Arthroscopic-Assisted Reduction and Percutaneous Fixation of Tibial Plateau Fractures

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Abstract: Tibial plateau fractures present a difficult range of fractures to treat. Arthroscopy allows for a less invasive option when compared with arthrotomy. Furthermore, visualization of the articular surface arthroscopically can allow for a precise reduction and assessment of any concomitant injuries to the articular cartilage and meniscus. By use of arthroscopy, unicondylar lateral plateaus were traditionally approached through a laterally based metaphyseal window. However, in carefully selected patients and fracture patterns, a medially based, arthroscopic-assisted approach can create long bony tunnels for subchondral support and allow for greater ease in fracture reduction. We present our technique using a medial approach for arthroscopic-assisted fixation of lateral tibial plateau fractures.

Tibial plateau fractures place the articular vitality of the knee at risk, with fixation aimed at restoring articular congruency and allowing for mobilization, all while limiting soft-tissue insults surgically. Arthroscopic-assisted techniques have shown comparable results to open methods of internal fixation. These techniques have used a laterally based metaphyseal window, which is not without limitations, including difficulty with reduction of the fracture, as well as bone grafting through the resultant short subchondral tunnel.

A medially based metaphyseal window to approach unicondylar lateral tibial plateau fractures has been described in the past with good results. This technique allows for minimal insult to the soft tissues, as with other arthroscopic techniques, with advantageous ease of reduction and grafting through a longer tunnel for subchondral support. We present this preferred technique of arthroscopic-assisted percutaneous fixation of lateral tibial plateau fractures (Video 1).

Indication
Surgical technique is dictated by the fracture pattern, and this technique can only be used in select cases. The first step in planning for appropriate technique is a thorough understanding of the lateral tibial plateau fracture with the appropriate imaging. Anteroposterior and lateral radiographs of the knee, as well as images of the joints above and below, are recommended. To fully understand the fracture pattern, a computed tomography (CT) scan is critical. When one is assessing the CT scan, it is important that the medial column of bone be intact for use of this technique. The medial column of bone is necessary to hold rafter screws to support the construct. The cortical envelope must be intact or easily restored and is required for this arthroscopic method (Fig 1). This technique relies on elevation of depressed fragments, and if there is no containment, they will merely displace medially or laterally.

Technique
The operating room setup requires proper positioning of the patient, fluoroscopy, and appropriate instrumentation. Arthroscopic and fluoroscopic monitors are placed on the ipsilateral side of the involved extremity. The fluoroscopy machine is placed on the contralateral side of the involved extremity. The leg holder is placed more proximal than usual to allow ample room for the fluoroscopy machine. The contralateral limb is abducted off the side of the table and the knee flexed over padding, ensuring that it is out of the way of imaging (Fig 2). Before surgical preparation and draping, anteroposterior and lateral images should be taken, showing that imaging can be obtained without obstruction. The extremity should be draped in the usual manner while keeping most of the leg uncovered to allow for

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continuous monitoring of compartments. The arthroscopy inflow should be set at either gravity or low pressure to decrease the likelihood of compartment syndrome.

The extremity should first be examined for stability. The usual arthroscopic portals are used, and diagnostic arthroscopy is conducted. Concomitant pathology, such as articular cartilage injury or a meniscal tear, is addressed as needed. The fracture is identified and debrided free of fibrous tissue and hematoma. The fracture is then mobilized with a standard freer elevator to allow for easy mobilization of the fragment during reduction. Depending on the location of the fracture, elevating the anterior horn of the meniscus often offers excellent visualization of the fracture reduction and allows for easy mobilization. This is accomplished by releasing the coronary ligament at the anterior meniscal-capsular junction. If a large anterior meniscal-capsular tear is created, we typically repair this either with inside-out suture arthroscopically using Arthrex Dart system cannulas with No. 2-0 FiberWire meniscal repair needles (Arthrex, Naples, FL) or through a small arthrotomy with 1 or 2 Arthrex 2.9-mm FASTak anchors. Smaller tears that are created to visualize the fracture fragment are typically not repaired.

An anterior cruciate ligament guide pin is placed percutaneously from the anteromedial tibia approximately 10 cm distal to the joint line. The area of maximal depression is targeted based on preoperative CT and radiographic evaluation. By use of anteroposterior and lateral images, the guide pin is positioned 1 to 2 cm distal to the depressed articular surface (Fig 3). Once satisfactory positioning is obtained, a 2- to 3-cm incision is made around the guide pin. Subperiosteal dissection is carried out with a Cobb elevator. A rigid 10- to 11-mm cannulated reamer set is used to ream to 1 to 2 cm distal to the articular surface.

Fracture reduction is accomplished with a bone tamp that fits easily into the previously reamed tunnel. A small amount of bone graft placed in the tunnel may be necessary before reduction. This is performed to ensure that the chondral surface is not perforated with the bone tamp. The bone tamp is then used to elevate the fracture fragment to the appropriate height (Fig 4). If medial-to-lateral compression is needed, then carefully planned stab incisions and a standard reduction clamp should be used to approximate these fragments, with care taken not to over-compress. Once satisfactory reduction is achieved, the bone tamp is left in the tunnel. Three to four percutaneous guide pins for 3.5- or 4.5-mm cannulated screws are placed from lateral to medial, both anterior and posterior to the tamp ensuring that the fracture fragment is being captured and supported. The fracture should be reassessed with both fluoroscopy and arthroscopy making additional adjustments as necessary. The guide pins should then be drilled and tapped, and the appropriate-length 3.5- or 4.5-mm partially threaded Synthes screws (Synthes, West Chester, PA) are placed. These screws act as rafters to support the articular surface and subchondral bone. Depending on whether compression is needed, partially threaded...
screws or fully threaded screws in lag mode can be used. If no compression is needed, then fully threaded screws should be used. After all the screws have been placed, final fluoroscopic and arthroscopic assessment should be conducted to ensure that fracture reduction has not been compromised (Figures 5 and 6). Once the surgeon is satisfied with the reduction, the entirety of the bone tunnel is tightly grafted. A reasonably solid tunnel of bone is optimal to increase subchondral support. The compartments are then examined to ensure no increasing firmness.

**Rehabilitation**

The patient is placed in a hinged knee brace and stays in the hospital overnight, with compartment checks and extremity elevations. Deep venous thrombosis prophylaxis should be used for 6 weeks postoperatively. The patient is started on gentle active and passive range of motion and remains non-weight bearing for 6 weeks. After 6 weeks, the patient is started on toe-touch weight bearing and advanced to full weight bearing by 12 weeks. Gentle quadriceps and hamstring strengthening should be initiated at 6 weeks.

**Fig 3.** Anteroposterior and lateral radiographs with the guide pin placed approximately 1 to 2 cm distal to the depressed articular fragment. The pin is placed distal to allow elevation of the depressed fragment with a bone tamp under subchondral bone to prevent chondral perforation. This is performed after reaming over the guide pin with a rigid 10-mm reamer to make room for the bone tamp.

**Fig 4.** Anteroposterior and lateral radiographs showing the use of a bone tamp to elevate the depressed articular fragment. A periarticular reduction clamp from medial to lateral is being used to compress the fragments and maintain the cortical envelope. A guide pin has been placed posterior to the bone tamp for future placement of a rafter screw.
Discussion

An arthroscopic-assisted medial approach to unicortylar tibial plateau fractures has similar advantages to the laterally based approach: minimal soft-tissue trauma with excellent arthroscopic visualization of the articular cartilage, both before and after reduction. Furthermore, these techniques allow for direct visualization of concomitant knee pathology, such as central pivot or meniscal injuries. The advantage of using a medial metaphyseal window is the creation of a longer bone tunnel, allowing more bone grafting support under the elevated fragment. This is hypothesized to provide a more sturdy platform to maintain the reduction obtained as compared with the shorter tunnel used with a lateral approach. The reduction is believed to be easier using the medial approach because starting on the medial side allows easier access to the entire lateral plateau, especially anteriorly. This technique has been shown to have good midterm results in the literature.6

Levy et al.5 reported on 16 patients with Schatzker type II fractures who underwent reduction and fixation using this technique. Of 16 patients, 15 obtained full, symmetric range of motion. Twelve patients rated their results as excellent and 4 as good. Using this technique, this study showed that patients can have a well-functioning knee and reasonable clinical outcomes. It showed no complications in the perioperative or immediate postoperative stage, including no cases of compartment syndrome or superficial or deep infection. Similar results have been reported in other series.7,8

Patient selection is important when using this technique. Preoperative planning with CT interpretation of the “cortical envelope” is essential. When this envelope is intact or is easily restored with a clamp, elevating the fracture through a medial window is achievable. Limitations of this technique are found in more complicated fracture patterns, when this envelope is disrupted. The advantage of this approach may be lost because elevating and reducing these fractures will lead to medial or lateral displacement because of lack of containment of fracture fragments. Levy et al.5 showed this in their series, in which 1 of the 16 patients had

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**Fig 5.** Anteroposterior and lateral radiographs showing anatomic reduction with 3 percutaneous rafter screws with washers.

**Fig 6.** Arthroscopic photograph showing anatomic reduction of the lateral tibial plateau fracture after all hardware has been placed and fluoroscopic images evaluated. This is the final check before the conclusion of the case.
Table 1. Key Points for Arthroscopic-Assisted Fracture Reduction and Percutaneous Fixation

A radiographic and CT review is performed to ensure that the fracture is amenable to arthroscopic treatment. Unicondyllar lateral tibial plateau fractures with an intact medial column of bone and an intact or easily restored cortical envelope can be treated with this technique. The bone needs to be of adequate quality to support a rafter screw construct.

Arthroscopic setup is performed with perfect AP/lateral radiographs of the knee. Vigilant compartment checks are performed preoperatively and intraoperatively. Diagnostic arthroscopy is performed with treatment of concomitant intra-articular pathology and mobilization of fracture fragments. A 10- to 11-mm reamer is used at the area of maximal depression based on preoperative imaging and intraoperative fluoroscopic images.

Elevation of depressed fragments with a bone tamp is performed for re-creation of the articular surface. It is often helpful to pack some bone graft proximally before elevation to ensure that chondral perforation with the bone tamp does not occur.

Percutaneous periarticular reduction clamp placement is used if medial-to-lateral compression is needed. Care must be taken not to over-compress if comminution is present.

Arthroscopic and fluoroscopic viewing is used to ensure anatomic reduction. The previously reamed tunnel is then bone grafted for increased subchondral bony support.

Table 2. Indications, Advantages, and Disadvantages of Medial Arthroscopic Reduction of Unicondyllar Tibial Plateau Fractures

| Indications         | Advantages                                                                                     |
|---------------------|-----------------------------------------------------------------------------------------------|
| Unicondyllar lateral tibial plateau fracture | There is limited soft-tissue disruption around the fracture. The technique allows assessment and treatment of concomitant intra-articular pathology. Arthroscopy allows one to ensure anatomic reduction of the articular surface. The medial tunnel increases the length of the subchondral bone tunnel, and reduction is easier compared with the lateral approach. |
| Intact or easily restorable cortical envelope assessed on CT | The bone quality that will support rafter screw construct                                      |
| Intact medial column of bone |                                                                                               |
| Bone quality that will support rafter screw construct |                                                                                               |

Table 3. Equipment

| 2.7-mm guide pin from any ACL set (Biomet system [Biomet, Warsaw, IN] is used in Video 1) |
| Rigid 10- to 11-mm reamer from any ACL set (Biomet system is used in Video 1)  |
| Guide pins, partially threaded screws, and washers for 3.5- or 4.5-mm Synthes cannulated screw set |
| Bone graft: allograft croutons mixed with demineralized bone matrix |
| Arthrex Dart system with No. 2-0 FiberWire needles for inside-out repair of meniscocapsular junction disruption |
| Arthrex 2.9-mm FASTak suture anchors for mini-open meniscocapsular junction repair |

Although painful hardware necessitating removal has been reported in 40% of patients, implementing small fragment screws can avoid this secondary procedure. Fractures amenable to arthroscopic fixation are often due to lower-energy injuries when compared with the more comminuted tibial plateau fractures; however, compartment syndrome is still a risk. With arthroscopy, there is some degree of fluid extravasation, which could increase the risk of compartment syndrome. The leg needs to be constantly monitored intraoperatively as well as postoperatively to ensure that this complication can be immediately recognized and addressed. Despite these limitations, the arthroscopic-assisted medial metaphyseal window approach can be successful in carefully selected patients with unicondyllar lateral tibial plateau fracture patterns with a maintained or easily restored cortical envelope (Tables 1-3).

References

1. Gill TJ, Moezzi DM, Oates KM, et al. Arthroscopic reduction and internal fixation of tibial plateau fractures in skiing. Clin Orthop Relat Res 2001;383:243-249.
2. Lemon RA, Bartlett DH. Arthroscopic-assisted internal fixation of certain fractures about the knee. J Trauma 1985;25:355-358.
3. Jennings JE. Arthroscopic management of tibial plateau fractures. Arthroscopy 1985;1:160-168.
4. Burdin G. Arthroscopic management of tibial plateau fractures: Surgical technique. Orthop Traumatol Surg Res 2013;95:S208-S218 (suppl).
5. Levy BA, Herrera DA, MacDonald P, Cole PA. The “medial approach” for arthroscopic-assisted fixation of lateral tibial plateau fractures: Patient selection and mid-to-long-term results. J Orthop Trauma 2008;22:201-205.
6. Chan YS, Chiu CH, Lo YP, et al. Arthroscopy-assisted surgery for tibial plateau fractures: 2- to 10-year follow-up results. Arthroscopy 2008;24:760-768.
7. Rossi R, Castoldi F, Blonna D, Marmotti A, Assom M. Arthroscopic treatment of lateral tibial plateau fractures: A simple technique. Arthroscopy 2006;22:678.e1-678.e6.
8. Chiu CH, Cheng CY, Tsai MC, et al. Arthroscopy-assisted reduction of posteromedial tibial plateau fractures with buttress plate and cannulated screw construct. Arthroscopy 2013;29:1346-1354.