

## Arthroscopy- Assisted Surgery for Tibial Plateau Fractures

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Like other intra-articular fractures, the tibial plateau fracture is challenging for orthopedic surgeons because of its severity of trauma, associated soft tissue injuries. Open reduction incurs serious complications, especially wound healing after traditional dissections. Unsatisfactory results often occur in complex or bicondylar tibial plateau fractures. Traditional surgical methods achieved satisfactory results in 70–80% of cases. However, these methods have a high incidence of complications including loss of reduction, infection, and septic arthritis. The advantages of arthroscopy-assisted reduction and internal fixation include direct visualization of intra-articular fracture, accurate fracture reduction, and reduced morbidity. It is straightforward in the diagnosis and treatment of meniscal and ligamentous injuries, and removal of loose fragments. Good early to medium-term results of arthroscopically assisted osteosynthesis of tibial plateau fractures have been reported. The author reviews the current surgical principles, pitfalls, approaches, clinical results, and complications of arthroscopy-assisted surgery for tibial plateau fractures. (*Chang Gung Med J* 2011;34:239-47)



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**Key words:** tibial plateau fracture, arthroscopy-assisted reduction, soft tissue injury

Like other intra-articular fractures, tibial plateau fracture is challenging for orthopedic surgeons because of the severity of trauma, and associated soft tissue injuries. Although tibial plateau fractures comprise only 1% of all fractures, the displaced fractures, and the associated injuries, can cause severe consequences if not properly treated.<sup>(1)</sup> Non-operative management has historically been the preferred treatment for such fractures.<sup>(2,3)</sup> However, to avoid prolonged immobilization and unstable reduction, surgical treatment is now the preferred treatment for displaced fractures. In any case, successful results depend on the quality of reduction, ligament stability, treatment of associated soft tissue injuries, and

preservation of the soft tissue envelope. Additionally, good visualization of the articular surface with minimal dissection can help to achieve this goal.<sup>(3-6)</sup> Open reduction involves numerous complications and risks, especially in wound healing, after traditional dissections. Unsatisfactory results most often occur in complex or bicondylar tibial plateau fractures. Previous surgical methods achieved satisfactory results in only 70–80% of cases. Unfortunately, they also have a high incidence of complications including loss of reduction, pin tract infections, deep infection, and septic arthritis.<sup>(3-5)</sup> Surgical treatment has evolved, and arthroscopy-assisted minimal invasive surgery is now the attrac-

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tive option among available surgical treatments.

The advantages of arthroscopic reduction and internal fixation for tibial plateau fractures are direct visualization of intra-articular fractures, accurate fracture reduction, reduced morbidity in comparison with arthrotomy, simplified diagnosis and treatment of meniscal and ligamentous injuries, thorough-joint lavage, and removal of loose fragments. Good early to medium-term results of arthroscopically-assisted osteosynthesis of tibial plateau fractures have been reported.<sup>(6-16)</sup> The present study reviews the surgical principles, pitfalls, approaches, clinical results, and complications commonly associated with arthroscopy-assisted surgery for tibial plateau fractures.

## Method

### *Surgical indication*

Tibial plateau fractures were categorized using the Schatzker classification system.<sup>(17)</sup> Indications for operative fixation included any varus instability exceeding 10° of medial tibial plateau fracture at full extension, lateral plateau fracture with valgus instability exceeding 10°, articular step-off exceeding 3 mm, or tibial condylar widening exceeding 5 mm.<sup>(18)</sup> Patients were excluded if they had any of the following features: a pathologic fracture, open growth plates, open fracture, severe head injury (initial Glasgow coma scale score of < 8), and severe systemic illness (active cancer, chemotherapy, hemophilia, or a medical contraindication for surgery).

### *Preoperative evaluation*

Preoperative evaluations included a detailed history and physical examination of the soft tissue envelope, the sensorimotor function of the limb, and vascular status of the pulsations over the dorsalis pedis and posterior tibialis arteries. All patients underwent plain-film study in anteroposterior and lateral views as well as computerized tomography of the knee. Computed tomography (CT) was the standard imaging for intra-articular fractures and was used in cases where additional assessment of intra-articular injuries was needed, particularly articular depression or comminution of fracture. In patients with complex tibial plateau fractures that had significant soft tissue trauma (swelling, ecchymosis, blistering, or abrasion), a calcaneal traction was first applied to allow the soft tissue injuries to be stabilized (Fig. 1). The



**Fig. 1** In patients with complex tibial plateau fractures that had significant soft tissue trauma (swelling, ecchymosis, blistering, or abrasion), a calcaneal traction was placed first to allow the soft tissue time to stabilize.

readiness of the soft-tissue envelope was determined by resolution of swelling marked by the return of skin wrinkles, reepithelialization of fracture blisters, and reduction of edema.<sup>(19)</sup> When the soft tissue was determined to be ready, the formal arthroscopy-assisted reconstruction was performed using minimal stripping and dissection to ensure the safe and effective stabilization of the affected bone.

### *Surgical Technique*

The patients were positioned supine on the operating table under general endotracheal anesthesia. Before surgery, a complete knee examination was performed. A pneumatic tourniquet was applied to the thigh, but a leg holder was not required because most arthroscopic manipulation was conducted in the “figure of 4” position. The anterolateral and anteromedial portals were used as the working portals. The inflow fluid was infused by gravity to avoid extravasation. The arthroscopic examination permits evacuation of hematoma and loose bodies. The capsuloligamentous structures were then probed, and the associated intra-articular lesions were evaluated. Incisions were made on the side of the fracture directly medial lateral (Type I-IV), starting from approximately 1 cm proximal to the articular surface and extending approximately 8 cm distally. The tibial metaphysis was carefully exposed, and care was taken to avoid arthrotomy and minimize periosteal stripping. The depressed fragments were located with a standard anterior cruciate ligament (ACL) tibial guide and a Kirschner wire was inserted through the metaphysis into the center of the displaced frag-

ment. This technique permits accurate placement of the cortical window, through which the subchondral bone and articular surface can be elevated. The resulting bone defect was then filled with either autogenic or allogeneic bone graft. The tibial plateau was reduced under direct vision via arthroscopy before fixation with a buttress plate.<sup>(8)</sup>

***Arthroscopically-assisted reduction with bilateral buttress plate fixation (ARBF) of complex tibial plateau fractures (Schatzker type V and VI)***

In bicondylar fractures (Types V and VI), two incisions are made as far apart as possible, and similar procedures were used for reduction. This surgical approach has the benefits of less soft tissue dissection and avoids arthrotomy in traditional open technique. The less comminuted condylar fracture is approached first, usually the medial side. The skin incision is extended proximally 1 cm proximal to the medial articular surface and 5 cm distally. The metaphysis of the tibia is then meticulously exposed. The ACL tibial guide is used to insert a Kirschner wire through the metaphysis and into the center of the displaced fragments. This allows accurate placement of the cortical window below the level of the fracture. A cannulated impactor or bone tamp is then used to elevate the subchondral bone and articular surface under arthroscopical visualization of fracture reduction. The resultant bone defect is grafted with either autogenic or allogeneic bone graft. In cases with split rather than split-compression condylar involvement, especially medially, the joy stick technique for fracture fixation is performed.<sup>(6)</sup> A Kirschner wire is introduced into one of the larger fragments to facilitate manipulation. When appropriate reduction is achieved, internal fixation with AO/ASIF buttress plate (Synthes, Bochum, Switzerland) is applied. For lateral condylar fractures, the same surgical technique is utilized. This includes arthroscopic reduction, bone grafting, and buttress plate fixation of the lateral tibial plateau fracture. After bicondylar fractures of the tibial plateau are fixed with dual buttress plates, fracture reduction can be verified with assessed arthroscopy or radiography. In some cases, interfragmental screws are needed to stabilize the larger fragments. When dual buttress plates are used, intra-operative radiographs are taken to confirm adequate reduction.<sup>(11,12)</sup> After arthroscopic joint irrigation, the incisions are closed. Compressive ice and a

postoperative knee brace are applied.

***Management of associated soft tissue injuries***

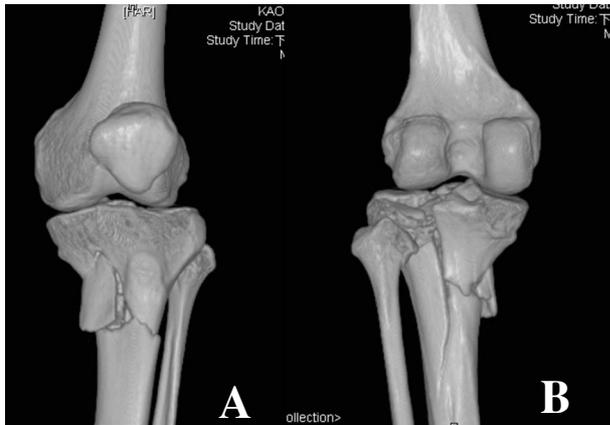
Concomitant injury is another important factor. The incidence of ligament and meniscus injuries were reported as high as 71%.<sup>(20-22)</sup> The associated intra-articular pathologies are treated appropriately after fracture fixation. Meniscal tears are repaired if the tear is within 5 mm of the meniscosynovial junction. The author prefers the inside-out technique using meniscal repair cannulas for the middle one-third to posterior one-third and outside-in technique for anterior one-third horn tears. Anterior cruciate ligament (ACL) avulsion fracture is treated by arthroscope-assisted fixation in one-stage. Elective reconstruction of ACL tear is performed after fracture has healed (Fig. 2-8).<sup>(22)</sup>

***Postoperative rehabilitation***

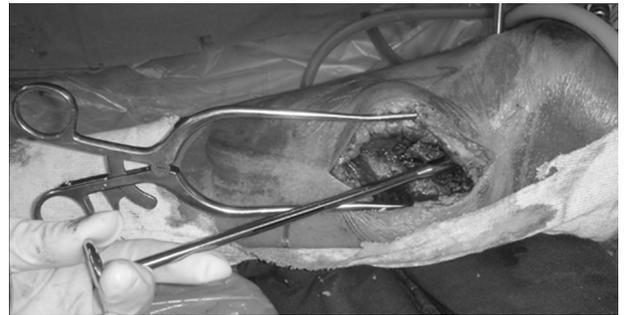
Immediate postoperative care includes compressive cryocuff therapy and a knee brace. Non weight-bearing ambulation is restricted to the use of crutches or walkers until radiographic evidence of healing is noted. The average time for fracture healing is approximately 3 months. At that time, ambulation



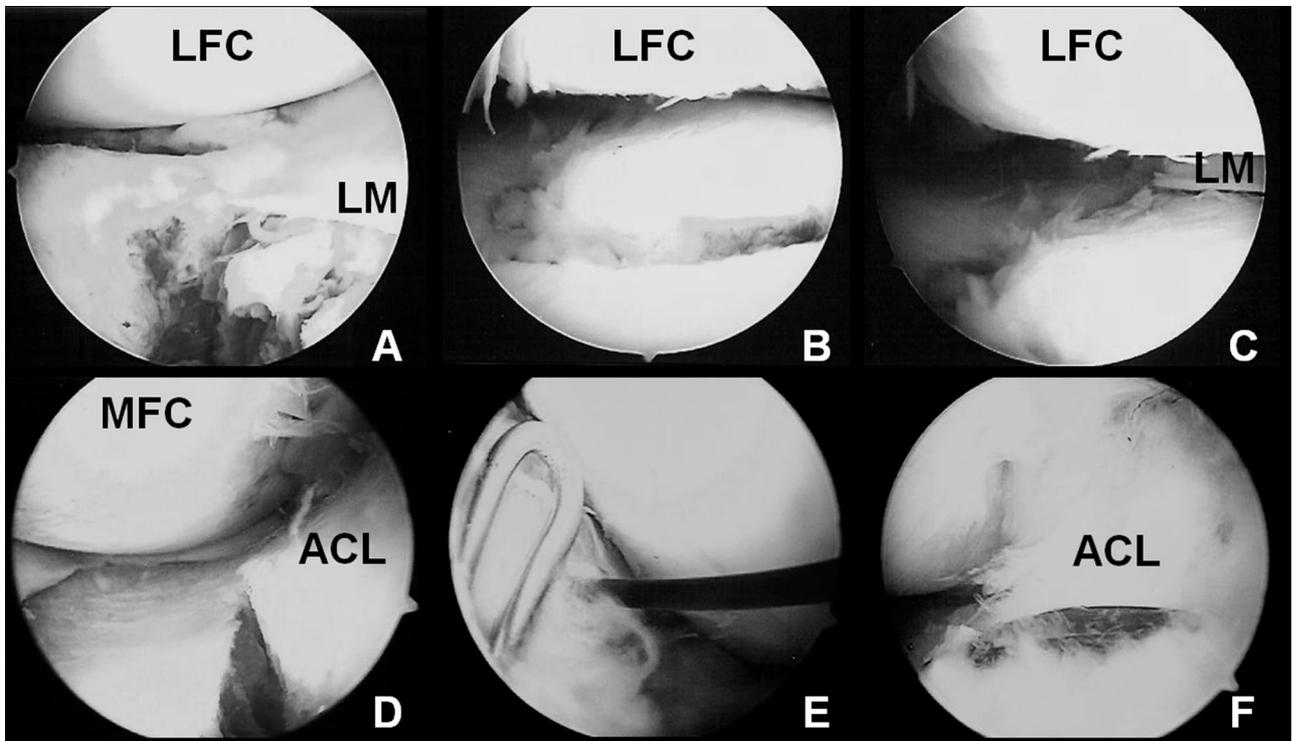
**Fig. 2** A 32-year-old woman, who was a victim of a motorcycle accident, had a Schatzker type VI tibial plateau fracture. (A) and (B) Plain radiographs (anteroposterior and lateral views) show bicondylar fractures with diaphyseal extension.



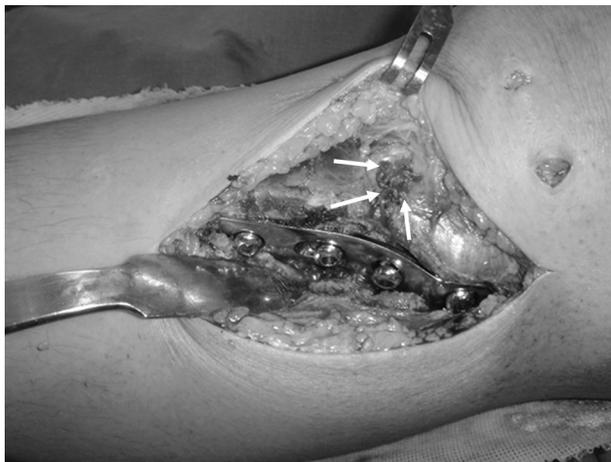
**Fig. 3** (A) Through viewing the anterior section of the computed tomography (CT) scan, the comminuted articular surface is demonstrated. (B) The posterior section of the CT scan shows severe depression of the bicondylar articular surface.



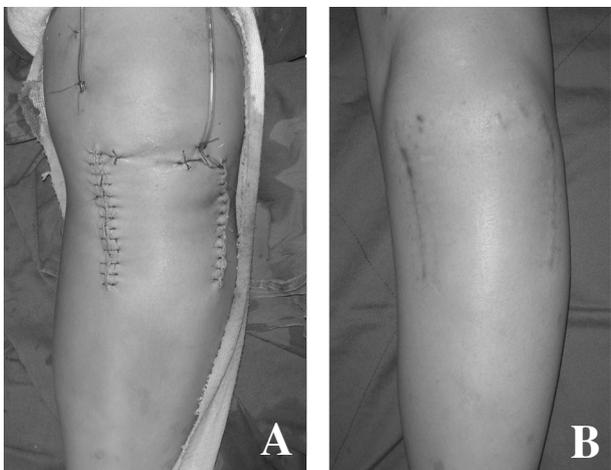
**Fig. 4** A cannulated impactor was used to elevate the subchondral bone and articular surface while arthroscopically visualizing the reduction. The resultant bone defect was grafted using either autogenic iliac crest bone graft or allogeneic bone graft alone.



**Fig. 5** Intraoperative arthroscopic view. (A) Preoperative arthroscopic view. Depression of the lateral tibial plateau is evident. (B) The depressed portion of tibial articular cartilage is elevated with assistance of the ARBF technique. (C) The articular surface after arthroscopic reduction, bone grafting, and rigid fixation. (D) The management of ACL avulsion fracture. (E) Arthroscopically assisted fixation by pullout suture. (F) Four No. 5 Ethibond sutures were tied firmly at the proximal tibial site and good reduction could be visualized by arthroscopy. Abbreviations used: LFC: lateral femoral condyle; MFC: medial femoral condyle; LM: lateral meniscus; ACL: anterior cruciate ligament.



**Fig. 6** Four No. 5 Ethibond sutures for the management of ACL avulsion fracture were tied firmly at the proximal tibial site (white arrowheads) after lateral buttress plate fixation for tibial plateau fracture.

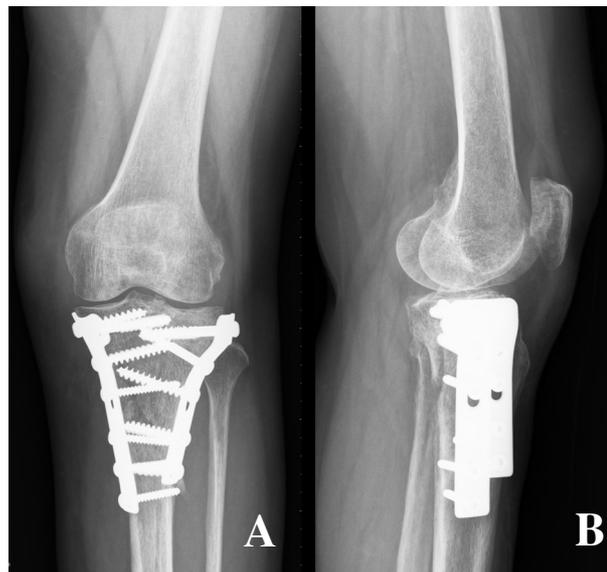


**Fig. 7** 2 Longitudinal wounds on either side of the leg after arthroscopy-assisted reduction with bilateral buttress plate fixation surgery. (A) The 2 longitudinal wounds at a point in time that was 1 month postoperatively. (B) No knee arthroscopy or extensive soft tissue dissection was performed in the patient.

with partial weight-bearing is allowed for 2 weeks, then full weight-bearing is permitted.

#### **Clinical and radiological results**

Chan et al. reported satisfactory (excellent to good) results in 96% of 54 cases at a 2 to 10-year follow-up when Rasmussen system score is used.<sup>(12,23)</sup>



**Fig. 8** After follow-up for more than 2 years, the plain radiographs (A, anteroposterior and B, lateral views) showed solid bone union with normal alignment. The knee joint was very stable. There was no joint surface depression or post-traumatic osteoarthritic changes in this case. The surgical outcome was excellent and patient satisfaction with the treatment (arthroscopy-assisted reduction with bilateral buttress plate fixation) was high.

The results are better than those treated with open reduction and internal fixation. Other studies report good results in 80–90% of cases using different rating systems.<sup>(3,4,17,24,25)</sup> Fracture type did not significantly influence the functional results in this ARIF series. Radiologically, 10 (19%) of the 54 knees showed secondary osteoarthritis on standing films at a mean follow-up of 7 years.<sup>(12)</sup> This change was mild in 7 knees and moderate in 3 knees. This success rate was lower than the 42% reported by Rasmussen after wire loop fixation at an average follow-up of 7.3 years and the 64% reported by Honkonen after open osteosynthesis of the tibial plateau at a mean follow-up of 7.6 years.<sup>(21,23)</sup> This ARIF method has the least dissection and the greatest precision in restoring articular congruity and may achieve the best results. Moreover, none of the 54 patients in this series had undergone total meniscectomy.<sup>(12)</sup> As advocated by others,<sup>(8,11,12,26,27)</sup> arthroscopic meniscal repair or minimal resection is performed whenever possible. This may account for the lower incidence of degenerative changes in the ARIF series.<sup>(8,11,12,26,27)</sup> However, a long-

term follow-up is needed for a final conclusion.

Bicondylar fractures tend to have less favorable results than those of monocondylar fractures.<sup>(24,25)</sup> Traditionally, the methods of treatment used for bicondylar fractures include skeletal traction with cast bracing, open reduction, internal fixation with bilateral buttress plates,<sup>(28-30)</sup> indirect reduction with percutaneous techniques, limited internal fixation, and hybrid external fixation.<sup>(31-35)</sup> Closed treatment for complex plateau fractures yields unsatisfactory long-term results in up to 70% of patients. The previous surgical methods had satisfactory results of between 70% and 82%. But, they have a high incidence of complications including loss of reduction, pin tract infections, deep infection, and septic arthritis.<sup>(31-36)</sup> Stamer et al reported 70% good to excellent results when treating 23 knees in 22 patients with Schatzker VI injuries.<sup>(32)</sup> They obtained an acceptable reduction and fixation percutaneously in 39% of the patients with a 100% infection rate when extensive dissection was performed to allow the use of a plate in conjunction with external fixation. Six of the 23 knees (26%) experienced complications, including 3 deep wound infections, 1 deep vein thrombosis, 1 malunion, and 1 pin tract infection.<sup>(32)</sup> Weiner et al were able to obtain a closed reduction in one-third of their patients although the other two-thirds required arthrotomy to obtain an acceptable reduction.<sup>(36)</sup> They documented 82% good to excellent results. Dendrinis et al treated 24 patients with high-energy tibial plateau fractures and successfully reduced 50% with ligamentotaxis and percutaneous techniques.<sup>(37)</sup> Seventy-five percent of patients obtain good or excellent results. Although deep infections, and significant wound problems, can be greatly reduced through the use of hybrid or unilateral frames, pin tract infections occur in as much as 38% of patients.<sup>(31-37)</sup> Septic arthritis has also been reported in as much as 10% of patients.<sup>(31-37)</sup> The author developed a new surgical technique (ARBF) for the treatment of complex tibial plateau fractures.<sup>(11,12)</sup> In the current study, 15 (83%) of patients reported that they had returned to work and 13 (72%) could return to their previous activity level, including sports. All patients were able to bear full weight on the affected joint within 12 weeks.<sup>(11)</sup> Through the use of this method, 16 out of the 18 (89%) patients had good to excellent results at a mean follow-up of 3 years. There were 13 of 18 patients (72%) in Chan's study

that had associated intra-articular lesions. A similar high incidence has been reported previously.<sup>(8,11,12,26,27)</sup> During ARBF surgery, diagnosis and treatment of most associated lesions can be carried out immediately. By doing so, a major cause of poor results in the treatment of tibial plateau fractures can be eliminated and the need for a second procedure can be reduced.

#### ***Safety and complications in ARIF surgeries for tibial plateau fractures***

Although the theoretical danger of compartment syndrome complicating arthroscopy for tibial plateau fracture warrants some caution, only 1 case of compartment syndrome in the leg following arthroscopic examination of a tibial plateau fracture has been reported.<sup>(38)</sup> Every patient should be preoperatively evaluated in detail. We recommended that surgical treatment should be delayed until the subsidence of swelling. A quick bone window and adequate intra-operative fluid drainage was performed in order to allow decompression to occur. Tourniquet time was minimized (often below 2 hours). Arterial supply and venous outflow were also maximized through the use of this procedure. After deflating the tourniquet, the legs were examined for pulse and distal circulation in the feet. If compartment syndrome is suspected, the compartmental pressure should be measured in all 4 compartments using a compartment measurement device.

Another major concern of traditional open reduction was the soft tissue condition and wound infection, which can occur in as high as 50% of all cases.<sup>(24,25,34,35,39)</sup> Operative treatment of high-grade tibial plateau fractures is reported to be frequently complicated by deep infection, wound dehiscence, and soft tissue complications. The overall prevalence of these complications can be noted in previous studies: 23% of bicondylar fractures reported by Schatzker et al.,<sup>(17)</sup> 23% by Moore and Harvey,<sup>(40)</sup> 80% reported by Mallik et al.,<sup>(41)</sup> and 87.5% reported by Young and Barrack.<sup>(39)</sup> These high incidence of wound complications may be related to the failure to recognize soft-tissue damage and inappropriate timing in acute surgical intervention through a soft-tissue envelope that is not ready to accept a second injury. We are able to gain access to, treat soft-tissue injuries, as well as monitor, the condition of the soft-tissue envelope. This allows us to assess when enough recovery time

has occurred to allow definitive fracture stabilization. The readiness of the soft-tissue envelope was determined by the resolution of swelling marked by the return of skin wrinkles, reepithelialization of fracture blisters, and reduction of edema.<sup>(18)</sup> No deep infection attributable to ARIF surgery with the least amount of soft tissue dissection was noted in the current series.<sup>(8,11,12,26,27)</sup>

#### **Learning curve for ARIF surgeries**

ARIF surgery for tibial plateau fractures is a technically demanding procedure, and requires learning experience. The learning curve for ARIF surgery is much longer than open techniques. Adequate experience in arthroscopy is mandatory. Clear visualization during arthroscopy-assisted surgery is vital for effective fracture reduction and management of associated soft tissue injuries. Patients with poor bone quality or fractures with severe comminution may require a single buttress plate fixation with bone grafting. In Type V and VI pattern fractures, dual buttress plate fixation can be applied through medial and lateral metaphyseal incisions.

#### **Conclusion**

Tibial plateau fractures exhibit a wide range of associated injuries. Meniscal injury (peripheral tear) was the most common lesion. Bony avulsions of the anterior cruciate ligament should be repaired arthroscopically following fracture fixation, while the reconstructive surgeries of midsubstance injuries of the anterior or posterior cruciate ligament should be delayed. Arthroscopy is recommended for all tibial plateau fractures. In cases of tibial plateau fractures, the best results can be achieved using arthroscopically assisted osteosynthesis of the fracture combined with arthroscopic management of the associated soft tissue injuries. It is a safe, reproducible, and effective procedure.

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## 微創性膝關節脛骨平台骨折關節鏡復位固定手術

詹益聖

膝關節脛骨平台骨折的處理，對骨科醫師而言，是比較棘手的問題。主要往往是患肢承受劇烈撞擊，導致其膝關節脛骨平台粉碎性骨折、移位並合併軟組織受損(韌帶、軟骨、肌肉、皮膚及神經)。傳統的開放式手術方式(Open reduction and internal fixation)需做較廣泛的軟組織破壞，其感染率高、病患術後患肢疼痛導致彎曲不良、關節僵硬、骨折未癒合、骨折不良癒合合併變形等諸多併發症；而以放射線做導引微創性骨折復位固定手術，嚴格來說並不能達成完美骨折復位的目標，更重要的是無法處理其合併高比率軟組織受損的問題。為了解決上述病患的痛苦與降低其手術併發症，在長庚醫院的大力配合與骨科部全體同仁的支持下，筆者研發出全球首創、獨步全國的微創性膝關節脛骨平台骨折關節鏡復位固定手術。綜合文獻回顧與臨床研究報告比較，微創性膝關節脛骨平台骨折關節鏡復位固定手術，較傳統的開放式手術方式，有更佳的治療效果，是個非常有效且安全的方法，值得大力推廣應用，嘉惠更多病患。(長庚醫誌 2011;34:239-47)

**關鍵詞：**膝關節脛骨平台骨折，關節鏡關節鏡復位固定，軟組織受損