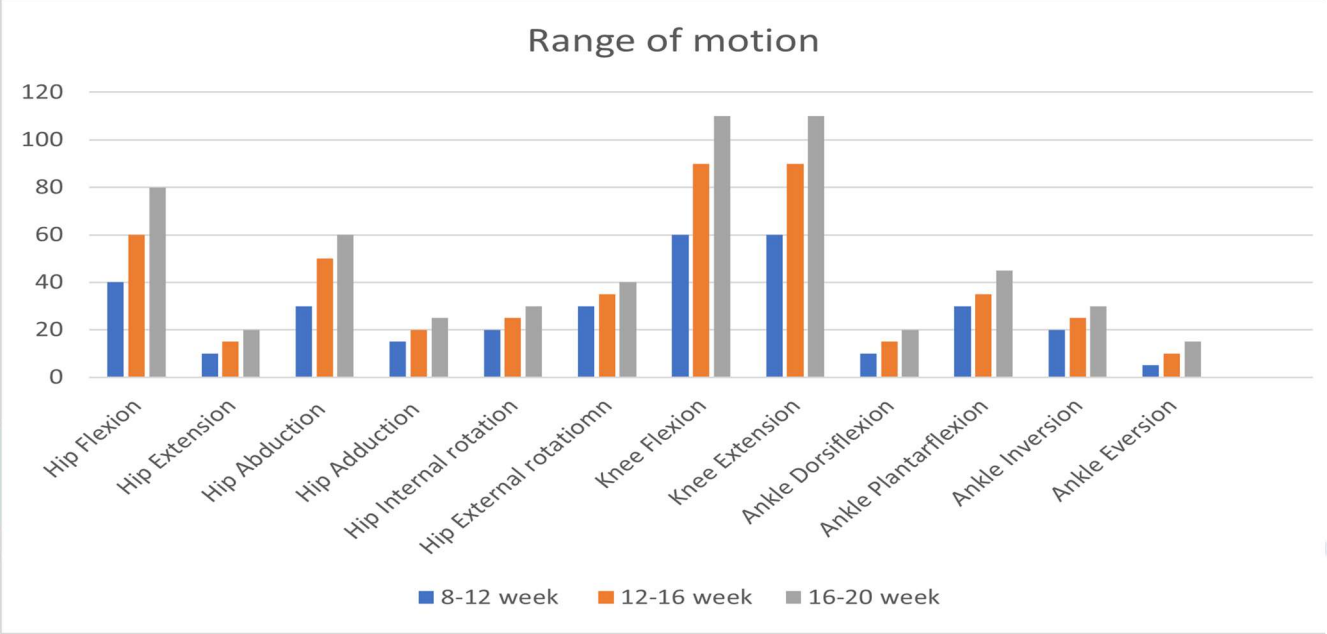


Fig 5 Range of motion - Affected limb (measured in degrees using universal goniometer)

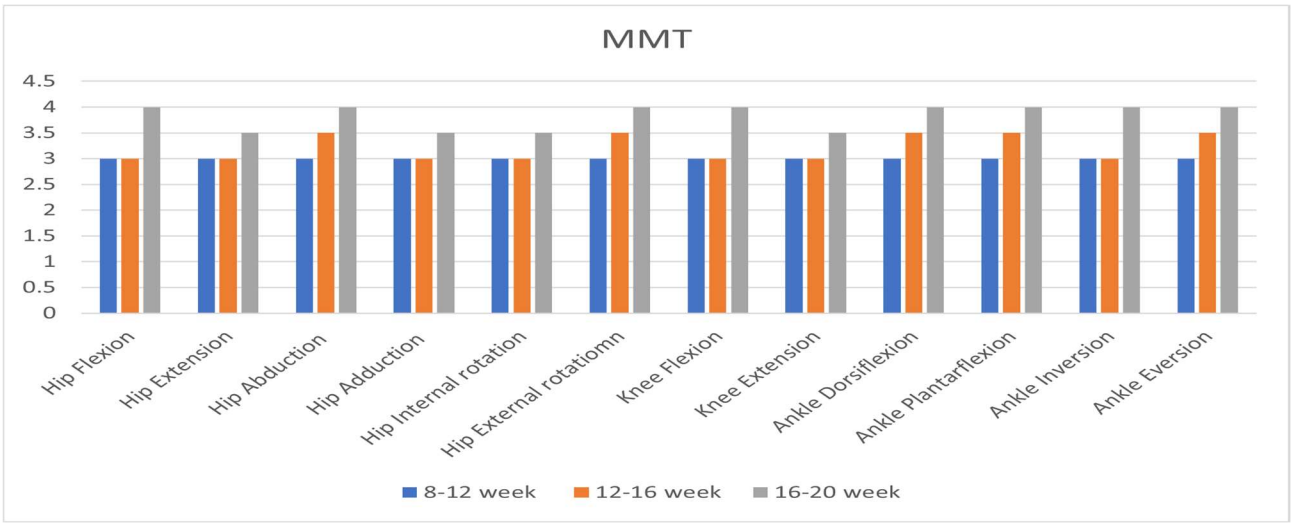


Fig 6 Manual Muscle testing - Affected limb (Grades on Y-axis - 3.5 indicate 3+/5 and 4.5 indicate 4+/5 grade)

ISSN [Online]: 2583-2654

XI. PHYSIOTHERAPY REHABILITATION

Stage	Symptom	Physiotherapy Goals	Intervention	Progression
Acute (0-8 weeks)	- Back Pain (8/10 - At rest)	- Manage pain and inflammation - Prevent stiffness - Initiate basic functional activities	- Isometric exercises for Knee, Neck and back - Ankle toe pumps - Passive ROM exercises for hip - Bed mobility skills turning, supine to sit, sit to stand - Basic transferring and walking using the walker (NWB) - 0-4 weeks - PWB 25% using walker 5-8 weeks	- 10-15 repetition with 10 second hold - Monitor pain and swelling response - Assess for signs of complication or impairment
Post-Cast Removal (8-12 weeks)	- Knee Pain (10/10 - On Movement), - Swelling, - Knee ROM at 9th week 0°-60°	- Manage Pain and Inflammation - Progress to partial weight-bearing - Improve functional mobility	- Apply Cold pack for swelling (10 minutes every 3 hours for first 2 weeks) Apply Hot pack to relax muscle for Knee PROM Mobilization (15 minutes before exercise) - PWB gait training with walker 25% 8-10 weeks 50% 10-12 weeks - Active-assisted ROM exercises for hip - Knee PROM, AAROM exercise - Stretching - TFL, Piriformis, Hamstring, Quadriceps & Calf - Bridging and crunches	- 10-15 repetition with 10 second hold - Strengthening exercises - 3 repetitions 30 second hold - Stretching exercises - Gradually transition of weight-bearing
Post-Cast Removal (12-16 weeks)	- Knee Pain (6/10 - On Movement), - Knee ROM at 12th week 0°-90°	- Restore knee ROM - Improve balance and stability during gait - Enhance core strength	- PWB 75% using cane stick - Knee ROM exercises - Dynamic Quadriceps - Quadruped and kneeling exercises - Hip Active ROM exercises (grade - 3)	- 10-15 repetition with 10 second hold - Gradually transition of weight-bearing - Start adding weight when the patient is able to hold a movement against gravity for more than 10 seconds
Functional Training (16-20 weeks)	- Complete knee ROM achieved At 16th week 0°-110° - Antalgic gait - Altered Balance	- Improve gait pattern - Improve balance and stability - Return to functional activities - Achieve independence	- Gait training without walking aids (Heel strike, foot clearance, and resisting trunk compensation) - Driving practice - Circuit training for functional activities and Balance training (Hurdle walk, Single leg standing, Side walk, Backward walk, etc) - Squats (Supported)	- 10-15 repetition with 10 second hold - Progress patient to independent gait - Monitor driving skills and safety - Gradually increase intensity of circuit training

ISSN [Online]: 2583-2654

XII. DISCUSSION

The patient underwent a multidisciplinary approach to management, including orthopedic surgery, medical management, and Physical therapy. Physiotherapy interventions were tailored to each stage of rehabilitation, focusing initially on pain management, edema control, and gentle range of motion exercises, progressing to partial weight-bearing, knee range of motion exercises, and functional training.

The patient received treatment using a holistic approach, structured into distinct phases to address various rehabilitation goals:

During the initial phase from 0 to 8 weeks, the focus was on postural strength, core strength, and maintaining joint integrity. Interventions included isometric exercises for the knee, back, and ankle, along with passive range of motion (ROM) exercises for the hip. The patient was also taught basic transferring and walking techniques using a walker. This phase aimed at managing pain, preventing stiffness, and ensuring the integrity of the joints during immobilization.

The focus during the 8 to 12-week phase was on achieving functional ROM and regaining lower limb strength. After the cast removal, partial weight-bearing exercises were introduced using a walker. Active-assisted ROM exercises for the hip were incorporated, and core stabilization exercises, such as bridging and crunches, were added to the regimen. This phase successfully improved the patient's ROM, particularly achieving 90 degrees of knee flexion, and addressed muscle strength loss due to immobilization.

From 12 to 16 weeks, the primary focus was on strength training for the lower limb and achieving complete knee ROM. Strength training exercises were progressively introduced for the lower limb muscles. The patient received gait training using a cane stick, and quadruped and kneeling exercises were added for balance and stability. Active ROM exercises for all joints continued, and core strengthening was intensified. This phase enabled the patient to attain complete knee ROM and prevented complications such as contractures, infections, and edema. Enhanced muscle strength supported improved functional mobility.

In the final phase, from 16 to 20 weeks, the focus shifted to achieving independence in functional activities and walking without assistance. Gait training was conducted, allowing the patient to gradually transition from using a walker to walking independently. Driving practice and circuit training for functional activities were also included. By the end of this phase, the patient achieved full independence in daily activities, walked without difficulty, and demonstrated complete functional recovery.

This structured, phase-wise rehabilitation approach ensured comprehensive recovery, emphasizing not only physical healing but also functional independence and quality of life for the patient.

Tibial plateau fractures are severe joint injuries of the lower extremity. Since a notable number of patients sustaining tibial plateau fractures are young, active and in the middle of their working life, these injuries may have a profound effect on the individual's professional career.

Kraus, T. M. Et al. in (2018) found a relationship between work intensity and the duration of incapacity of work after surgically treated tibial plateau fractures. The post-injury shift to less demanding jobs and the reduction of working hours highlight the impact of a tibial plateau fracture on a patient's physical ability to work.

Gálvez-Sirvent et al. (2022). Explained Complications of the surgical treatment of fractures of the tibial plateau. He showed The gold standard for treating tibial plateau fractures is surgical: ORIF to restore joint congruence and achieve an adequate mechanical axis, stable knee, and early mobilisation. The complications of this treatment have been decreasing over the decades due to the increased understanding and management of these fractures.

In this case, complications were avoided by early

ISSN [Online]: 2583-2654

mobilization, consistent physiotherapy even while the cast was on, adopting a holistic approach, maintaining proper posture to prevent limping, and having regular follow-ups to monitor for any warning signs.

XIII. FUTURE RESEARCH DIRECTIONS BASED ON CASE OUTCOMES

1. Comparative Studies on Rehabilitation Protocols:
Conduct studies comparing different rehabilitation protocols for Stage 6 comminuted tibia fractures to identify the most effective methods in terms of recovery time, functional outcomes, and complication rates.

2. Long-Term Outcomes of Holistic Rehabilitation Approaches:
Investigate the long-term outcomes of patients who undergo holistic rehabilitation approaches, like the one described in this case, to assess sustained functional independence, quality of life, and the incidence of long-term complications.

3. Role of Advanced Physiotherapy Techniques:
Explore the impact of advanced physiotherapy techniques, such as aquatic therapy, virtual reality-based rehabilitation, and robotic-assisted exercises, on the recovery of patients with severe tibial fractures.

4. Psychological Impact and Support:
Examine the psychological impact of severe lower limb fractures and the effectiveness of integrated psychological support in improving rehabilitation outcomes.

5. Biomarkers and Predictors of Recovery:
Identify potential biomarkers and predictors of recovery to tailor rehabilitation programs more effectively and improve patient outcomes.

These future research directions aim to enhance the understanding and management of severe tibial fractures, leading to improved patient outcomes and more effective rehabilitation strategies.

XIV. CONCLUSION

Comminuted tibia fractures present complex challenges in terms of management and rehabilitation. A comprehensive and multidisciplinary approach is essential to optimize outcomes and facilitate the patient's return to pre-injury functional status. This case highlights the importance of early intervention, appropriate surgical management, and tailored physiotherapy protocols in achieving successful rehabilitation outcomes for patients with severe lower limb injuries.

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