Staged Management of High-Energy Proximal Tibia Fractures

Nirmal C. Tejwani, M.D., and Pramod Achan, F.R.C.S.

Abstract

High-energy proximal tibia fractures are complicated by soft tissue compromise and this may result in sub-optimal outcomes. There is a high association of open injuries, compartment syndromes, and vascular injuries with these bony disruptions. Surgical treatment of these injuries has been associated with significant complications such as infection, knee stiffness, mal-union, loss of fixation, soft tissue failure, and amputations. The loss of fixation is an issue especially in the elderly, with failure associated with age more than sixty years, premature weight bearing, preoperative displacement, fracture fragmentation, and severe osteoporosis.

The use of two-stage reconstruction for the treatment of distal tibia fractures has been successful in decreasing the complication rates, including wound compromise. The two stages involve: 1. stabilization of the injured limb with a bridging external fixator to allow the soft tissues to improve and recover and 2. definitive fixation for reconstruction of the articular surface and meta-diaphyseal fractures. The use of such a protocol has been proposed for high-energy proximal tibia fractures to decrease the high rate of soft tissue compromise associated with traditional open methods of treatment. The choice of definitive fixation may include plates, nails, or non-bridging external fixation.

The high energy trauma associated with comminuted fractures of the proximal tibia (both intra- and extra-articular) involves significant injury to the surrounding soft tissues as is evident by swelling, degloving, and blistering commonly seen in these injuries. There is a high incidence of associated open fractures, contamination, vascular injury, compartment syndrome, and neurological compromise. An incidence of up to 80% for associated soft tissue injuries in the knee joint, including meniscal and or ligamentous ruptures, has also been reported.

The popliteal artery is closely related to the proximal tibia as it courses just posteriorly and may be lacerated or torn with displaced fractures. The anterior and medial aspects of the proximal tibia are subcutaneous with no muscle bulk to provide protection to the skin in fractures. The tibial nerve and the deep peroneal nerve are also in close proximity posteriorly and laterally, making them vulnerable to stretch and injury in proximal injuries.

Traditional methods for treating these injuries with early open reduction and internal fixation have been associated with high levels of morbidity, soft tissue complications, wound breakdowns, and infections.

The primary issue in treating these complex injuries is whether the soft tissue envelope is able to tolerate the additional trauma caused by formal open reduction and internal fixation necessary to reduce and stabilize this injury. The concept of damage control orthopaedics, whereby the least invasive and most rapid way of stabilizing the patient’s injuries to save his life and limb is being used today on an increasing level. In patients with multiple injuries, an external fixator can be applied quickly with minimal blood loss for pelvic fractures, femur fractures, and unstable peri-articular fractures around the knee.

Tibial plateau fractures are commonly classified using the Schatzker classification, which subdivides these injuries into six types (Table 1). The OTA/AO classification can be used to classify these injuries, both intra- and extra-articular ones. The Gustillo-Anderson and the Tscherne classifications are used for open and closed injuries respectively. Many of the proximal tibial fractures can be immobilized in a long leg splint or knee immobilizer or skeletal...
traction; however the high energy unstable fractures with compromised soft tissue envelope requiring observation are unsuitable for such techniques. For complex proximal tibia fractures, the current trend at trauma centers has been to delay definitive surgical intervention until the soft tissues have calmed sufficiently to allow fracture fixation without catastrophic wound consequences. This involves a two-stage procedure where the open fractures, vascular injuries, and compartment syndromes are managed with appropriate emergency care and a temporary spanning external fixator applied across the knee to provide bony stability. The reduction achieved by traction helps to decrease any additional trauma, allows patient transport ("traveling traction"), and reduces swelling and soft tissue compromise. The soft tissues are then monitored until signs of improvement with loss of swelling, reduced diameter, and, most notably, wrinkling of the skin are noted.\textsuperscript{6,7} At this point the definitive procedure is carried out to stabilize the fracture, restore the articular surface, and allow early joint mobilization.

**Initial Evaluation**

The high-energy trauma patient is usually hypotensive, coagulopathic, and may have multi-system injuries. He is initially managed using accepted ATLS protocols for trauma victims. The patient is administered intravenous antibiotics and tetanus prophylaxis as needed. The patient after initial resuscitation may be taken to the operating room for further care. Open injuries need to be treated with appropriate debridement and soft tissue procedures. Compartments syndromes are identified with clinical examination and pressure monitoring, and a four-compartment fasciotomy performed if needed. Radiographs obtained in the emergency room including anteroposterior, lateral, and oblique views. Further imaging is obtained as required once the fixator has been applied.

**Indications**

Multiple extremity and pelvic fractures are often present in patients with polytrauma and immediate stabilization of these injuries using internal fixation would require prolonged anesthesia, surgical time, soft tissue and bony devitalization, and blood loss. Optimal radiological imaging required for complex intra-articular fractures might also not be available. Extremity fractures may be rapidly and easily spanned and stabilized using external fixators with minimal morbidity, decreased operating room time, and blood loss. This is desirable in a patient who requires time to be hemodynamically stabilized and needs monitoring.\textsuperscript{3}

The use of this protocol is unnecessary in low-energy tibial plateau injuries such as Schatzker type I-III fractures, which are amenable to early definitive fixation or stabilization using an external splint. The high-energy fractures, Schatzker type IV-VI, would benefit from such treatment due to the associated soft tissue insult or heavy soft tissue contamination. Once stabilized, the patient could also be transferred to another facility if either the surgeon or the hospital is not equipped to handle internal fixation for complex plateau fractures. A spanning external fixator is useful in rural hospitals, battlefield settings, and in instances involving mass casualties as initial stabilization to transfer patients from a place with limited surgical facilities.\textsuperscript{8}

The joint spanning fixator also allows the patient to receive nursing care, evaluation of the soft tissues, and better analgesic control. It also provides a lower risk of decubiti and facilitates easier mobilization of the patient for further imaging (such as computerized tomography or magnetic resonance imaging). If adequate support exists at home and the patient expresses a desire to do so, they may even go home (soft tissues permitting) and be followed up as outpatients prior to scheduling the second stage surgery.

**Table 1** Schatzker Classification for Tibial Plateau Fractures\textsuperscript{4}

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Split type lateral plateau fractures</td>
</tr>
<tr>
<td>Type 2</td>
<td>Split depressed lateral plateau fractures</td>
</tr>
<tr>
<td>Type 3</td>
<td>Depressed lateral plateau fracture</td>
</tr>
<tr>
<td>Type 4</td>
<td>Medial tibial plateau fracture</td>
</tr>
<tr>
<td>Type 5</td>
<td>Bicondylar plateau fracture</td>
</tr>
<tr>
<td>Type 6</td>
<td>Bicondylar fracture with meta-diaphyseal dissociation</td>
</tr>
</tbody>
</table>

**Figure 1** Injury film showing an open comminuted proximal tibia fracture with intra-articular extension in a 44-year-old male patient post MVA.
This protocol allows adequate preparation of the patient as well as adequate time for the surgeon to complete his pre-operative evaluation, obtain all the necessary imaging, and determine the ideal mode of treatment, if this requires special equipment. In essence it converts an emergency operation into a semi-elective, planned operation with the associated benefits.

**Technique**

The primary procedure is performed as early as possible once the patient has been resuscitated, is hemodynamically stable, and deemed to be ready for the operating room. An attempt is made to apply the external fixator within 6 hours of the injury for open fractures and within 24 hours for closed injuries with no compartment syndrome.

Using standard spine precautions, the patient is preferably positioned supine on a radiolucent table. This allows approach to the head, chest, abdomen, or the pelvis. Further radiographs or fluoroscopy may be obtained as needed.

The position of the half pins in the tibia should be considered carefully so as to avoid all future definitive fixation hardware. Haphazard pin placement may result in compromising future incisions and also increase the risk of pin tract infections. The pins are generally placed percutaneously using soft tissue protectors. The bone should be pre-drilled and the pins not placed too close to each other for fear of creating a stress riser after pin removal. One should try and avoid injured soft tissue including areas of blistering, avulsion, or open wounds. The two femoral pins are inserted anteriorly, or anterolaterally, approximately 10 centimeters proximal to the superior pole of the patella. The two tibial pins are inserted on the anteromedial border.

The pins are connected using bars and clamps at the level of the knee joint after traction is applied to regain length and alignment. The reduction relies on ligamentotaxis and care must be taken to avoid over-distraction. The knee is kept in 20° of flexion for comfort. The frame is either anterior or anterolateral depending on soft tissue status and the need for further debridements or other wound care and surgeon preference. A posterior splint may be added for comfort.

The definitive surgical reconstruction is carried out when the soft tissues are deemed “settled” – classical signs being healing and re-epithelialization of blisters and absence of pitting edema and the “wrinkle sign.”

**Postoperative Care and Further Plan**

Once the fixator has been applied additional enhanced imaging can be obtained in order to identify the fracture lines in both coronal and sagittal planes and delineate the size of various fracture fragments. It also prepares the surgeon...
for the degree of comminution and any joint depression that exists but may be unclear on plain radiographs. Chan\textsuperscript{9} showed the importance of a CT scan as it changed the classification and operative plans in a significant number of patients with tibial plateau fractures. Magnetic resonance images may be obtained if there is a suspicion of associated intra-articular soft tissue pathology provided a compatible fixator is used.\textsuperscript{1,10} A spanning fixator also permits vascular studies for arterial injury, Doppler scans for thrombosis, and compartment pressure monitoring without difficulty. A plan for definitive fixation, whether internal or external, can now be deliberated with the advantage of requisite studies. Usually, it takes between 7 to 14 days for the soft tissues to calm and settle before fixation is carried out. This also allows the surgeon to order in special plates or screws that may be optimal to the specific injury.

The pins and the clamps are usually cleaned and used in the final procedure as a reduction tool allowing traction for distraction and joint visualization. The fixator can be used as supplemental fixation, if minimal internal fixation is used for the articular fracture fixation, or converted to a non-joint spanning frame for fracture stabilization. Postoperatively, it may be retained as a splint for comfort and wound care.

**Discussion**

The factors determining prognosis in the high-energy proximal tibia fractures are:

1. The degree of articular depression,
2. The extent and separation of the condylar fractures,
3. Diaphyseal-metaphyseal comminution and dissociation,
4. The integrity of the soft tissue envelope, and
5. The associated ligamentous injuries.

These fractures are the result of a combination of forces, axial loading and valgus stress. The forces have been measured at 1,600 to 8,000 inch/pounds\textsuperscript{11} resulting in multiple fracture lines or “explosive” fracture patterns.

The goal of surgical treatment is anatomic articular restoration and mechanical axis alignment to reduce long-term complications. Multiple studies have shown that a staged protocol provides significant improvement
over historical infection rates for acute internal fixation for these complex high-energy injuries.\textsuperscript{12} Watson and colleagues\textsuperscript{3} reported on 107 patients with pilon fractures treated using a standard staged protocol for patients with open fractures, compartment syndromes, and polytrauma. They reported significant reduction in the infection rate compared to historical controls. Haidukewych and associates\textsuperscript{13} reported on conversion of spanning external fixation to internal fixation at a mean of 10 days. They had a 6\% infection rate associated with spanning fixation at the ankle with only one case of infection after plateau fractures, at the site of previous half pin.

At ten years follow up, Weigel and associates\textsuperscript{14} showed that patients with a high-energy fracture of the tibial plateau treated with external fixation have a good prognosis for satisfactory knee function in the second five years after injury. The knee joint cartilage appears to be tolerant of both the injury and mild-to-moderate residual articular displacement, which was associated with a low rate of severe arthrosis.\textsuperscript{14}

The results of long-term salvage in the form of total knee arthroplasty have been associated with significant complications. A retrospective analysis of total knee arthroplasties performed at an average of 38.6 months after open reduction and internal fixation of a fracture of the tibial plateau in 15 consecutive patients showed poor long-term results (33\% failure at six years).\textsuperscript{15} Weiss and colleagues reported on a series of 62 knee arthroplasties after plateau fractures in which they had a 21\% re-operation rate at 4.7 years.\textsuperscript{16} They also reported a 10\% intra-operative and a 26\% postoperative complication rate.

All these studies lead us to the conclusion that articular reduction should be achieved as close to anatomic as possible. To facilitate an open approach to articular reduction, the soft tissue envelope must be violated and the use of the two stage protocol will allow optimal conditions to proceed. Treatment options range from non-operative, to minimally invasive approaches, to complex reconstruction using circular or hybrid frames.\textsuperscript{14,17,18}

Conclusion

The use of a staged protocol, with the initial application of a bridging external fixator followed by delayed internal fixation, is suggested for treatment of complex tibial plateau fractures. The use of such a protocol for pilon fractures has been successful in reducing the historically high rates of wound complications associated with these high-energy injuries. Early reports, including the authors’ own experience,\textsuperscript{19} suggest that in high-energy tibial plateau fractures this may allow improved outcomes.

References