Arthroscopic Management of Tibial Plateau Fractures

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ABSTRACT

Arthroscopic reduction with internal fixation has long been recognized as a treatment option for select tibial plateau fractures. Benefits of direct visualization of chondral surface reduction, diagnosis and treatment of associated intraarticular soft tissue injuries, joint lavage, decreased soft tissue dissection, and improved rehabilitation have been described in the literature. A review of surgical techniques and instrumentation for various fracture types is presented.

Keywords: arthroscopy, tibial plateau fracture, surgical treatment, surgical technique, review

INTRODUCTION

The arthroscope has long been recognized as a useful aid in the management of intraarticular fractures. The following article will review fracture types commonly seen in alpine skiing, present a rationale for arthroscopic reduction and internal fixation (ARIF), and review surgical techniques, results, and pitfalls.

HISTORICAL PERSPECTIVE

Fractures of the tibial plateau are a common alpine skiing injury. Data from our practice, encompassing injuries from 4 ski resorts from 2003 to 2006, show that a total of 85 tibial plateau fractures were treated operatively; of these, 55 were of the lateral plateau (3 Schatzker type I, 40 type II, and 12 type III), 10 medial Schatzker type IV, 9 Schatzker type V bicondylar fractures, and 10 type VI. Of these fractures, 15 (17%) were treated with ARIF. Demographics indicate equal numbers of men and women, with average age of 47.8 ± 11.3 years for men and 48.2 ± 12.2 years for women.

Indications for surgical management of tibial plateau fractures has been inconsistent with limits of acceptable articular displacement, ranging from 2 to 10 mm. Residual tilt of the tibial plateau and varus or valgus malalignment have been associated with higher risk of arthrosis. Biomechanical studies on articular stepoff show that a 6-mm stepoff of the lateral plateau produces 7.6 degrees of increased valgus and a 208% increase in contact pressure. Holzack has recommended surgical treatment of ski-related plateau fractures with 2 mm or more of displacement. Honkonen evaluated outcomes in 131 tibial plateau fractures and recommended surgical management for more than 5 degrees of valgus malalignment, more than 3 mm of articular stepoff, and more than 5 mm of condylar widening. In actuality, multiple factors likely contribute to long-term outcome, and consideration should be given to fracture type, presence of laxity on examination, location of articular displacement (central vs submeniscal), associated soft tissue injuries, and patient’s factors such as age, activity level, and comorbidities.

Inherent in our philosophy of treating intraarticular fractures, particularly in weight-bearing joints, is the goal of anatomical stable fixation of the joint surface for early functional rehabilitation. Visualization of the knee joint via arthroscopy has lead to its broader application to fracture management.

ARTHROSCOPICALLY ASSISTED TREATMENT OF TIBIAL PLATEAU FRACTURES

The potential advantages of ARIF are well documented: better visualization of joint surface reduction, lavage and removal of hematoma, and small loose fracture fragments, treatment of concomitant soft tissue injuries to ligaments/meniscus, limited soft tissue dissection with no need to peripherally detach the meniscus to gain visualization, and improved postoperative recovery, including decreased pain, shorter hospital stay, and return of knee range of motion. A review of current literature addressing these issues follows.

Anatomic Reduction

Review of the literature suggests ARIF to be equal to or better than open reduction internal fixation (ORIF) in achieving anatomical reduction. In the study of Bernfeld...
et al of a small series of 9 fractures, all reductions remained anatomic at a mean follow-up of 10 months. In the study of Kiefer et al of a series of 31 fractures, 25 showed anatomic reduction at a mean of 25 months. Van Glabbeek and van Riet were unable to arthroscopically reduce only 1 of 20 split/depression fractures. Ohdera and Tokunaga reported 16 of 19 type II and III fractures were able to be anatomically reduced via ARIF. Gill and Moezzi were able to correct articular depression from an average of 7.7 to 0.8 mm in 25 patients.

Problematic in such studies involving small patient numbers will be varying degrees of selection bias and a mixture of fracture types. Extensive articular comminution yields difficulties in obtaining reduction regardless of surgical technique, and cartilage loss may be amenable only to autogenous osteochondral transplantation or delayed reconstruction with allograft or prosthetics. Factors that may make arthroscopic reduction difficult include articular fragments depressed so far into metaphyseal bone that visualization through the joint is impaired or multiple fracture fragments may be displaced and, in particular, rotated in various planes.

**Associated Soft Tissue Injury**

This is perhaps the most compelling reason to incorporate arthroscopy routinely in the treatment of tibial plateau fractures, because these fractures have a high incidence of soft tissue injury within the joint. In a review of 98 arthroscopically managed plateau fractures, Abdel-Hamid and Chang found soft tissue injury in 71%, including 57% meniscal injury, 25% anterior cruciate ligament tear, 5% posterior cruciate ligament tear, 3% lateral collateral ligament tear, 3% medial collateral ligament tear, and 1% peroneal nerve injury. In the study of Shepherds and Abdollahi of a series of 20 ARIF cases, 90% had significant soft tissue injury, including 80% meniscal tears, and 40% incidence of ligament injury. Gardner et al found that soft tissue injury could be predicted based on plain radiographic findings. Articular depression of more than 6 mm and widening of more than 5 mm were associated with lateral meniscal tear in 83% (vs 50% for less displacement) and more than 8 mm was associated with increased risk of medial meniscal tear (53%–78%). Ligament injury to lateral collateral and posterior cruciate ligaments occurred 30% (vs 0%) for displacement of more than 4 mm.

Because the incidence of accompanying soft tissue injury is so high, and the fact that magnetic resonance imaging (MRI) is quite accurate, we routinely use MRI in all tibial plateau fractures, with computed tomography becoming more the exception. Medical literature strongly supports the use of MRI. Kode and Lieberman compared computed tomography to MRI in evaluating fracture pattern and found the 2 modalities to be equal, with MRI additionally being able to detect meniscal injury (55%) and ligament injury (68%). Yacoubian and Nevins found better interobserver agreement using MRI, and found that MRI actually changed treatment plan in 23% of cases. Holt et al found similar benefits to preoperative MRI in surgical planning. A preponderance of literature supports use of MRI in evaluation of tibial plateau fractures and their soft tissue injury components.

**Improved Postoperative Recovery**

Arthroscopy holds theoretical advantages in patient cosmesis and, more importantly, soft tissue handling. Less iatrogenic soft tissue injury may reduce intraarticular scarring, thus improving recovery of range of motion. Wound healing and risk of infection may be improved for higher energy fractures, and postoperative pain may be less.

Some of these factors have been examined in the literature. Even as early as 1985, Jennings noted more rapid recovery, with earlier return of knee motion and reduced pain in 21 patients. Ohtera and Tokunaga found easier and faster rehabilitation, with time to recovery of 120 degrees of knee flexion 4.6 versus 9.1 weeks for ORIF. Fowble et al noted more rapid return to full weight bearing at 8.95 versus 12.30 weeks and shorter hospital stay at 5.36 versus 10.27 days. In our patient population, the ARIF group averaged 1.5 ± 1.1 days in the hospital versus 3.2 ± 2.2 days for ORIF.

**Complications**

Reported complications arising specifically from ARIF are rare. In type I, II, IV, V, and VI fractures, direct communication exist between the joint space and muscle compartments. Extravasation of arthroscopy fluid during the procedure can contribute to the development of compartment syndrome. Case report of this complication is presented in the literature by Belanger and Fadale. General complications such as deep venous thrombosis, infection, neurovascular injury, and arthrofibrosis are infrequently reported in ARIF series, and may be related to selection bias of less severe fracture types for arthroscopic treatment.

**PREOPERATIVE PLANNING**

Careful review of the MRI is the initial step in surgical planning. Fractures with less severe comminution and degrees of depression will be more amenable to arthroscopic techniques. The presence of other soft tissue injuries, in particular meniscal tear, may also
present an indication for use of the arthroscope. The next critical step is evaluation of each patient’s soft tissue envelope and degree of swelling. Although the arthroscope may provide a less invasive option, one must anticipate conversion to an open reduction. Thus, surgical timing is still of critical importance in preventing patient morbidity. This being said, we have noted that alpine skiing mechanisms are generally lower in energy, and at the time of initial evaluation soft tissue swelling is minimal, and immediate same-day treatment can be considered.

**SURGICAL TECHNIQUES**

**General Considerations**

Patient positioning is somewhat of a dilemma, because the arthroscope requires varying degrees of knee flexion and varus/valgus stress to adequately view the joint and concomitant fluoroscopic viewing is generally with the knee extended. We have found that use of an arthroscopic leg holder with the foot of the operating room table dropped 90 degrees is restrictive for leg positioning options and requires an assistant to support the leg. We use the supine position on a flat radiolucent table with a hinged stress post positioned laterally that can be used for medial compartment viewing and can be flipped down when not needed. A figure-4 position allows good access to the lateral compartment with little to no assistance, and the fluoroscope can be brought in from the opposite side of the table and appropriately angled (Fig. 1). In more tightly constrained joints, visualization and instrument placement may still be limited despite the varus force provided by the figure-4 position. In these cases, a femoral distractor can be placed on the lateral side percutaneously to provide mechanical distraction of the lateral compartment (for lateral-sided fractures). If the proximal pin is placed near the lateral femoral epicondyle, flexion/extension mobility of the joint is adequately preserved during the case. The distal pin is placed in the tibial shaft, and the connecting bar is flipped posteriorly out of the way of instrumentation.

Arthroscopic fluid use should be monitored to decrease risk of compartment syndrome. Whenever possible, the tourniquet should not be inflated. Gravity or lower pressure pump inflow should be chosen, with frequent attention given to the lower leg to check for increasing size or firmness. An outflow cannula is recommended and assists in hematoma evacuation. If the preoperative plan calls for an incision to place hardware, placement of this incision early in the case may allow for venting of fluid and extravasation from the fracture out through the skin instead of into the compartment.3 Another alternative is use of “dry” arthroscopy if intraarticular bleeding is minimal.

In some cases, fracture visualization may be impaired by overlying meniscus, particularly on the lateral side where a larger percentage of the articular surface is covered. In these instances, meniscal retraction will be beneficial. This can be accomplished simply using a hooked arthroscopic probe (Fig. 2). If prolonged retraction and exposure is needed, a temporary suture

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**FIGURE 1.** Operating room setup with lateral fluoroscopic view.

**FIGURE 2.** (A) Fracture viewed arthroscopically. (B) Meniscus retracted.
loop can passed around the meniscus or torn meniscal fragment using an outside-in meniscal repair technique or meniscal retraction hooks found in the Arthrex arthroscopic fracture management system. A displaced but repairable meniscal tear can be retracted using a suture loop toward the intercondylar notch to allow visualization of the articular surface.27

■ SCHATZKER TYPE I FRACTURES: LATERAL SPLIT

This pattern usually represents the simplest and most amenable to arthroscopic fixation. Many of these fractures are treated successfully with fluoroscopic reduction and percutaneous fixation alone28; however, the potential added benefit of the arthroscope in hematoma evacuation, removal of smaller chondral fragments, and direct visualization are worth the small amount of extra effort.

Elevation and compression of the split fragment is achieved using large bone reduction forceps (Fig. 3). If sagittal plane rotational displacement exists, the addition of an anterior to posterior Steinman pin may be useful as a joy stick for assisting reduction. Alternately, the 2 parallel guide pins typically used for large cannulated screw fixation can be advanced into the subchondral bone of the fracture fragment and used to manipulate the fragment before being advanced across the fracture site and into medial metaphyseal bone. In normal bone, these 2 screws, placed approximately 1 cm beneath the joint surface, are adequate fixation.29 The addition of an antiglide screw and washer at the lower apex of the fracture should be considered in pathological bone.

■ SCHATZKER TYPE II FRACTURES: LATERAL SPLIT WITH DEPRESSION

Type II fractures are often amenable to ARIF with the additional complexity of joint surface elevation, often involving more than one osteochondral fragment. The arthroscopic approach obviates the need for detachment of the anterior portion of the lateral meniscus. Fractures with milder degrees of depression in the 3- to 10-mm range have less comminution and are usually more easily addressed arthroscopically. With higher-energy and poorer-quality bone comes greater degrees of impaction into the metaphysis, multiple osteochondral fragments, multiple planes of rotational displacement, and greater surgical challenge. Initial reduction of the

**FIGURE 3.** Large reduction clamp.

**FIGURE 4.** Ideal “angle of attack” from planned medial cortical window to elevate depressed segment.

**FIGURE 5.** Multiple fragments rotated in different planes, which makes it more difficult to perform ARIF.
cortical split will reestablish the correct articular height of the plateau’s rim, but visualization may require meniscal retraction. Overreduction of the lateral cortical wall may create tibial condylar narrowing blocking reduction of the central plateau fragments. Placement of the bone reduction clamp lower in the metaphyseal region may prevent this.

The depressed central plateau is accessed through either medial or lateral cortical windows with the goal of derotating and elevating the major fragments, maintaining enough supporting subchondral bone for fixation, and maintaining a congruous surface. Displaced meniscal tissue may be trapped within the fracture and must be excised if irreparable, reduced for later repair, or retracted toward the intercondylar notch to allow adequate visualization and reduced and repaired later in the case. The key tools are an arthroscopic guide, reamer, tamps, and reduction tools. Arthrex (Naples, Fla) manufactures an arthroscopic fracture set that contains the basic instrumentation, however typical anterior cruciate ligament reconstruction instruments can be adapted. The choice of medial or lateral cortical window can be debated. The medial side represents uninjured bone with easy subcutaneous access. The lateral side can generally be accessed through the fracture site if compression is released from the bone reduction clamp. Medial, lateral, or combined approach may be necessary based on fracture geometry and the desired angle of attack to achieve reduction (Figs. 4, 5). The plateau adjacent to the tibial spine is usually rotated centrally and can be elevated via a medial approach. Lateral fragments can be rotated posteriorly and laterally, and the medial approach may be more difficult because it necessitates “pulling” of these fragments. A small arthroscopic hook found in the Arthrex fracture system may be used in these instances. Another approach is through the lateral split fracture line, which usually occurs in the interval between the tibial tubercle and Gerdy’s tubercle. An oblique incision representing the upper arm of a traditional “hockey stick” incision can provide access to this split, and incision through the muscle fascia of the anterior compartment can be added to place a submuscular buttress plate. This incision can be extended if the arthroscopic procedure is abandoned for an open approach.
The basic sequence involves initially placing a guide wire up through metaphyseal bone to the apex of the fragment using a guide (Fig. 6). An anterior cruciate ligament tibial guide usually works well if its profile is not too high. Once position is checked fluoroscopically and arthroscopically, the cortical window is created with a reamer up to within 15 to 20 mm of subchondral bone. An 8- to 10-mm diameter is adequate, and a coring reamer has the added advantage of creating a cancellous plug that can be saved and used as the primary initial structural graft during the bone grafting portion of the procedure. A bone tamp is placed through the cortical window, underneath the depressed fragment and used to elevate the fragment under direct visualization (Fig. 7).

In the Arthrex set (Fig. 8), these tamps are cannulated and have options of angled tamping surfaces. Narrow instruments such as curved osteotomes or periosteal elevators can be used through this window. A tool that can be useful in reduction is a narrow Cobb elevator. It can be inserted through the vertical lateral split, rotated 90 degrees in metaphyseal bone giving a wider flat surface to provide leverage in disimpacting depressed fracture fragments.

Once the joint surface congruity is restored, reduction is maintained using smooth Steinman pins through subchondral bone, placing permanent fixation distally, or using guide pins for cannulated screws that act as final fixation (Fig. 9). Choice of fixation device depends on bone quality and degree of comminution. Two large 6.5- or 7.3-mm cannulated screws work well for simple fractures; however, multiple (3–4) smaller-diameter screws are preferable in more comminuted fractures to act as a “raft” in support of the articular surface. Soft osteopenic bone may benefit from a periarticular buttress or locked plate inserted submuscularly through a limited lateral incision. The distal fixations holes in these plates can be accessed percutaneously, and for longer plates, some manufacturers are designing targeting devices similar to the original LISS system from Synthes (West Chester, Pa) (Fig. 10).

Bone graft from multiple sources—synthetic, autograft, and allograft—have been successful. We
prefer allograft chips or croutons to avoid donor site morbidity and to provide some initial structural support. The autogenous bone obtained during reaming of the access window can be placed preferentially adjacent to the fracture site to provide increased osteoinductivity.

■ SCHATZKER TYPE III FRACTURES: LATERAL PLATEAU CENTRAL DEPRESSION

These fractures are similar in many ways to the type II fractures in their surgical technique with the sequence of guide wire placement, fracture access via reamer, elevation with tamp, temporary fixation percutaneously, bone grafting, and final fixation with cannulated screws. Access to the central plateau through an open technique usually requires creation of a lateral cortical split and hinging of a lateral cortical shell to visualize the central plateau. The benefit of the all-arthroscopic approach is therefore more appealing.

■ SCHATZKER TYPE IV FRACTURES: MEDIAL PLATEAU FRACTURES

These fractures may come in many varieties and are generally thought to be associated with higher energy mechanisms due to the stronger subchondral bone of the medial plateau. Medial fractures are less common than lateral-sided injuries. Simple splits are relatively easy to reduce arthroscopically, and depressed fractures can be managed with techniques similar to lateral fractures. A subgroup of triplanar fractures represents a potentially more unstable fracture that is inherently more difficult to reduce and may require a posteromedial approach to reduce and stabilize the medial coronal plane component.

■ SCHATZKER TYPE V AND VI FRACTURES: BICONDYLAR

In these more complex high-energy fractures, arthroscopic indications are stretched. Fluid extravasation is more likely, and risk of compartment syndrome even in ORIF is more significant. The arthroscope may be of benefit in treating meniscal injury determined by preoperative MRI or used to assist in articular reduction. The appeal of the arthroscope is its benefit to more severely injured surrounding soft tissues. Extensive incisions or dual incisions may be avoided with theoretical lower complication rate. In actuality, however, most of these fractures are not amenable to arthroscopic treatment.

For less displaced fractures, axial alignment may be reestablished using a femoral distractor. Ligamentotaxis through distraction may assist in reducing condylar splits. The arthroscope may be used in manipulation of larger articular fragments either through the fracture splits or again using a cortical window, with limited incisions. With the development of locked plating, a fixed-angle periarticular construct can be achieved unilaterally. Submuscular placement with percutaneous screw insertion lessens surgical dissection. One word of caution, the placement of locked screws in a plate will create the effect of an “internal” external fixator; however, it will also increase the stresses on the plate and could contribute to earlier hardware failure. Therefore, judicious use is of locked screws is recommended.

■ POSTOPERATIVE MANAGEMENT

One primary goal of internal fixation is to provide adequate fracture stability to allow immediate unrestricted range of motion to promote cartilage health and prevent arthrofibrosis of the knee. Deep venous thrombosis prophylaxis is begun on admission to the hospital with foot compression devices and low-molecular weight heparin is begun 24 hours after surgery. Continuous passive range-of-motion machines are started postoperatively along with toe touch weight bearing in a hinged knee brace. Progression of weight bearing is not generally begun for 8 weeks. Muscle isometric exercise and electrical stimulation are begun as comfort allows.

■ SUMMARY

Arthroscopy as an adjunct in the treatment of intraarticular fractures, including fractures of the tibial plateau has its merits, including diagnosis and treatment of associated intraarticular soft tissue components, visualization of the chondral surface reduction, lavage of hematoma and smaller loose fragments, decreased soft tissue dissection and risk of scarring, and more rapid recovery. The literature overall indicates results equal to or better than ORIF with low surgical risk. However, these are selected small series, poorly controlled, and with potential bias, and well-designed studies are needed to evaluate long- and short-term function and risk of posttraumatic osteoarthritis in ARIF patients. This technique can be useful in select patients by an experienced arthroscopist for simpler lower-energy fracture types, generally Schatzker types I, III, and select II and IV. Finally, a poorly executed ARIF should never substitute for a well-done ORIF.

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