Arthroscopically Assisted Reduction and Internal Fixation for Tibial Plateau Fractures

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Learning Point of the Article:

Arthroscopically assisted reduction and internal fixation (ARIF) provides a minimally invasive yet effective approach for tibial plateau fractures by enabling precise fracture reduction and simultaneous management of intra-articular soft tissue injuries, resulting in improved outcomes and fewer complications compared to traditional methods.

Abstract

Tibial plateau fractures are complex intra-articular injuries resulting from high-energy trauma in young patients or low-energy mechanisms in osteoporotic individuals. Proper management is crucial to restore joint congruity, stability, and function, ultimately preventing long-term complications such as post-traumatic osteoarthritis. Open reduction and internal fixation have been the traditional approach but are associated with significant morbidity, including extensive soft-tissue damage and infection risk. Arthroscopically assisted reduction and internal fixation have emerged as a minimally invasive alternative that allows for precise fracture reduction, direct assessment of intra-articular soft-tissue injuries, and lower complication rates. This review discusses the indications, surgical technique, advantages, limitations, outcomes, and future perspectives of ARIF in the management of tibial plateau fractures.

Keywords: Arthroscopy; Assisted reduction; Tibial plateau; Internal fixation

Introduction

Tibial plateau fractures occur due to a combination of axial loading and varus or valgus forces, resulting in a spectrum of intra-articular injuries, including chondral damage, meniscal tears, and ligamentous instability. These fractures pose a significant challenge in orthopedic trauma due to their potential to disrupt knee biomechanics, leading to long-term disability and joint dysfunction if not managed appropriately. The primary goal of surgical intervention is to restore joint congruity, maintain mechanical alignment, and promote early mobilization to optimize functional outcomes [1]. Open reduction and internal fixation (ORIF) has long been considered the gold standard for managing tibial plateau fractures, offering stable fixation and

reliable anatomical reduction. However, the approach is associated with several drawbacks, including extensive softtissue dissection, risk of wound complications, infection, and prolonged rehabilitation [2]. In contrast, closed reduction and internal fixation (CRIF) minimizes soft-tissue disruption but often falls short in achieving precise articular reduction, particularly in complex fracture patterns involving significant comminution or displacement [3]. Arthroscopically assisted reduction and internal fixation (ARIF) has emerged as a promising alternative, combining the benefits of direct intraarticular visualization with minimally invasive surgical techniques. Arthroscopy enables real-time assessment of articular step-off, allows for the identification and treatment of



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associated meniscal and ligamentous injuries, and facilitates precise reduction of intra-articular fragments while preserving soft-tissue integrity. By minimizing surgical exposure and reducing the risk of post-operative complications, ARIF has demonstrated improved functional recovery and reduced rates of stiffness compared to traditional methods. The growing preference for minimally invasive orthopedic procedures has fueled interest in ARIF as a superior approach for select tibial plateau fractures. However, the technique is not without its challenges, including a steep learning curve, the need for specialized equipment, and potential limitations in addressing highly comminuted fractures requiring extensive stabilization. Despite these concerns, ARIF continues to gain traction in orthopedic trauma surgery, offering a compelling alternative to conventional methods [4]. This review aims to comprehensively examine the role of ARIF in the management of tibial plateau fractures, comparing its efficacy with ORIF and CRIF. It will explore the technical aspects of arthroscopically assisted fixation, discuss its clinical outcomes, and highlight its advantages, limitations, and future applications in orthopedic trauma.

Traditional Treatment Methods: ORIF and CRIF

The surgical management of tibial plateau fractures has traditionally relied on two primary techniques: ORIF and CRIF [5]. Each approach has distinct advantages and limitations, influencing the choice of treatment based on fracture complexity, soft-tissue condition, and surgeon preference.

ORIF involves direct surgical exposure of the fracture site, allowing for meticulous anatomical reduction and rigid internal fixation using plates and screws. This technique provides excellent mechanical stability and ensures precise realignment of displaced fracture fragments. As the most commonly performed surgical intervention for tibial plateau fractures, ORIF is particularly effective in cases of severe comminution or significant articular depression. However, the extensive soft-tissue dissection required increases the risk of complications such as deep infection, wound dehiscence, and delayed healing. Moreover, large surgical incisions contribute to prolonged rehabilitation, often delaying early mobilization and functional recovery [5, 6].

In contrast, CRIF is a less invasive alternative that relies on indirect reduction techniques and percutaneous fixation to stabilize fractures. Reduction is typically achieved using methods such as ligamentotaxis, joystick manipulation, and percutaneous screw fixation, which help realign fracture fragments without the need for extensive surgical exposure. By preserving soft-tissue integrity, CRIF reduces the risk of wound complications and infection. However, it has notable limitations, particularly in cases involving complex intraarticular fractures where precise anatomical restoration is critical. The inability to directly visualize the articular surface may lead to residual malalignment and inadequate fixation stability, resulting in suboptimal functional outcomes and an increased risk of post-traumatic arthritis [7].

ARIF Versus Traditional Methods

Arthroscopically, ARIF represents a hybrid approach that combines the advantages of both ORIF and CRIF while mitigating their respective drawbacks. Unlike ORIF, ARIF requires smaller incisions, significantly reducing the risk of softtissue complications and post-operative infections. Simultaneously, arthroscopic visualization allows for a more accurate reduction of intra-articular fragments compared to CRIF, where indirect reduction techniques may fail to fully restore joint congruity. A key advantage of ARIF is its ability to facilitate simultaneous treatment of associated intra-articular injuries, such as meniscal tears, chondral defects, and ligamentous injuries, which are commonly overlooked in conventional techniques. Addressing these concurrent pathologies during the initial fixation improves long-term joint function and reduces the likelihood of secondary procedures 4.

Clinical studies have demonstrated that ARIF leads to superior post-operative outcomes, including better joint function, lower rates of post-traumatic osteoarthritis, and a faster return to weight-bearing activities. The minimally invasive nature of ARIF, combined with improved visualization and precision, makes it an increasingly preferred option in select cases of tibial plateau fractures. While ARIF requires specialized training and equipment, its benefits in soft-tissue preservation, improved fracture reduction, and enhanced recovery position it as a promising alternative to traditional fixation methods [8].

Indications for ARIF

The indications for ARIF are primarily based on the extent of intra-articular involvement and the necessity for soft-tissue preservation. ARIF is highly suitable for displaced intraarticular fractures requiring anatomical reduction, whereas conventional ORIF may pose risks of excessive soft tissue injury. It is particularly beneficial for fractures with minimal comminution, where precise visualization aids reduction and optimal joint congruity can be maintained. Patients with associated meniscal or ligamentous injuries requiring arthroscopic intervention benefit greatly from ARIF, as these injuries can be simultaneously addressed. In addition, ARIF is preferable for patients at high risk of soft-tissue complications with conventional ORIF, such as those with compromised skin integrity or diabetes [9].

appropriately selected cases [11].

Challenges and Limitations

Surgical Technique

The ARIF procedure involves meticulous planning and execution to ensure optimal outcomes. The patient is positioned supine with the operative limb secured, allowing for efficient arthroscopic access. A tourniquet is applied to the thigh to reduce bleeding and enhance visualization. Standard anterolateral and anteromedial arthroscopic portals are created, allowing access to the joint for diagnostic evaluation. The intraarticular space is thoroughly inspected for associated injuries such as meniscal tears, ligament disruptions, or chondral damage [10].

Fracture reduction is achieved using percutaneous techniques such as joystick manipulation, ligamentotaxis, or balloonassisted elevation. Depressed fragments are elevated under arthroscopic guidance to restore joint congruity, ensuring minimal articular step-off. Once reduction is achieved, fluoroscopy is utilized to confirm the alignment. Fixation is performed using cannulated screws, minimally invasive plate osteosynthesis, or bioabsorbable implants in select cases. If meniscal or ligamentous injuries are identified, appropriate surgical repairs, such as meniscal suturing or ligament reconstruction, are carried out in the same setting. After fixation, the final arthroscopic assessment ensures the absence of residual step-off or impingement. The incisions are closed meticulously, and the limb is immobilized. Post-operative rehabilitation protocols vary based on fracture type and fixation stability [9].

Advantages of ARIF

ARIF offers several advantages over conventional ORIF. Enhanced visualization of the intra-articular structures ensures more accurate reduction, leading to superior functional outcomes. The minimally invasive nature of ARIF significantly reduces the need for extensive soft-tissue dissection, thereby lowering infection rates and wound complications. Simultaneous treatment of meniscal, ligamentous, and chondral injuries enhances overall joint recovery and function. ARIF has been associated with lower rates of post-operative stiffness, deep infections, and implant-related complications compared to ORIF. Furthermore, patients undergoing ARIF typically experience reduced post-operative pain and a quicker return to function, making it an attractive option in Despite its numerous advantages, ARIF has certain limitations. The technique requires significant expertise in arthroscopy and minimally invasive fixation, presenting a steep learning curve for surgeons unfamiliar with these methods. ARIF is not suitable for highly comminuted fractures or cases requiring extensive fixation beyond what can be accomplished arthroscopically. Cost and accessibility remain barriers in many centers, as arthroscopic equipment and trained personnel may not be available. In addition, the longer operative time associated with ARIF in the hands of inexperienced surgeons can impact efficiency in busy trauma centers [12].

Conclusion

ARIF has revolutionized the management of tibial plateau fractures by providing a minimally invasive alternative to ORIF. While it offers several advantages, including superior visualization, reduced soft tissue complications, and faster recovery, careful patient selection and surgeon expertise are crucial to achieving optimal outcomes. As technology continues to evolve, ARIF is likely to become an integral part of orthopedic trauma surgery, providing enhanced treatment options for complex intra-articular fractures.

Clinical Message

• ARIF offers a minimally invasive yet highly effective approach for managing tibial plateau fractures by allowing precise intra-articular fracture reduction and simultaneous treatment of meniscal or ligamentous injuries, leading to better functional outcomes and fewer complications compared to ORIF

• Enhanced arthroscopic visualization in ARIF facilitates accurate anatomical restoration of the joint surface while minimizing soft-tissue trauma, thereby reducing the risk of post-operative infections, joint stiffness, and the need for secondary procedures

• Careful case selection and surgical expertise are crucial for successful ARIF outcomes, especially in fractures with minimal comminution or those accompanied by soft-tissue injuries; however, the technique may not be suitable for highly comminuted or complex fractures.



Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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