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Case Report: Progressive Exercise Improves ROM and Strength in Late-Phase Post-ORIF Tibial Plateau Fracture

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Abstract

Background: Tibial plateau fractures are complex intra-articular injuries often associated with joint stiffness, muscle weakness, and functional limitations following open reduction and internal fixation (ORIF).

Objective: To evaluate the effectiveness of progressive exercise in improving range of motion (ROM), muscle strength, pain, and functional independence in a post-ORIF patient.

Methods: This case report involved a 30-year-old male five months after ORIF due to trauma. A six-week progressive exercise program based on the FITT principle was implemented, including isometric exercise, active ROM, resistance training progressing from open to closed kinetic chain, and functional training. Outcomes were assessed using Numeric Rating Scale (NRS), goniometry, Manual Muscle Testing (MMT), and the Barthel Index.

Results: Knee flexion ROM improved from 70° to 80°, muscle strength increased from 4-/5 to 4/5, and pain decreased from 5/10 to ≤3/10 during activity. The Barthel Index improved from 79 to 90, indicating enhanced functional independence. No adverse events were reported.

Conclusion: Progressive exercise appears to be a safe and beneficial approach for improving mobility, strength, pain, and functional outcomes in late-phase post-ORIF rehabilitation. This case highlights the importance of structured progressive rehabilitation in addressing persistent functional limitations during the late postoperative phase.

Keywords
Tibial Plateau Fractures; Exercise Therapy; Range of Motion, Articular; Muscle Strength; Fracture Fixation, Internal

Introduction

Tibial plateau fractures are among the most complex intra-articular injuries affecting the knee joint, often resulting from high-energy trauma such as road traffic accidents or falls from height.[1] These injuries involve disruption of the articular surface and surrounding soft tissues, including ligaments and menisci, which are essential for maintaining joint stability and biomechanical alignment. Consequently, patients frequently experience long-term complications, including joint stiffness, muscle weakness, and impaired functional mobility.[2]

Open reduction and internal fixation (ORIF) is the standard surgical approach for displaced or unstable tibial plateau fractures, aiming to achieve anatomical reduction, restore joint congruency, and provide sufficient stability for early mobilization.[3] Despite successful surgical outcomes, functional recovery is highly dependent on postoperative rehabilitation. Without appropriate rehabilitation, patients remain at risk of persistent impairments that may compromise daily activities and quality of life.[4]

Postoperative complications are commonly associated with prolonged immobilization and restricted weight-bearing, which are often necessary to ensure proper bone healing. However, these restrictions may lead to secondary impairments such as decreased joint mobility, muscle atrophy, and altered neuromuscular control.[5,6] In particular, quadriceps and hamstring weakness significantly contributes to knee instability and reduced functional performance, thereby delaying recovery.[7]

Exercise-based rehabilitation plays a central role in addressing these impairments. Progressive exercise, guided by the FITT principle (frequency, intensity, time, and type), enables gradual adaptation of musculoskeletal tissues while minimizing the risk of overload or reinjury.[8] This approach typically involves a transition from isometric exercises and active range of motion (ROM) training to resistance and functional exercises, including progression from open kinetic chain to closed kinetic chain movements.[9] Such progression is essential for restoring neuromuscular control and preparing patients for full weight-bearing activities.

Previous studies have demonstrated that structured rehabilitation programs can improve functional outcomes following intra-articular knee fractures.[10] Early mobilization and progressive loading have been associated with better ROM, reduced pain, and enhanced functional independence.[11] However, most available evidence focuses on early postoperative phases, while limited attention has been given to patients in the late postoperative phase who continue to experience functional limitations despite surgical intervention.[12]

Moreover, there is a lack of detailed clinical documentation regarding the implementation and progression of exercise protocols in individual cases, particularly those based on the FITT principle.[13] This gap is important because individualized rehabilitation strategies are essential in clinical practice, where patient responses to intervention may vary significantly.

This case is clinically significant because it presents a patient who continued to experience pain, restricted ROM, and dependence on assistive devices five months after ORIF. Such persistence of impairments highlights the need for targeted rehabilitation strategies beyond the early recovery phase. Additionally, this report provides a detailed description of a structured progressive exercise program and its clinical outcomes, offering practical insights for physiotherapists managing similar cases.

Therefore, this case report aimed to evaluate the effectiveness of a progressive exercise program in improving ROM, muscle strength, pain, and functional independence in a patient in the late postoperative phase following ORIF of a tibial plateau fracture.

Methods

This study was conducted as a single-patient case report following the CARE (CAse REport) guidelines to ensure transparency and completeness in clinical reporting. The report describes the physiotherapy management of a patient undergoing a structured progressive exercise program during the late postoperative phase following open reduction and internal fixation (ORIF) for a tibial plateau fracture.

The patient was a 30-year-old male, self-employed, who presented five months after ORIF of a left tibial plateau fracture caused by a high-energy traumatic incident (road traffic accident). The patient reported persistent knee pain, stiffness, and limited range of motion, accompanied by difficulty achieving full weight-bearing and continued reliance on crutches. These symptoms had persisted since the postoperative period, although partial improvement had been noted. The patient denied any history of chronic systemic diseases, prior musculoskeletal disorders, or regular use of analgesic medication at the time of assessment. Baseline functional status prior to injury was reported as fully independent in daily activities. Psychologically, the patient expressed fear of full weight-bearing due to concern about pain and potential reinjury, indicating elements of fear-avoidance behavior that could influence rehabilitation outcomes.

A comprehensive physiotherapy assessment was performed. The patient was fully conscious (compos mentis), cooperative, and hemodynamically stable. Clinical examination revealed no edema around the left knee, and the surgical incision had healed well without signs of infection. Palpation elicited localized tenderness around the incision area, with normal local temperature. Pain intensity was assessed using the Numeric Rating Scale (NRS), a valid and reliable tool for pain evaluation. The patient reported pain scores of 3/10 at rest, 4/10 upon palpation, and 5/10 during walking.

Joint range of motion (ROM) was measured using a goniometer, which has demonstrated acceptable validity and reliability in clinical settings. Knee ROM was limited to 0°–0°–70°, indicating significant restriction in flexion. Muscle strength was evaluated using Manual Muscle Testing (MMT), a widely used and reliable clinical method, showing a grade of 4-/5 in the quadriceps and hamstring muscle groups. Ligament stability tests, including valgus and varus stress tests as well as anterior and posterior drawer tests, were negative, indicating no ligamentous instability. Functional ability was assessed using the Barthel Index, a validated instrument for evaluating independence in activities of daily living, with a baseline score of 79, indicating moderate dependency.

From an International Classification of Functioning, Disability and Health (ICF) perspective, impairments were identified in body functions (limited ROM, reduced muscle strength, and pain), activity limitations (difficulty walking and performing daily tasks), and participation restrictions (reduced independence in occupational and social roles).

Radiological evaluation based on medical records (plain X-ray) indicated satisfactory postoperative alignment, stable internal fixation, and signs of progressive bone union without complications such as implant failure or displacement. In addition to the primary diagnosis of post-ORIF tibial plateau fracture, differential diagnoses such as residual ligament injury, meniscal pathology, and early post-traumatic osteoarthritis were considered. These conditions were clinically excluded based on negative ligament stability tests, absence of mechanical symptoms such as locking or catching, and the patient's radiological findings indicating stable fixation and satisfactory healing progression.

Pharmacological management included Caviplex (multivitamin and mineral supplementation), Lapibal 500 mg (non-opioid analgesic), and Oscal (calcium and vitamin D supplementation), aimed at supporting tissue healing, pain control, and bone mineralization. The physiotherapy intervention consisted of a structured progressive exercise program based on the FITT principle, emphasizing gradual progression in intensity and functional complexity. The program was conducted over six weeks with a frequency of 3–4 sessions per week. The intervention included isometric quadriceps exercises, active ROM exercises, stretching, progressive resistance training using elastic bands or light weights, balance training, and functional training progressing from partial to full weight-bearing. To enhance clarity and reproducibility, the progression of interventions is summarized in Table 1.

Table 1. Timeline and Progression of Physiotherapy Intervention

Phase	Timeframe	Intervention Focus	Key Components
Phase 1	Week 1–2	Pain control and activation	Isometric exercise, active ROM, cryotherapy
Phase 2	Week 3–4	Strength and mobility	Resistance training (OKC), stretching, balance
Phase 3	Week 5–6	Functional restoration	CKC exercise, gait training, stair training

Exercise intensity was adjusted according to patient tolerance using a pain-monitoring model, ensuring that pain did not exceed NRS ≤5 and did not persist beyond 24 hours post-exercise. Progression from partial to full weight-bearing was guided by clinical evaluation and radiological findings indicating adequate bone healing. Safety measures were implemented throughout the intervention. Exercise was modified or discontinued if the patient experienced increased pain (NRS ≥6), swelling, instability, or signs of inflammation. Environmental safety, appropriate footwear, and correct use of assistive devices were also emphasized.

Each component of the intervention was selected based on its clinical rationale. Isometric exercises were used to prevent muscle atrophy during limited mobility, while active ROM exercises aimed to restore joint mobility. Progressive resistance training was introduced to enhance muscle strength and neuromuscular control, and the transition from open to closed kinetic chain exercises was intended to improve joint stability and functional performance during weight-bearing activities.

Outcome evaluation was conducted descriptively by comparing baseline and post-intervention findings across pain, ROM, muscle strength, and functional independence. No statistical analysis was performed due to the nature of a single case report.
Written informed consent was obtained from the patient prior to participation and publication. Ethical approval was not required for this case report in accordance with institutional guidelines; however, all procedures adhered to ethical standards for clinical research involving human participants.

Results

The clinical outcomes demonstrated measurable improvements across all domains following the progressive exercise program. At baseline, the patient presented with knee ROM of 0°–0°–70°, muscle strength of 4-/5, pain intensity of 5/10 during activity, and a Barthel Index score of 79, indicating moderate dependency.

Following the intervention, knee ROM improved progressively to 75° at week 2 and 80° at week 3. Muscle strength increased to 4/5 by week 3, indicating improved functional muscle performance. Pain intensity decreased from 5/10 at baseline to ≤4/10 at week 2 and ≤3/10 at week 3 during activity.

Functional independence also improved, as reflected by an increase in the Barthel Index score from 79 at baseline to 84 at week 2 and 90 at week 3. This improvement corresponded with reduced reliance on assistive devices and increased confidence in weight-bearing activities. No adverse events were reported during the intervention period. To provide a clear comparison of clinical changes, the pre- and post-intervention outcomes are summarized in Table 2.

Table 2. Clinical Outcome Progression

Outcome	Baseline	Week 2	Week 3
Pain (NRS – activity)	5/10	≤4/10	≤3/10
ROM (Flexion)	70°	75°	80°
Muscle Strength (MMT)	4-/5	—	4/5
Barthel Index	79	84	90

As shown in Table 2, pain intensity decreased both at rest and during walking, reflecting improved pain control and tolerance to functional activities. Although exact post-intervention values were not documented, the reduction in pain was clinically meaningful, as reported by the patient during reassessment. These findings indicate an absolute improvement of 10° in knee flexion ROM, a one-grade increase in muscle strength, a reduction of 2 points in pain intensity, and an 11-point increase in the Barthel Index. To further illustrate the progression of clinical outcomes, changes in pain intensity, range of motion, and functional independence over the intervention period are presented in Figure 1.

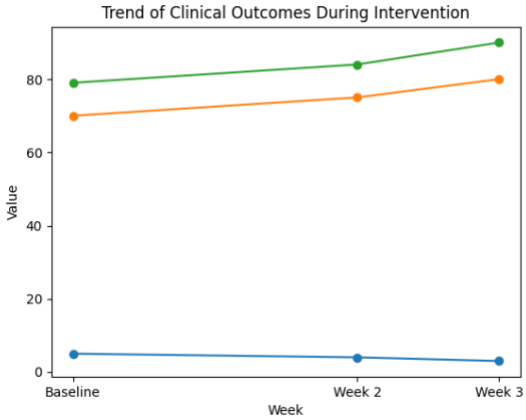

Figure 1. Trend of Clinical Outcomes During Intervention

Figure 1. Trend of clinical outcomes during the three-week progressive exercise program. Pain intensity (NRS) decreased from 5 to 3, knee flexion ROM improved from 70° to 80°, and the Barthel Index increased from 79 to 90.

Knee ROM demonstrated an increase in flexion capacity compared to baseline limitations (0°–0°–70°), indicating improved joint mobility. Similarly, muscle strength in the quadriceps and hamstring groups improved from the initial grade of 4-/5, supporting enhanced joint stability and functional movement.

Functional outcomes also improved, as reflected by an increase in the Barthel Index score from the baseline value of 79. This improvement corresponded with reduced dependence on assistive devices and greater independence in daily activities, particularly in mobility-related tasks.

Throughout the intervention period, no adverse events such as increased pain, swelling, or signs of joint instability were observed. The patient tolerated the progressive exercise program well, and adherence to the prescribed protocol was maintained. Overall, the findings demonstrate consistent improvements across impairment, activity, and functional domains following the structured progressive exercise program.

Discussion

This case report demonstrates that a structured progressive exercise program may contribute to improvements in joint mobility, muscle strength, pain reduction, and functional independence in a patient during the late postoperative phase following ORIF of a tibial plateau fracture. These findings are consistent with previous literature emphasizing the importance of exercise-based rehabilitation in restoring musculoskeletal function after intra-articular knee injuries.[12]

In this case, the patient demonstrated a 10° improvement in knee flexion ROM (from 70° to 80°), a reduction in pain intensity from 5/10 to ≤3/10, and an increase in the Barthel Index from 79 to 90. These changes indicate clinically meaningful improvements in joint mobility, pain control, and functional independence. A 10° increase in knee flexion ROM is considered functionally relevant, as it contributes to improved performance in activities such as sitting, walking, and stair climbing. Similarly, a reduction of 2 points in NRS reflects a meaningful clinical improvement in pain perception. The patient initially presented with limited knee ROM, moderate pain, and reduced muscle strength, which are common consequences of postoperative immobilization and disuse.[14] Prolonged restriction of movement is known to impair synovial fluid diffusion, reduce tissue extensibility, and promote periarticular adhesions, ultimately leading to joint stiffness.[13] The observed improvement in ROM following intervention may be attributed to the combined effects of active mobilization and stretching exercises, which facilitate collagen remodeling and restore joint elasticity.[15,16]

Muscle strength improvement, particularly in the quadriceps and hamstring groups, reflects neuromuscular adaptation to progressive resistance training. Weakness in these muscle groups is frequently associated with impaired knee stability and functional deficits.[17] The transition from open kinetic chain (OKC) to closed kinetic chain (CKC) exercises likely played a critical role in enhancing joint stability through co-contraction mechanisms and improved proprioceptive control.[18,19] These findings are supported by previous studies indicating that progressive resistance training effectively improves lower limb strength and functional outcomes.[20]

Pain reduction observed in this case may be explained by physiological responses to therapeutic exercise, including improved circulation, reduction of muscle tension, and activation of endogenous pain inhibitory mechanisms.[21] Reduced pain is clinically important, as it facilitates greater patient participation in rehabilitation and promotes confidence in weight-bearing activities. This is particularly relevant in this case, where fear of full weight-bearing was initially identified as a barrier to functional recovery.[22]

From a functional perspective, improvements in the Barthel Index suggest enhanced independence in activities of daily living. These changes are consistent with evidence showing that functional training combined with progressive loading contributes to better recovery of mobility and participation.[23] Gradual progression from partial to full weight-bearing appears to support safe mechanical adaptation without compromising the stability of internal fixation.[22]

A key strength of this case lies in the structured implementation of a progressive exercise program based on the FITT principle, with clear progression from basic activation to functional training. Unlike many reports that describe rehabilitation in general terms, this case provides a detailed, phase-based approach that may enhance clinical applicability. Furthermore, this case is unique because it focuses on the late postoperative phase (five months post-ORIF), where functional limitations persisted despite surgical intervention. This highlights the importance of continued rehabilitation beyond the early recovery phase, which is often underreported in the literature.

Clinical decision-making in this case was guided by continuous assessment of pain, movement quality, and weight-bearing tolerance. The progression of exercise intensity and complexity was individualized based on patient response, ensuring safety while promoting functional gains. This approach reflects real-world clinical reasoning, where standardized protocols must be adapted to patient-specific conditions.

Despite these positive findings, several limitations should be acknowledged. First, this report involves a single patient, limiting generalizability. Second, the absence of complete quantitative post-intervention data restricts the ability to precisely quantify the magnitude of improvement. Third, no knee-specific outcome measures such as WOMAC or KOOS were used, which may have provided more detailed functional assessment. Additionally, the lack of long-term follow-up prevents evaluation of sustained outcomes.

The clinical implications of this case suggest that progressive exercise can be considered a safe and effective rehabilitation strategy in patients with persistent functional limitations following ORIF of tibial plateau fractures. Early identification of barriers such as fear-avoidance behavior and individualized progression of exercise intensity are essential to optimize recovery. Future research should focus on larger sample sizes and controlled study designs to strengthen the evidence base for progressive exercise in late-phase postoperative rehabilitation.

The patient reported that the progressive exercise program helped reduce pain and improve confidence in performing daily activities. Initially, the patient expressed fear of full weight-bearing due to concerns about pain and reinjury. However, over the course of the intervention, the patient felt more stable when standing and walking and gradually reduced dependence on crutches. The patient also reported increased confidence in performing work-related activities and perceived the exercise program as beneficial and manageable.

Conclusion

This case report demonstrates that a structured progressive exercise program may contribute to improvements in joint mobility, muscle strength, pain reduction, and functional independence in a patient following ORIF of a tibial plateau fracture. In this case, knee flexion ROM improved from 70° to 80°, muscle strength increased from 4-/5 to 4/5, pain intensity decreased from 5/10 to ≤3/10 during activity, and the Barthel Index increased from 79 to 90.

These findings indicate clinically meaningful improvements in both impairment and functional domains, particularly in facilitating weight-bearing activities and reducing dependence on assistive devices. The intervention was well tolerated, with no adverse events reported during the rehabilitation period.

However, as this report is limited to a single case with short-term follow-up, the findings should be interpreted with caution and cannot be generalized. Further studies with larger samples and standardized outcome measures are required to confirm the effectiveness of progressive exercise in post-ORIF rehabilitation.

Author Contribution

Gatra Azzuma Wicaksana: Conceptualization, Investigation, Data Curation, Formal Analysis, Methodology, Writing – Original Draft.
Suryo Saputra Perdana: Supervision, Methodology, Validation, Writing – Review & Editing, Project Administration.
Reza Arshad Yanuar: Clinical Supervision, Validation, Investigation, Resources, Writing – Review & Editing.

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Conflict of Interest Statement

The author declares no conflict of interest.

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Ethics Statement

This study was conducted in accordance with ethical principles for clinical research involving human participants. As this report describes a single patient, formal ethical approval was not required based on institutional policy. However, written informed consent was obtained from the patient for participation and publication of this case report and any accompanying data.

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