Current Concepts

Part I: Arthroscopic Management of Tibial Plateau Fractures

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Abstract: Arthroscopy is a valuable tool for the assessment of tibial plateau fractures and is the treatment of choice for associated intra-articular pathology. In addition, (all)-arthroscopic reduction and internal fixation (ARIF) is recommended for type III fractures and is a consideration for types I, II, and IV. Published outcome studies of ARIF of tibial plateau fractures describe results that appear to equal outcomes of open reduction and internal fixation, but these studies suffer from susceptibility bias. Key Words: Arthroscopy—Tibial plateau fracture—Treatment—Technique.

Management of fractures of the tibial plateau can be challenging for orthopaedic surgeons. Traditional treatment methods included cast immobilization, skeletal traction, or open reduction and internal fixation (ORIF). With the evolution of minimally invasive surgical techniques, arthroscopic evaluation of tibial plateau fractures provided a valuable adjunct to open treatment. Now, (all)-arthroscopic reduction and internal fixation (ARIF) of tibial plateau fractures is the developing state-of-the-art. In Part I of this Current Concepts review, we consider current and emerging understanding of ARIF of tibial plateau fractures.

ANATOMY

The knee is the largest joint in the body. Knee function requires stability, range of motion in bending and rotation, and transmission of large muscular loads. The tibia is the major weight-bearing bone of the knee joint. At its proximal articular surface, the tibia widens to form the medial and lateral condyles. Between the condyles, the intercondylar eminence serves as the site of attachment for the fibrocartilaginous menisci and the anterior and posterior cruciate ligaments. The relatively flattened condylar portions of the proximal tibia comprise the weight bearing aspects of the plateau. The medial and lateral condyles articulate with corresponding medial and lateral femoral condyles. Anatomically, the medial tibial plateau is larger and stronger than the lateral tibial plateau. This may explain why lateral condylar tibial plateau fractures occur more frequently than medial condylar fractures.

EPIDEMIOLOGY

Fractures of the tibial plateau constitute approximately 1% of all fractures and generally occur as a result of trauma such as a fall or a motor vehicle versus pedestrian accident. Approximately 5% to 10% of tibial plateau fractures are sports related, and proximal tibial fractures are especially common in skiers.

MECHANISMS OF INJURY

Fractures involving the tibial plateau can result from forces directed medially, laterally, or axially. Forces directed medially (valgus force moment) are often classic “bumper fractures” (motor vehicle versus pedestrian accidents). More complex mechanisms in-
volve combinations of both axial and varus or valgus directed forces. In most cases, the medial or lateral femoral condyle acts as an anvil imparting a combination of both shearing and compressive force to the underlying tibial plateau.4

EVALUATION

A patient with a fracture of the tibial plateau generally presents with a painful, swollen knee injured as a result of some traumatic event.6 Usually, the patient is unable to bear weight on the affected leg, although this is not always the case.6 Occasionally, the patient can accurately describe the precise mechanism of injury, as in bumper injuries or accidents sustained playing football or soccer, while skiing, or in a fall. However, patients are not usually able to describe the precise mechanism.3

Despite the common inability to rely on a patient’s history when determining the specific mechanism of injury of a tibial plateau fracture, it is useful to ascertain the level of force involved in the injury, specifically high-energy or low-energy forces.3 This is not a purely academic point: associated injuries such as fracture blisters, compartment syndromes, disruptions of the menisci or ligaments, or injuries to adjacent nerves and blood vessels occur most often in association with high-energy forces.3

On examination of the affected extremity, there is limitation of both active and passive knee motion as a result of pain and swelling. In addition to pain and swelling, voluntary or involuntary muscle guarding or spasm may cause difficulty in clinical determination of the status of the ligaments or the extent of the fracture. Despite this limitation, an effort to examine the patient in order to determine associated ligamentous damage is recommended. In all cases, careful attention must be paid to peripheral pulses, neurologic function, and the status of the compartments of the injured extremity. Any open wounds must also be carefully evaluated to ascertain their relationship to the fracture site or joint space.3

IMAGING

Radiographic evaluation must include anteroposterior, lateral, and 2 oblique views. To assess the slope of the tibial plateau and the degree of articular depression, a 15° caudal tibial plateau view may also be helpful. However, measurement of the amount of depression of the fractured tibial plateau using standard radiographs may be inaccurate. (In addition, standard radiographs are not considered the best studies to evaluate healing after either closed or open treatment of tibial plateau fractures.9)

Axial computed tomography (CT) combined with coronal sagittal plane reconstructions provides precise information regarding the extent and pattern of both articular and extra-articular components of the fracture.9 However, CT is limited in that the soft tissue of the knee may not be visualized adequately.3

Magnetic resonance imaging (MRI) is the examination of choice for soft tissue injuries in association with tibial plateau fractures. MRI is an especially valuable preoperative planning tool because the status of the menisci or ligaments is difficult to ascertain when pain prevents a reliable physical examination.7

In summary, CT scanning is the standard for evaluating bony injury including articular depression, and MRI is the standard for evaluating associated soft tissue injury, such as meniscal, ligamentous, or chondral injury, in association with fractures of the tibial plateau. Use of arteriography is a consideration when there is any alteration in the distal pulses and is indicated in cases of knee dislocation or when the possibility of arterial injury is a concern.3 Schatzker type IV, V, or VI tibial plateau fractures (discussed later) and injuries sustained as a result of high-energy trauma or in association with compartment syndrome should also alert the surgeon to consider an arteriogram. Of note, ultrasound evaluation is not recommended as an alternative to arteriography, because ultrasound does not reliably detect intimal arterial damage.3

Diagnostic arthroscopic evaluation allows direct visualization of the menisci, cruciate ligaments, and articular surfaces including the articular portion of the fracture site.1,3,8,9 In addition to its diagnostic role, arthroscopy may be useful for treatment (discussed later) with a goal of precise reduction of fracture fragments under direct visualization.

CLASSIFICATION

The most commonly accepted classification scheme in current use is that described by Schatzker.3,10 The Schatzker classification owes a debt to the landmark work by Hohl and Moore.11 The Schatzker classification (Fig 1) divides tibial plateau fractures into 6 types based on fracture pattern and fragment anatomy.

Type I is a wedge or split fracture of the lateral aspect of the plateau, usually as a result of valgus and axial forces. With this pattern, there is no compression (depression) of the wedge fragment because of strong
underlying cancellous bone. This pattern is usually seen in younger patients.

Type II is a lateral wedge or split fracture associated with compression. The mechanism of injury is similar to that of a type I fracture, but the underlying bone may be osteoporotic and unable to resist depression, or the forces may be greater.

Type III is a pure compression fracture of the lateral plateau. As a result of an axial force, the depression is usually located laterally or centrally, but it may involve any portion of the articular surface.

Type IV is a fracture that involves the medial plateau. As a result of either varus or axial compression forces, the pattern may be either split or split and compression. Because this fracture involves the larger and stronger medial plateau, the forces causing this type are generally greater than those associated with types I, II, or III.

Type V fractures include split elements of both the medial and lateral condyles and may include medial or lateral articular compression, usually as a result of a pure axial force occurring while the knee is in extension.

Type VI is a complex, bicondylar fracture in which the condylar components separate from the diaphysis. Depression and impaction of fracture fragments is the rule. This pattern results from high-energy trauma and diverse combinations of forces.

ASSOCIATED INJURIES

Associated injuries are common with fractures of the tibial plateau and may include injury to the menisci, ligaments, or articular surfaces of the femur, tibia, or patella. Although tibial plateau fractures may occur as isolated lesions, concurrent injuries are the rule. In cases of disruption of the lateral collateral ligament complex, injuries to the peroneal nerve or the popliteal vessels may be associated with greater frequency.

Up to 47% of knees with closed tibial plateau fractures have injuries of the menisci that may require surgical repair; it is difficult to predict the degree of meniscal injury based on fracture pattern alone. Up to 32% of knees with tibial plateau fractures have complete or partial tears of the anterior cruciate ligament (ACL).

The tibial intercondylar eminence is often avulsed in association with fractures of the tibial plateau. In addition, isolated intercondylar eminence (ACL avulsion) fractures may be considered a unique tibial plateau fracture pattern. Tibial intercondylar eminence fractures will be considered in Part II of this Current Concepts review.

MANAGEMENT

The ultimate goals of tibial plateau fracture treatment are to re-establish joint stability, alignment, and articular congruity while preserving full range of motion. In such a case, painless knee function may be obtained and post-traumatic arthritis could be prevented.

Not all fractures of the tibial plateau require surgery. The first challenge in the management of upper tibial fractures is to decide between nonoperative or surgical treatment.

Fractures that are stable and are minimally displaced may be amenable to cast immobilization, or bracing may allow early motion (and delayed weight bearing). Other indications for nonoperative treatment may include injuries to the peripheral (submeniscal) rim of the plateau and fractures in elderly, low-demand, or osteoporotic patients.

Advantages of nonsurgical treatment include a short hospital stay and no risk of sepsis. However, prolonged immobilization (greater than 2 or 3 weeks) can result in unacceptable joint stiffness. If traction is a viable option, good motion may be obtained but at the cost of a lengthy hospital stay and the risk of a pin-tract infection. In addition, there are inadequate data on the amount of articular depression and displacement that may lead to post-traumatic arthritis. Finally, pain during recovery after closed treatment can be as severe as with open procedures, especially in cases with prolonged hemarthrosis.

When considering nonoperative treatment, a CT scan of the affected extremity should be obtained because occult articular depression might change the plan from a closed to an open approach. As part of
the closed treatment plan, patients should be followed-up with imaging studies every 2 weeks for the first 6 weeks to monitor alignment and healing, and activities should be restricted for 4 to 6 months.6 Possible complications of nonoperative treatment may include limited range of motion, pulmonary embolism, phlebitis, instability, and post-traumatic arthritis.14

When articular compression or fracture displacement exists, surgery is required to restore joint congruity and alignment, to stabilize the knee, and to allow early joint motion.6,7 Recommendations regarding absolute indications for operative versus nonoperative management vary. Some investigators suggest that fracture displacement ranging from 4 to 10 mm may be treated nonoperatively, whereas others state that surgery is essential for articular depression greater than 3 or 4 mm.3 In addition, in cases of nondisplaced but unstable fractures, rigid internal fixation may still be considered for active patients and athletes in whom early range of motion is a priority.

ORIF using buttress plates and/or cancellous lag screws has been the mainstay of the treatment of displaced tibial plateau fractures. This technique may be applied to practically every type of tibial plateau fracture, so long as the soft tissue envelope permits surgical intervention.6 External fixation of tibial plateau fractures may also be considered as a treatment option.15

THE ROLE OF ARTHROSCOPY

Arthroscopy is accepted as a valuable adjunct in the treatment of some tibial plateau fractures. While ORIF has been the recent standard of care for displaced or compressed fractures,6 ARIF may represent a viable alternative to open surgery and may reduce morbidity associated with fracture repair.9,16 Arthroscopy is minimally invasive in comparison with ORIF.7 In addition, arthroscopy allows for accurate fracture reduction while obviating the need for extensive operative exposure.14 In some regards, arthroscopy narrows the gap between the extremes of open versus nonoperative management.

There are additional advantages to arthroscopic treatment of tibial plateau fractures. The entire articular surface may be visualized without the extensive dissection required for traditional ORIF.7 Specifically, there is no need for meniscal detachment and repair as compared with open treatment requiring arthrotomy. The arthroscope allows for evacuation of hemarthrosis and any fracture debris.5 In addition, arthroscopic treatment of meniscal and ligamentous injuries is often superior to repair or reconstruction using larger, open incisions.5,7 Arthroscopy may offer the advantages of more rapid recovery, reduced pain, early full range-of-motion, improved fracture healing, and more complete and functional recovery.6,7,14 Finally, patients with healed but symptomatic fractures may often benefit from arthroscopic intervention.17

The tibial plateau fracture patterns most amenable to ARIF, in the experience of the authors, include Schatzker types I to IV (fractures with split, split and compression, or pure compression) as well as tibial intercondylar eminence avulsions. We acknowledge that percutaneous lag or buttress screws, percutaneous plates, or even open buttress plating may be required in such cases, and we specifically define ARIF as surgery where anatomic reduction and rigid internal fixation is achieved without (a large or submeniscal) arthrotomy.

More complex or higher-energy injury patterns (Schatzker types V or VI) may not be amenable to arthroscopic treatment.7,8 although some have attempted such treatment.18-21 In addition, the authors believe that while ARIF is the definitive treatment for type III (central compression) fractures, ORIF may have advantages over ARIF in some type I, II, and IV fractures. In cases where ORIF is preferred, arthroscopy remains useful both for diagnosis and for treatment of associated intra-articular pathology.7

Potential disadvantages of ARIF or arthroscopically assisted ORIF of tibial plateau fractures require consideration. Even with the use of a tourniquet, bleeding from the fracture site makes arthroscopy technically difficult. Although this challenge can be to some degree mitigated with the use of a pump, increased pump pressure compounds a different problem, extravasation of arthroscopic fluid.22

With the exception of isolated type III compression fractures or intercondylar eminence avulsions, the tibial plateau fracture clefts are direct conduits linking the knee joint to the compartments of the leg. In addition, type III fractures and intercondylar eminence avulsions may be associated with capsular disruption, which may also link the knee joint to the compartments. The complication of iatrogenic compartment syndrome requiring fasciotomy, always a concern when knee arthroscopy is performed in association with acute trauma, must be watchfully considered in all cases of arthroscopic treatment of upper tibia fractures. Such a scenario, iatrogenic compartment syndrome requiring fasciotomy, has been reported.23 and
has occurred in the experience of the first author (unpublished data).

A disadvantage of limited visualization of the submeniscal articular surface of the tibia has also been described. In our experience, specially designed (double hooked, self-retaining) meniscal retractors (Arthrex, Naples, FL) allow adequate visualization.

**ARTHROSCOPIC TECHNIQUE**

Our recommended technique represents modifications of techniques suggested by Caspari et al., Jennings, and Buchko and Johnson. Operative treatment must be designed specifically for each fracture type. We recommend ARIF for central compression (Schatzker type III) fractures, and we recommend consideration of ARIF for split and split compression fractures (Schatzker types I, II and IV). Before surgery, an examination of the knee under anesthesia may be of value for evaluation of the ligaments.

A circumferential leg holder and tourniquet are used with the leg off of the end of the table. The fluoroscope (C-arm) is turned upside down so that the flat (image acquiring) plate may be used as an operating table under the proximal tibia and knee joint. Standard anterolateral (viewing) and anteromedial (instrumentation) portals are used. Often, the arthroscope is placed anteromedially to view lateral fractures. The instrumentation portal or accessory portals may accommodate meniscal retractors in cases of peripheral and submeniscal pathology. These blunt, double-hooked retractors (Arthrex) may be used in a self-retaining mode with the use of spring-loaded suction cups (designed to additionally prevent fluid extravasation).

Thorough lavage is required to remove hematicrosis or grossly loose and small osteochondral fragments. When possible, reduction of the fracture may be performed in a dry field to decrease the risk of fluid extravasation and increased compartment pressure. In all cases, inflow pressure is kept to a minimum and the compartments are carefully and continuously palpated to assess pressure. This is especially important in split fractures where fluid extravasation occurs directly through the fracture lines. To avoid excessive fluid leak into the compartments, an incision should be made before arthroscopy in the location where placement of the fixation device is planned; the fluid will leak out through the incision rather than into the muscle compartments (personal communication, Donald H. Johnson, M.D., January 2004). In cases of suspected increased compartment pressure, formal pressure measurement is recommended; fasciotomy is required should compartment syndrome occur.

Split fractures are reduced first; reduction forceps are recommended and sometimes an open incision (but not an arthrotomy) is required. Fluoroscopy may supplement the arthroscopic assessment of fracture reduction and is required for placement of wires for provisional split fracture reduction. For type I fractures, percutaneous, cannulated lag screws may be placed over the wires. If mild fragment instability is suspected, a buttress screw, often used with a washer, is placed at the inferior apex of the split fragment. If greater instability or poor bone quality is of concern, buttress plates may be percutaneously placed or placed through traditional, extra-articular secondary incisions.

In type II and type IV fractures, compressed elements must be addressed before definitive fixation. Under arthroscopic guidance, an ACL guide with a modified spoon-shaped tip (to mimic the curve of the femoral condyle) (Arthrex) is used to place a 2.4-mm drill-tipped guide pin in the center of the compressed fragment through a small incision in the proximal anteromedial tibial metaphysis. (A lateral muscle splitting approach can be considered for lateral fractures.) A coring reamer is used to fully and circumferentially penetrate the tibial cortex while removing as little bone as possible. A cannulated tamp, specially angulated so the leading flat surface is parallel to the plateau (Arthrex), is used to elevate the fracture site under direct arthroscopic visualization (Fig 2). Sometimes, it is helpful to over-reduce the fracture and then bring the knee through a full range-of-motion, allowing the femoral condyle to anatomically mold the tibial plateau. The underlying metaphyseal bone and cortical disc serve as autograft. In addition, the resulting defect may be grafted using bone autograft or allograft or bone substitute. Our current preference is freeze-dried allograft croutons.

For most type III patterns, cannulated screws may be introduced percutaneously, directly under the subchondral plate, to buttress the elevated fragments. In addition to the use of fluoroscopic guidance, the guidewire(s) for the screw(s) is advanced while the tamp is still in place. If the wire meets the tamp, accurate screw placement directly beneath the compression fracture is confirmed. The tamp is then removed and the guidewire (or wires) is further advanced; ultimately, the cannulated screw (or screws) is placed, and the guidewire(s) is removed using standard techniques.

In cases of type II or type IV fractures, similar
cannulated lag screw techniques will buttress the compression and provide rigid internal fixation of the split fragment. A buttress screw or screw and washer can be placed additionally at the inferior apex of the split fragment. Again, if greater instability or poor bone quality is of concern, buttress plates may be placed percutaneously or placed through traditional, extra-articular secondary incisions.

Postoperatively, continuous passive motion is recommended for a minimum of 6 to 10 hours a day for 3 weeks. Early range-of-motion is encouraged with goals of 0° to 90° at 2 weeks and full range-of-motion at 6 weeks. Weight bearing is not permitted for 3 months. Partial weight bearing is recommended during month 4, especially in cases of compression fractures. A hinged brace is required for 6 weeks in cases of associated collateral ligament injury.

**CLINICAL OUTCOME STUDIES**

Most published outcome studies of ARIF of tibial plateau fractures are case series involving relatively small numbers of patients. In addition, the series often combine patients with diverse fracture patterns, resulting in susceptibility bias. There are also several case reports describing single patients. The following is a review of the published case series.

In 1985, Caspari et al. reported on 30 tibial plateau fractures treated over a 5-year period. Of these, arthroscopy was part of the management in 20 patients and varied from diagnostic examination to debridement, partial meniscectomy, closed reduction, ARIF, or grafting. The authors reported that diagnostic arthroscopy revealed information not otherwise available, and in 15 cases adequate reduction and stabilization and/or grafting was achieved arthroscopically. Arthroscopy was also valuable in cases where symptoms persisted after fracture healing, frequently revealing arthroscopically treatable intra-articular pathology.

In the same year, Jennings described 21 tibial plateau fractures treated arthroscopically over a 5-year period. Patients had only mild postoperative pain. Sixteen patients had good outcomes. Jennings concluded that arthroscopic diagnosis and treatment of tibial plateau fractures offered many advantages with few complications.

Cassard et al. described 26 patients treated arthroscopically for tibial plateau fractures that included follow-up at 32.7 months for 19 cases. Patient age ranged from 18 to 70 years, and fracture patterns were diverse (2 type I, 17 type II, 6 type III, and 1 type IV). Complications included 1 case of septic arthritis (the only case where a hydroxyapatite plug was used) and 1 case of early bone subsidence (lateral at 4 months). The mean Knee Society Score (KSS) score was 94.1 for pain and 94.7 for function. Two patients had early radiographic signs of osteoarthritis, and 2 had valgus deviation. There were no cases of late bony collapse. The authors concluded that results of arthroscopic management were as good as or better than what might be expected from ORIF.

Roerdink et al. reported 80% excellent results of ARIF of diverse (6 type I, 13 type II, 5 type III, 3 type IV, 2 type V, and 1 type VI) fracture patterns in patients older than 55 years.

Gill et al. described 29 tibial plateau fractures in skiers treated with ARIF that included types I, II, III, and IV fracture patterns. The mean postoperative Rasmussen score was 27.5 (range, 21 to 30). The authors concluded that results of ARIF are comparable to ORIF and that ARIF offers the advantages of improved visualization, evacuation of hemarthrosis and chondral debris, decreased morbidity, shorter hospital stay, and the ability to reliably diagnose and treat associated intra-articular injuries, eliminating a major cause of secondary procedures and poor results.
In a series of 5 cases of ARIF of diverse tibial plateau fractures (types I, II, III), Guanche and Markman\textsuperscript{25} reported that all patients returned to their previous level of activity without complication. Bernstein et al.\textsuperscript{26} described "satisfactory" results, good or excellent function, and 1 complication of peroneal neuropraxia (that resolved) in a series of 9 "unselected" fractures. Holzach et al.\textsuperscript{27} reported a series of 16 patients, 15 of whom were available for follow-up and 14 were rated excellent using the Davos Knee Scoring System. In a study comparing autograft to hydroxyapatite, van Glabbeek et al.\textsuperscript{28} found that all 13 of their patients regained excellent active range-of-motion without extension lag. In a series of 20 diverse cases, (7 type I, 9 type II, 1 type III, 2 type IV, and 1 type V fracture), Itokazu and Matsunaga\textsuperscript{29} reported that all patients healed with good to excellent results (Rasmussen criteria); superior results were noted in type I and II fractures. Of 28 tibial plateau fractures treated under arthroscopic and fluoroscopic control by Oz et al.,\textsuperscript{30} the Hospital for Special Surgery knee scores were 80% excellent, 15% good, 5% fair, and 0% poor. Complications included cases of malalignment and/or malunion, and 3 patients with arthrofibrosis that required arthroscopic release. The authors concluded that arthroscopic treatment of tibial plateau fractures is technically demanding and has a protracted learning curve that is offset by improved diagnostic evaluation and safe and effective treatment.\textsuperscript{31}

Hung et al.\textsuperscript{32} described 31 patients with tibial plateau fractures treated arthroscopically; 30 of the injuries (97%) were sustained during traffic accidents. There were 1 type I, 9 type II, 7 type III, 9 type IV, 3 type V, and 2 type VI fractures. Twenty-five patients achieved excellent Hospital for Special Surgery scores, 4 were good, and 2 were fair. Twenty-eight patients (91%) returned to normal work and 26 patients (84%) returned to previous activity level, including sports.\textsuperscript{19} Of 15 tibial plateau fractures treated arthroscopically, Schiavone et al.\textsuperscript{15} described long-term results as normal or near normal in all cases. In a series of 27 patients, Handelberg et al.\textsuperscript{30} reported that 22 (81.5%) had good or excellent results of ARIF (21 cases) or arthroscopic reduction without fixation (6 cases) at the 2-year follow-up. The authors recommend use of "an external fixator acting as a buttress" for more complex fracture patterns.\textsuperscript{30} Chan et al.\textsuperscript{20} described arthroscopically assisted reduction with bilateral buttress plate fixation of 11 type V and 7 type VI fractures. Results were 22% excellent, 67% good, and 11% fair.

Of the few studies comparing ARIF and ORIF, a comparison of 19 patients treated with ARIF and 9 patients using ORIF showed no difference in duration of the operation, postoperative flexion, or clinical results, as reported by Ohdera et al.\textsuperscript{31} Faster, easier postoperative rehabilitation was noted in the group managed arthroscopically. In addition, anatomic reduction was achieved in 85% of patients treated arthroscopically versus only 55% treated by open surgery. Fowble et al.\textsuperscript{32} retrospectively compared 12 cases of ARIF with 11 cases of ORIF of either split or split-compression fractures. Follow-up was as short as 6 weeks and the mean follow-up was less than 7 months. The patients with ARIF were reported to have more accurate and stable reduction, shorter hospitalization, faster recovery, fewer and less severe complications, and the advantage of treatment of concomitant pathology.

In our opinion, future prospective study of ARIF of tibial plateau fractures will require a more rigorous description of patient selection criteria to allow comparison of arthroscopic with open treatment. Because of the relative infrequency of each individual type of tibial plateau fracture at a given institution, multicenter, prospective, randomized controlled trials comparing ARIF and ORIF of each specific tibial plateau fracture type is recommended.

**SUMMARY**

Arthroscopy is a valuable tool for assessment of tibial plateau fractures and is the treatment of choice for associated intra-articular pathology. In addition, ARIF of selected tibial plateau fractures allows achievement of anatomic reduction and rigid internal fixation with less morbidity than with ORIF and it has the advantage of superior visualization of the entire joint. We recommend ARIF for type III fractures and consideration of ARIF for types I, II, and IV. Some authors have applied ARIF to more complex (type V or VI) fracture patterns. Published outcome studies of ARIF of tibial plateau fractures describe results that appear to equal outcomes of ORIF, but these studies suffer from extreme susceptibility bias.

**REFERENCES**