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Arthroscopic-Assisted Tibial Plateau Fracture Fixation Enables Simultaneous Identification and Management of Associated Intra-Articular Injuries: A Case Series of Eight Patients

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Abstract

Background: Tibial plateau fractures are complex intra-articular injuries that require accurate restoration of the articular surface to optimize knee function and minimize post-traumatic osteoarthritis. Conventional fluoroscopy-assisted fixation may not adequately detect residual articular incongruity or associated intra-articular soft tissue injuries. Arthroscopic-assisted reduction and internal fixation (ARIF) enables direct visualization of the joint surface while simultaneously allowing diagnosis and treatment of concomitant meniscal and ligamentous injuries. **Methods:** We performed a retrospective case series of patients with tibial plateau fractures treated using arthroscopic-assisted reduction and internal fixation at Hospital Selayang. Patient demographics, fracture characteristics, associated intra-articular injuries, surgical technique, radiographic outcomes, fracture union, complications, range of motion, and functional outcomes were reviewed. Arthroscopy was utilized to assess articular reduction, remove loose fragments, and manage associated meniscal injuries where indicated. **Results:** All patients achieved radiographic union without loss of reduction or implant failure. Anatomical or near-anatomical reduction of the articular surface was obtained in all cases under direct arthroscopic visualization. Associated intra-articular injuries, predominantly meniscal tears, were identified and managed during the same procedure. Patients demonstrated satisfactory postoperative knee range of motion with no major complications such as deep infection, compartment syndrome, or neurovascular injury. Functional outcomes were generally good to excellent at final follow-up. **Conclusion:** Arthroscopic-assisted reduction and internal fixation is a safe and effective technique for selected tibial plateau fractures. It facilitates accurate reduction of the articular surface while enabling simultaneous treatment of associated intra-articular pathology, resulting in favourable radiological and functional outcomes. Larger comparative studies are warranted to further define its advantages over conventional fixation techniques.

Keywords

Tibial Plateau Fracture, Arthroscopy, Internal Fixation, Arthroscopic-Assisted Reduction, Meniscal Injury, Knee Trauma

1. Introduction

Tibial plateau fractures are complex intra-articular injuries accounting for approximately 1% of all fractures and are frequently associated with significant injury to the menisci, articular cartilage, cruciate ligaments, collateral ligaments, and periarticular soft tissues [1]-[4]. The reported incidence of associated soft-tissue and intra-articular injuries varies considerably according to fracture morphology, injury energy, and the method of assessment [2]-[5]. Failure to identify and appropriately manage these concomitant injuries may contribute to persistent pain, instability, mechanical symptoms, restricted knee motion, inferior functional recovery, and post-traumatic osteoarthritis [2]-[5].

The principal goals of tibial plateau fracture management are anatomical restoration of the articular surface, stable fracture fixation, restoration of limb alignment and joint stability, and initiation of appropriate rehabilitation [1] [2] [6]. Open reduction and internal fixation remain a widely accepted treatment for displaced tibial plateau fractures [2] [6]. However, conventional fluoroscopic assessment provides only an indirect evaluation of the articular surface and does not permit direct assessment of the menisci, cruciate ligaments, articular cartilage, or small intra-articular fragments. Consequently, clinically relevant meniscal tears, chondral lesions, ligamentous injuries, and loose bodies may remain unrecognized during conventional fracture fixation [3]-[5].

Arthroscopic-assisted reduction and internal fixation has emerged as an alternative technique that combines fracture stabilization with direct visualization of the articular surface and intra-articular structures [7]-[9]. Arthroscopy permits assessment of residual articular step-off or separation that may not be readily apparent on fluoroscopy. It also facilitates the identification and simultaneous treatment of associated pathology, including meniscal repair or debridement, chondroplasty, removal of loose bodies, fixation of osteochondral fragments, and management of ligamentous avulsion injuries during the index operation [7]-[9].

Previous clinical series and systematic reviews have reported satisfactory clinical and radiological outcomes following arthroscopic-assisted fixation of tibial plateau fractures [7]-[10]. The technique has traditionally been used most frequently for Schatzker type I - III fractures; however, more recent evidence suggests that it may also have a role in selected high-energy and complex fracture patterns when combined with appropriate plate-and-screw fixation [8]-[10]. Contemporary comparative evidence indicates that arthroscopic-assisted fixation provides clinical outcomes and complication rates broadly comparable with conventional open reduction and internal fixation, while offering the additional advantage of direct intra-articular assessment and simultaneous management of associated injuries [8]-[10].

Nevertheless, the existing literature remains heterogeneous with respect to fracture patterns, operative sequences, fixation methods, management of associated intra-articular injuries, rehabilitation protocols, and reported outcome measures [8]-[10]. Relatively few case series have specifically emphasized the full spectrum of intra-articular pathology identified arthroscopically and the procedures performed to treat these lesions during the same operation.

Therefore, the purpose of this case series was to describe the clinical and radiological outcomes of arthroscopic-assisted tibial plateau fracture fixation, with particular emphasis on the identification and simultaneous management of associated intra-articular injuries. We hypothesized that arthroscopic assistance would facilitate assessment of fracture reduction, enable one-stage treatment of associated meniscal, chondral, and ligamentous injuries, and result in satisfactory fracture union and knee range of motion at one-year follow-up.

2. Materials and Methods

2.1. Study Design

This retrospective case series included eight consecutive patients with tibial plateau fractures who underwent arthroscopic-assisted fracture fixation between June 2023 and June 2025 at Hospital Selayang, Malaysia.

Clinical records, operative notes, preoperative imaging, intraoperative arthroscopic findings, postoperative radiographs, fracture union, knee range of motion at one-year follow-up, and complications were reviewed.

Radiographic union was defined as evidence of progressive bridging trabeculae or callus across the fracture site with loss of the visible fracture line and absence of secondary displacement on serial radiographs. Articular reduction was considered anatomical or near-anatomical when the residual articular step-off or gap was ≤2 mm. Fracture union and maintenance of reduction were assessed on serial anteroposterior and lateral knee radiographs by the treating orthopaedic surgical team.

Patients were considered for ARIF when operative fixation of the tibial plateau fracture was indicated and arthroscopic assessment was considered beneficial for direct evaluation of the articular surface and associated intra-articular pathology. The technique was applied across Schatzker types I - VI when fracture configuration and the condition of the surrounding soft tissues permitted safe arthroscopic intervention.

All patients underwent preoperative plain radiography and computed tomography (CT) for characterization of fracture morphology and surgical planning. Magnetic resonance imaging (MRI) was not performed in any patient, as associated intra-articular pathology was systematically assessed by direct arthroscopic visualization during the index surgical procedure. Surgical intervention was performed within one to two weeks following the initial trauma, allowing appropriate preoperative assessment, surgical planning, and optimization of the local soft-tissue condition.

Patients with pathological fractures, active infection, severe soft-tissue compromise precluding arthroscopy, or incomplete clinical and radiological records were excluded.

Ethical approval for this study was obtained from the Ministry of Health Malaysia (NMRR ID: NMRR-26-01653-ZWM).

2.2. Surgical Technique

All procedures were performed by the same orthopaedic surgical team with the patient in the supine position under general or regional anaesthesia. A pneumatic tourniquet was routinely applied to the proximal thigh. Standard anterolateral and anteromedial arthroscopic portals were utilized throughout the procedure [11] [12].

Unlike the conventional arthroscopic-assisted reduction technique, diagnostic arthroscopy was not performed at the beginning of the procedure. Following fluoroscopic reduction of the fracture, temporary fixation was achieved using Kirschner wires (K-wires) to stabilize the fracture fragments. This preliminary fixation minimized fracture displacement during arthroscopy and was intended to reduce irrigation fluid extravasation into the fractured metaphyseal region, thereby potentially decreasing the risk of compartment syndrome [8] [11]-[13].

For depressed fractures, the articular surface was elevated through a cortical window using a bone tamp under fluoroscopic guidance. The metaphyseal defect was subsequently filled with autologous cancellous bone graft to provide structural support beneath the reduced articular surface [2] [6]. Temporary fixation with K-wires was maintained until satisfactory reduction was confirmed fluoroscopically.

Diagnostic arthroscopy was then performed. Due to acute haemarthrosis, visualization during the initial stage of arthroscopy was frequently compromised. Thorough arthroscopic lavage was performed to evacuate the intra-articular haematoma, allowing adequate visualization of the articular surfaces and soft tissue structures [7] [8].

A systematic arthroscopic examination of the knee was subsequently performed, including assessment of the suprapatellar pouch, patellofemoral joint, medial compartment, intercondylar notch, cruciate ligaments, lateral compartment, menisci, and articular cartilage [11] [12]. Fracture reduction was carefully inspected under direct arthroscopic visualization to confirm restoration of the articular surface and identify any residual step-off or gap not readily apparent on fluoroscopy.

Following confirmation of satisfactory reduction, definitive fixation was completed using locking plate fixation with supplementary cannulated screws according to fracture configuration. Arthroscopy was subsequently repeated to reassess the final reduction and identify associated intra-articular injuries.

Meniscal tears were assessed arthroscopically according to tear location, morphology, stability, tissue quality, and repairability. Unstable tears considered amenable to preservation, including peripheral longitudinal, bucket-handle, posterior horn, and root tears with adequate tissue quality, were repaired. Irreparable tears with poor tissue quality or non-reconstructable morphology were treated with limited arthroscopic debridement while preserving as much functional meniscal tissue as possible [14]-[16].

Articular cartilage lesions were classified according to the Outerbridge classification. Unstable chondral flaps and loose cartilage fragments were treated with chondroplasty to achieve a stable cartilage margin. Displaced and unstable ACL tibial avulsion fractures were reduced and fixed arthroscopically using a standard ACL tibial guide. Intra-articular loose bodies and unstable osteochondral fragments were removed arthroscopically.

Final arthroscopic inspection was performed to confirm satisfactory fracture reduction, stable fixation, restoration of articular congruity, and successful management of all associated intra-articular injuries before wound closure.

2.3. Postoperative Rehabilitation

A standardized postoperative rehabilitation protocol was implemented for all patients, as each patient underwent concomitant arthroscopic treatment of associated intra-articular injuries in addition to fracture fixation.

A hinged knee brace locked in full extension was applied immediately after surgery. All patients remained non-weight bearing for six weeks. Supervised physiotherapy was commenced immediately after surgery, with knee flexion limited to 30˚ during the first two weeks, 60˚ between two and four weeks, and 90˚ between four and six weeks. Knee flexion beyond 90˚ was gradually permitted after six weeks according to patient tolerance and radiographic evidence of fracture healing [17]-[19].

Serial radiographs were obtained during follow-up to assess fracture union. Once early callus formation was evident, the hinged knee brace was discontinued and patients progressed to partial weight bearing with supervised physiotherapy. Full weight bearing was permitted after an additional two to four weeks following confirmation of satisfactory fracture healing.

Rehabilitation thereafter focused on restoration of knee range of motion, quadriceps strength, proprioception, and return to functional activities [17]-[19].

3. Results

3.1. Patient Demographics and Fracture Characteristics

Eight consecutive patients who underwent arthroscopic-assisted reduction and internal fixation (ARIF) for tibial plateau fractures between June 2023 and June 2025 were included in this case series. The mean age was **28.6 years** (range, 16 - 49 years). There were **five males (62.5%)** and **three females (37.5%)**. All injuries resulted from **motor vehicle accidents (100%)**. The fractures involved the left knee in four patients and the right knee in four patients. According to the Schatzker classification, there were **two type I fractures (25%)**, **three type II fractures (37.5%)**, **one type IV fracture (12.5%)**, **one type V fracture (12.5%)**, and **one type VI fracture (12.5%)**. All patients completed a minimum follow-up of 12 months. Patient demographics and fracture characteristics are summarized in Table 1.

Table 1. Patient demographics and fracture characteristics.

Case	Age	Sex	Mechanism of Injury	Side	Schatzker Type	Follow-up (months)
1	21	Male	Motor vehicle accident	Left knee	1	12 months
2	29	Female	Motor vehicle accident	Right knee	2	12 months
3	23	Male	Motor vehicle accident	Left knee	2	12 months
4	16	female	Motor vehicle accident	Right knee	4	12 months
5	31	Male	Motor vehicle accident	Right knee	6	12 months
6	49	Male	Motor vehicle accident	Left knee	5	12 months
7	28	Male	Motor vehicle accident	Left knee	2	12 months
8	32	Female	Motor vehicle accident	Right knee	1	12 months

3.2. Associated Intra-Articular Injuries and Arthroscopic Management

Arthroscopy identified **associated intra-articular injuries in all eight patients (100%)**. Meniscal injuries were the most frequently encountered pathology, occurring in **seven patients (87.5%)**. These included two bucket-handle tears, one posterior root tear, two midbody tear, one posterior horn tear, and one posterior horn tear extending into the meniscal body. Six patients underwent arthroscopic meniscal repair, while one patient underwent arthroscopic debridement for an irreparable meniscal tear.

Articular cartilage injuries were identified in **all patients (100%)**, predominantly involving the lateral tibial plateau. The severity of chondral injury ranged from **Outerbridge grade I to grade IV**, with lesion sizes ranging from **10 × 10 mm to 20 × 30 mm**. Chondroplasty was performed in all patients to stabilize unstable cartilage and remove loose chondral flaps where indicated.

Anterior cruciate ligament (ACL) tibial avulsion fractures were identified in **three patients (37.5%)** and were treated with arthroscopic reduction and fixation during the same surgical procedure. In addition, **four patients (50.0%)** were found to have intra-articular loose bodies or osteochondral fragments, all of which were removed arthroscopically. No patient required a secondary procedure for treatment of the associated intra-articular pathology. A detailed summary of the arthroscopic findings and procedures performed is presented in Table 2.

Table 2. Arthroscopic findings and concomitant intra-articular injuries by case.

Case	Meniscal Injury	Chondral Injury (Outerbridge Grade)	ACL Avulsion	Other Findings	Arthroscopic Treatment
1	Lateral meniscus Bucket handle tear	Lateral tibia plateu grade 2. 15 × 10 mm	Acl intact	Chondral loose body	Meniscus repair, chondroplasty and removal of loose bodies
2	Lateral meniscus midbody tear	Lateral tibial plateu grade 3, 15 × 15 mm	Acl intact	No loose bodies	Meniscus repair and chondroplasty done
3	Lateral meniscus bucket handle tear	Lateral tibial plateu, grade 4, 20 × 30 mm	Acl avulsion fracture	Loose bodies-bone fragments	Meniscus repair, acl avulsion fixation and chondroplasty
4	No meniscus injury	Medial tibial plateu grade 4 and medial femoral condyle grade 2, 20 × 10 mm	Acl avulsion fracture	No loose bodies	Acl avulsion fixation and chondroplasty procedure
5	Lateral meniscus posterior root	Lateral and medial femoral condyle grade 2 - 3, 20 × 20 mm, lateral tibial plateu grade 3 20 × 15 mm	Acl avulsion fracture	Loose bodies-bone fragments	Acl avulsion fixation, lateral meniscus root repair and loose bodies removal with chondroplasty procedure
6	Lateral meniscus posterior horn tear	Lateral tibial platu grade 3, 20 × 10 mm Lateral femoral condyle, medial tibial plateu grade 2, 10 × 15 mm	Acl intact	Loose bodies-bone fragments	Lateral meniscus repair and loose bodies removal with chondroplasty procedure
7	Lateral meniscus posterior horn tear extending to body	Lateral tibial plateu 20 × 20 mm grade 3, lateral femoral condyle grade 2 10 × 15 mm	Acl intact	No loose bodies	Lateral meniscus repair and chondroplasty procedure
8	Lateral meniscus midbody tear	Lateral tibial plateu grade 2 10 × 10 mm, lateral femoral condyle grade 1 15 × 10 mm	Acl intact	No loose bodies	Lateral meniscus debridement and chondroplasty procedure done

3.3. Fracture Healing and Clinical Outcomes

Definitive fixation was achieved using lateral tibial plateau plating in six patients, posteromedial plating in one patient, and combined lateral and posteromedial plating in one patient. Autologous cancellous bone grafting was utilized in **five patients (62.5%)**, primarily for the management of depressed articular fractures.

Radiographic fracture union was achieved in **all eight patients (100%)**, with a mean time to union of **20.8 weeks** (range, 20 - 24 weeks). At the one-year follow-up, knee range of motion ranged from **0˚ - 110˚ to 0˚ - 130˚**, with a mean maximum flexion of approximately **120˚**.

There were no cases of loss of reduction, implant failure, non-union, compartment syndrome, or deep infection. One patient developed a superficial surgical site infection, which was successfully managed with a single surgical debridement and a one-week course of antibiotics. No additional complications were observed during the follow-up period. Clinical outcomes are summarized in Table 3.

Table 3. Summary of fixation method, union, range of motion, and complications.

Case	Fixation Method	Bone Graft	Time to Union (weeks)	Knee ROM at 1 Year	Complications
1	Lateral tibia plateu plating	No bone graft used	20 weeks	0 - 120	No issue
2	Lateral tibia plateu plating	autograft	22 weeks	0 - 130	No issue
3	Lateral tibia plateu plating	autograft	20 weeks	0 - 120	No issue
4	Posteromedial plate	No bone graft used	20 weeks	0 - 130	No issue
5	Lateral and posteromedial plate	Autograft	24 weeks	0 - 110	Complicated with superficial surgical site infection—debrided ×1 and started on antibiotic for 1 week.
6	Lateral tibial plateu plating	Autograft	20 weeks	0 - 120	No issue
7	Lateral tibial plateu plating	autograft	20 weeks	0 - 110	No issue
8	Lateral tibial plateu plating	No bone graft	20 weeks	0 - 120	No issue

A summary of the frequency of individual arthroscopic findings and the procedures performed to treat them, expressed as counts and percentages, is presented in Table 4.

Table 4. Summary of arthroscopic findings.

Variable	n (%)
Meniscal injury	7 (87.5)
Bucket-handle tear	2 (25.0)
Posterior horn/root tear	3 (37.5)
Midbody tear	2 (25.0)
Chondral injury	8 (100)
ACL avulsion	3 (37.5)
Loose bodies	4 (50.0)
Meniscus repair	6 (75)
Meniscus debridement	1 (12.5)
Chondroplasty	8 (100)
ACL avulsion fixation	3 (37.5)

4. Discussion

The principal finding of this case series is that arthroscopic-assisted reduction and internal fixation (ARIF) enabled the identification and simultaneous treatment of associated intra-articular injuries in all patients undergoing surgical fixation of tibial plateau fractures. Although ARIF has traditionally been advocated to facilitate direct visualization of fracture reduction, our findings highlight an equally important advantage: comprehensive assessment and definitive management of concomitant soft tissue injuries during the index procedure. In our series, every patient demonstrated at least one associated intra-articular lesion, including meniscal tears, chondral injuries, anterior cruciate ligament (ACL) tibial avulsion fractures, or intra-articular loose bodies. All lesions were treated arthroscopically during the same operation without the need for staged arthroscopic intervention. Furthermore, all fractures achieved radiographic union, satisfactory knee range of motion was restored at one-year follow-up, and only one patient developed a superficial surgical site infection.

The management of tibial plateau fractures has evolved from focusing solely on osseous reduction to restoring the entire osteochondral and soft tissue environment of the knee [20]-[23]. While conventional open reduction and internal fixation (ORIF) remains the standard treatment for displaced fractures, fluoroscopy alone cannot reliably evaluate the integrity of the menisci, cruciate ligaments, articular cartilage, or detect small intra-articular loose bodies [3] [4] [20]. Consequently, associated injuries may remain unrecognized during fracture fixation and subsequently contribute to persistent pain, instability, mechanical symptoms, restricted motion, or early post-traumatic osteoarthritis [5] [20] [21].

Previous systematic reviews and meta-analyses have consistently demonstrated that ARIF provides clinical and radiological outcomes comparable to conventional ORIF while offering the additional advantage of diagnosing and simultaneously treating associated intra-articular pathology [9] [10] [22]-[24]. These findings are consistent with our series, in which arthroscopy facilitated one-stage management of all associated intra-articular lesions identified during surgery.

One of the most notable findings in our study was the remarkably high incidence of associated intra-articular pathology. Arthroscopy demonstrated concomitant injuries in 100% of patients, including meniscal tears in 87.5%, chondral lesions in 100%, ACL tibial avulsion fractures in 37.5%, and intra-articular loose bodies in 50%. Gardner *et al.* demonstrated a high prevalence of associated soft tissue injuries using preoperative MRI in operatively treated tibial plateau fractures, while Abdel-Hamid *et al.* reported meniscal tears in more than half of patients undergoing arthroscopic assessment [3] [4]. Similarly, Deng *et al.* reported that meniscal tears were identified in approximately two-thirds of surgically treated tibial plateau fractures, emphasizing that concomitant meniscal pathology is considerably more common than previously appreciated [25].

Our findings further support the concept that arthroscopy should not simply be regarded as a tool for confirming fracture reduction. Instead, it functions as a comprehensive diagnostic and therapeutic modality that enables systematic assessment of the entire knee joint while allowing definitive treatment of associated pathology during the index procedure [8] [9] [15] [22].

4.1. Associated Intra-Articular Injuries and the Role of Arthroscopy

The present study demonstrated that all patients had at least one associated intra-articular injury requiring arthroscopic treatment. This finding reinforces the concept that tibial plateau fractures should be regarded as combined osteochondral and soft-tissue injuries rather than isolated osseous fractures [3] [4] [25] [26]. Although fracture morphology can be accurately assessed using computed tomography, associated meniscal tears, chondral injuries, cruciate ligament injuries, and loose bodies may be underestimated or remain undetected until direct arthroscopic visualization is performed [3] [4] [25].

Meniscal injury was the most common associated lesion in the present series, occurring in 87.5% of patients. The predominance of lateral meniscal injuries observed in our study is consistent with the mechanism of valgus and axial loading responsible for most lateral tibial plateau fractures [3] [25] [27]. Previous studies have consistently demonstrated that preservation of the meniscus is associated with superior long-term joint function and reduced progression of degenerative osteoarthritis when compared with meniscectomy [28] [29]. Consequently, arthroscopy provides an important advantage by permitting direct assessment of tear morphology and allowing repair whenever technically feasible.

Chondral injury was identified in every patient in the present study. Previous arthroscopic investigations have similarly reported that cartilage injury is substantially more common than appreciated on conventional imaging [10] [26]. Direct arthroscopic visualization enables accurate assessment of lesion size, stability, and severity according to the Outerbridge classification while facilitating immediate chondroplasty of unstable cartilage flaps. Although the long-term influence of acute chondroplasty on post-traumatic osteoarthritis remains uncertain, stabilization of unstable cartilage may reduce mechanical symptoms and improve the intra-articular environment for rehabilitation [10] [30].

Anterior cruciate ligament tibial avulsion fractures were identified in three patients and treated arthroscopically during the index procedure. Arthroscopic fixation has become an accepted treatment for displaced ACL tibial avulsion fractures because it allows anatomical reduction while simultaneously addressing associated intra-articular pathology [14]-[16]. In our series, performing ACL fixation after definitive fracture stabilization provided a stable osseous construct and avoided potential disruption of the ligament repair during fracture manipulation.

An additional advantage of arthroscopy was the identification and removal of loose osteochondral fragments and intra-articular loose bodies. These fragments may contribute to persistent pain, recurrent effusions, locking, and accelerated cartilage wear if left untreated [30]. Their removal during the index procedure eliminated the need for planned secondary arthroscopy in all patients within our series.

Taken together, these findings suggest that the principal value of arthroscopy extends beyond assisting fracture reduction alone. Instead, arthroscopy provides comprehensive evaluation of the entire knee joint and enables definitive treatment of associated intra-articular pathology during a single operation. This integrated approach may reduce the need for secondary procedures while preserving meniscal function, restoring ligament stability, and optimizing the intra-articular environment for postoperative rehabilitation [8]-[10] [22] [24].

4.2. Modified Arthroscopic-Assisted Surgical Technique

Several arthroscopic-assisted fixation techniques have previously been described, with most authors advocating diagnostic arthroscopy before fracture reduction to assess the articular surface and identify associated injuries [7] [8] [11]-[13]. In contrast, our surgical sequence was intentionally modified by performing preliminary fluoroscopic reduction and temporary K-wire stabilization before arthroscopy.

The rationale for this modification was to provide provisional fracture stability while reducing communication between the joint cavity and the metaphyseal fracture void. Fluid extravasation during arthroscopy-assisted fixation has been recognized as a potential concern, particularly in high-energy fractures with metaphyseal comminution, because excessive irrigation-fluid leakage into the surrounding soft tissues may theoretically increase the risk of compartment syndrome [8] [13]. Although compartment syndrome did not occur in our series, preliminary K-wire stabilization represents a simple and reproducible technical modification that may reduce fluid extravasation while maintaining fracture reduction throughout arthroscopic assessment.

Another important aspect of our technique was delaying definitive plate fixation until satisfactory arthroscopic assessment had been completed. Acute haemarthrosis frequently compromises visualization during arthroscopy of fresh tibial plateau fractures. Thorough arthroscopic lavage effectively removed blood clots and debris, allowing systematic evaluation of all intra-articular structures and accurate confirmation of fracture reduction [7] [11] [12]. Although the independent effect of haemarthrosis evacuation on postoperative functional recovery remains uncertain, removal of the inflammatory intra-articular environment may contribute to improved postoperative rehabilitation and warrants further investigation.

Following definitive plate fixation, repeat arthroscopy was routinely performed to confirm maintenance of fracture reduction, assess articular congruity, and exclude intra-articular screw penetration or secondary displacement. Meniscal repair and ACL tibial avulsion fixation were subsequently performed only after stable fracture fixation had been achieved. This sequence minimized the risk of disrupting repaired soft tissues during plate application and ensured that all intra-articular procedures were performed on a stable osseous construct.

Although the present study was not designed to compare different operative sequences, this modified workflow proved reproducible in all patients and facilitated simultaneous management of associated intra-articular pathology without compromising fracture healing. We believe this technique represents a practical modification of previously described arthroscopic-assisted fixation methods and may be particularly useful in selected tibial plateau fractures associated with depression, metaphyseal comminution, or significant soft-tissue injury.

4.3. Clinical Outcomes and Rehabilitation

Radiographic fracture union was achieved in all patients in the present series, with a mean union time of 20.8 weeks and satisfactory knee range of motion at one-year follow-up. These findings are comparable to previously published arthroscopic-assisted tibial plateau fracture series, which have consistently demonstrated high union rates, restoration of joint congruity, and favorable functional outcomes [9] [10] [22]-[24].

Although standardized patient-reported outcome measures such as the Lysholm Knee Score, IKDC score, or KOOS were not routinely collected in the present study, all patients achieved fracture union and regained functional knee motion ranging from 110˚ to 130˚. These results suggest that stable fracture fixation combined with simultaneous treatment of associated intra-articular injuries can provide satisfactory short-term clinical recovery. However, larger prospective studies incorporating validated functional outcome scores are required to confirm these observations [9] [10] [24].

An important aspect of our management was the use of a standardized rehabilitation protocol for all patients. Since every patient underwent concomitant arthroscopic treatment of associated intra-articular pathology, postoperative rehabilitation was designed to protect both the fracture fixation and repaired soft tissues. Non-weight bearing was maintained for six weeks, followed by gradual progression to partial and full weight bearing according to radiographic fracture healing. Knee flexion was increased in a staged manner to minimize stress on repaired meniscal and ligamentous structures while reducing the risk of postoperative stiffness [17]-[19].

Despite the relatively protective rehabilitation protocol, all patients recovered satisfactory knee motion by one year. We believe several factors contributed to these outcomes, including anatomical restoration of the articular surface, stable internal fixation, preservation of meniscal tissue whenever possible, treatment of associated ligamentous injuries, and systematic arthroscopic evacuation of haemarthrosis. Although the independent contribution of each factor cannot be determined within this study, comprehensive management of both the fracture and associated intra-articular injuries likely facilitated functional recovery.

The overall complication rate in the present series was low. One patient developed a superficial surgical site infection, which resolved following surgical debridement and a short course of antibiotics. No patient experienced deep infection, implant failure, secondary displacement, non-union, neurovascular injury, postoperative compartment syndrome, or reoperation during the follow-up period. These findings are consistent with published systematic reviews demonstrating that arthroscopic-assisted fixation does not increase complication rates compared with conventional ORIF while providing the additional benefit of direct intra-articular assessment [9] [10] [22]-[24].

Although our study was not designed to compare arthroscopic-assisted fixation with conventional ORIF, the consistently satisfactory radiographic healing, restoration of knee motion, and successful treatment of all associated intra-articular injuries support the use of ARIF in carefully selected tibial plateau fractures. Future prospective comparative studies incorporating long-term follow-up, validated patient-reported outcome measures, and cost-effectiveness analyses will further clarify the role of arthroscopy in the management of these challenging injuries.

5. Conclusions

Arthroscopic-assisted reduction and internal fixation represents an effective treatment option for selected tibial plateau fractures by combining accurate restoration of the articular surface with comprehensive assessment of the intra-articular structures. In this case series, arthroscopy identified associated intra-articular pathology in every patient, including meniscal tears, chondral injuries, ACL tibial avulsion fractures, and loose bodies, all of which were successfully treated during the index procedure without the need for planned secondary arthroscopic intervention.

The modified surgical sequence described in this study, incorporating preliminary fracture stabilization before arthroscopic assessment and definitive soft-tissue repair after stable fracture fixation, proved to be safe, reproducible, and clinically effective. All fractures achieved radiographic union with satisfactory knee range of motion at one-year follow-up and a low complication rate.

The findings of this case series support the role of arthroscopy not only as an adjunct for fracture reduction but also as a valuable diagnostic and therapeutic tool for the simultaneous management of associated intra-articular injuries. Larger prospective comparative studies incorporating validated functional outcome measures and long-term follow-up are required to determine whether this comprehensive approach results in superior long-term clinical outcomes compared with conventional fixation techniques.

Author Contributions

Conceptualization, Hrishinilaavenn, Shri Kapilan and Nishand, Azmi and Leong; methodology, Hrishinilaavenn, Shri Kapilan; software, Hrishinilaavenn, Shri Kapilan, Nishand, Azmi; validation, Hrishinilaavenn and Shri Kapilan; formal analysis, Hrishinilaavenn, Shri Kapilan; investigation, Hrishinilaavenn; resources, Hrishinilaavenn, Shri Kapilan.

Data curation, Shri Kapilan, Hrishinilaavenn.

Writing—original draft preparation, Hrishinilaavenn, Nishand, Azmi and Shri Kapilan.

Writing—review and editing, Hrishinilaavenn, Shri Kapilan, Azmi, Nishand and Leong; visualization, Hrishinilaavenn; supervision, Shri Kapilan, Leong YC.

Project administration, Hrishinilaavenn, Shri Kapilan; funding acquisition, Shri Kapilan and Leong YC.

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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