Surgical Management of Tibial Tubercle Fractures in Association With Tibial Plateau Fractures Fixed by Direct Wiring to a Locking Plate

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Summary: Tibial tubercle fractures disrupting the extensor mechanism of the knee can occur in association with complex tibial plateau fractures (AO type 41A, B, C). The management of these fractures can be difficult; a stable repair of the tibial tubercle fragment is essential if the extensor mechanism is to be reconstituted. There are few reported techniques described to manage tibial tubercle fractures in conjunction with complex proximal tibial injuries. Traditionally, tibial tubercle fractures have been repaired by lagging the tubercle fragment to the posterior cortex of the tibia using 1 or more screws. However, the cortex of the posterior tibia does not always offer good purchase for screw fixation, particularly in osteopenic bone. Additionally, in complex proximal tibial fractures, comminution often extends posteriorly, further complicating stable lag screw fixation. Placement of an anteroposterior lag screw can also be complicated by "screw traffic" if there are a large number of screws fixing the primary fracture. In this article, we report a novel surgical approach for the management of tibial tubercle fracture fragments occurring in association with complex proximal tibial fractures. Using this technique, the tibial tubercle fragment is stabilized by wiring it directly to the screws of a locking plate. It allows for reduction and fixation of the tibial tubercle fragment that is stable enough to allow immediate full active range of motion. Over the past 5 years, we have applied this technique in 16 patients. Our preliminary results using this new technique have demonstrated a high rate of clinical and radiographic union with near normal return of extensor mechanism function.

Key Words: tibial tubercle, tibial plateau, fracture, surgical technique, less invasive stabilization system

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SURGICAL TECHNIQUE

Our technique relies on the stable fixed-angle construct created in applying a locking plate to the proximal tibia and involves wiring the tibial tubercle to the locking screws of the plate (Fig. 1). The order of either placing the cerclage wires and then the locking plate or placing the locking plate first and then the cerclage wires is unimportant; however, we generally place the wires first and then fix the fracture, as described below.

Initially, the tibial plateau fracture and tibial tubercle fragment are exposed through a lateral parapatellar or curvilinear "hockey stick" incision. Throughout the procedure, it is important to minimize dissection to preserve soft tissue attachments to bone fragments and maintain the vascular supply to the bone. First, the continuity of the extensor mechanism to the tibial tubercle is confirmed. The tibial tubercle fragment is then reflected medially, exposing the medullary cavity of the proximal tibia (Fig. 2). Care is taken to preserve as much of the medial soft tissue attachments to the tibial tubercle fragment as possible.

Three or four 16-gauge stainless steel wires (Ethicon, Somerville, NJ) are then passed from the lateral side of the fracture, inside of the tibia, through the medial fracture line itself and then tunneled subcutaneously around to the medial side (Fig. 3). The free end of the wire can usually be pushed through the soft tissue with a needle driver or a wire passer can be employed. This is done carefully to avoid devitalizing the tubercle fragment. The number of wires used is dependent upon the size of the tubercle fragment; however, we have found that 3 wires are usually sufficient. The tibial plateau fracture is then reduced and fixed with a lateral locking plate construct. Once the locking plate has been applied, attention is turned to reduction and fixation of the tibial tubercle fragment. The lateral free ends of the wire are then looped around the visible lateral screw shafts and brought out to the lateral side of the fracture site (Fig. 4). The avulsed tibial tubercle fragment is now reduced into position and provisionally secured with K-wires or Weber clamps. The medial wires are brought over the top of the tubercle fragment and sequentially twisted around the lateral wires, compressing the fragment into position. Care

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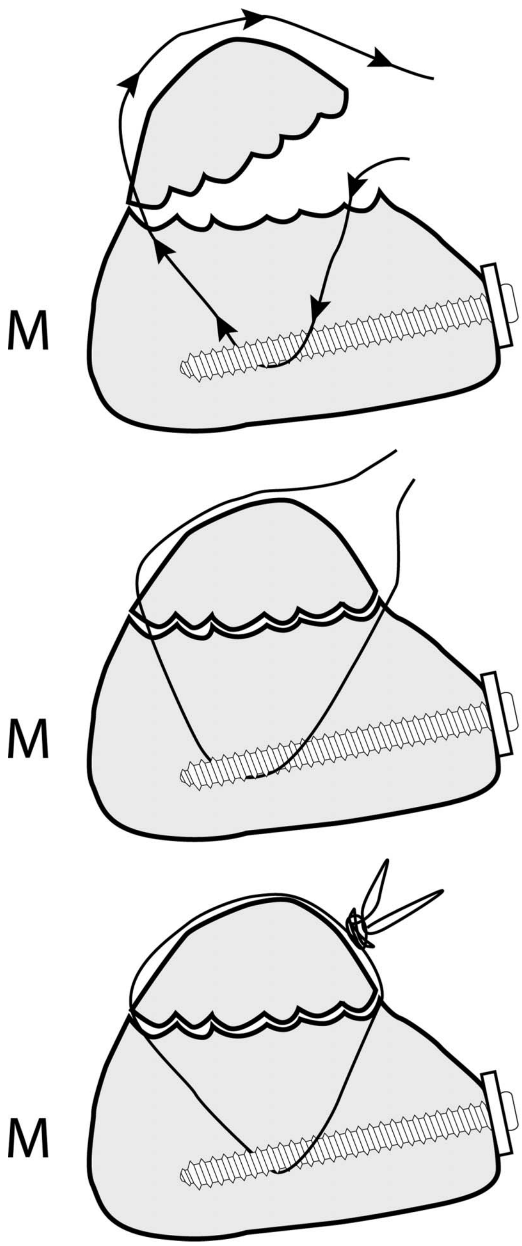

FIGURE 1. A diagrammatic representation of an axial cross section of the tibia following fixation of a fracture utilizing this technique. The wire looped around both the tibial tubercle fragment and the locking screw traversing the medullary cavity of the tibial. As this wire is tightened the tibial tubercle fragment is compressed into place.

must be taken not to overtighten the wires to prevent further fracture of the tibial tubercle fragment. The twisted wires are then cut and the sharp end bent against the tibia to prevent soft tissue irritation (Fig. 5). The knee is ranged through a full arc of motion to assess the stability of the construct and to ensure that there is no proximal migration of the tubercle fragment. The wound is irrigated and closed in the standard layered fashion.

Postoperatively, the patient is placed in a hinged knee brace as part of our standard postoperative protocol for C-type tibial plateau fractures. We hypothesize that bracing prevents a lateral bending moment across the repaired tibial plateau should the patient inadvertently bear weight. Assuming that adequate fixation of both the tibial plateau and the tibial tubercle has been obtained, unrestricted active range of motion is initiated immediately. Weight bearing is initially restricted to touchdown on the injured leg. Bracing is typically discontinued at 4–6 weeks. Advancement of weight bearing is dependent upon the healing of the tibial plateau.

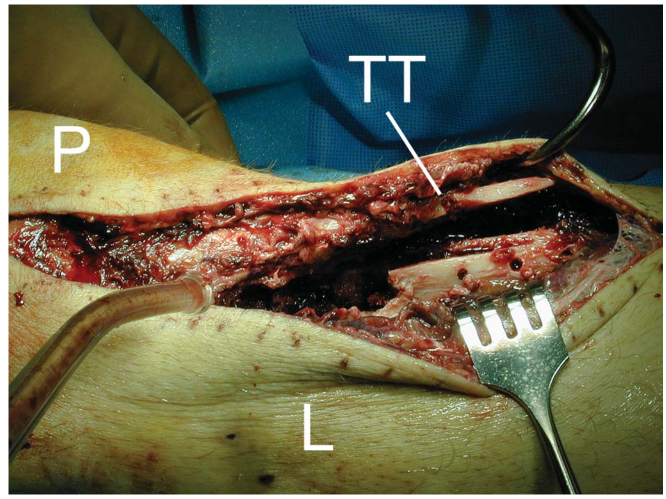

FIGURE 2. A communited tibial plateau fracture, which had failed previous treatment (note screw holes), was associated with a large tibial tubercle fragment (TT). The proximal tibia was approached through a lateral incision, and the fracture was prepared for reduction and fixation. The lateral fracture line has been booked open, with the medial soft tissue attachments of the tubercle fragment undisturbed. The medullary cavity of the proximal tibia is visible. P, proximal; L, lateral.

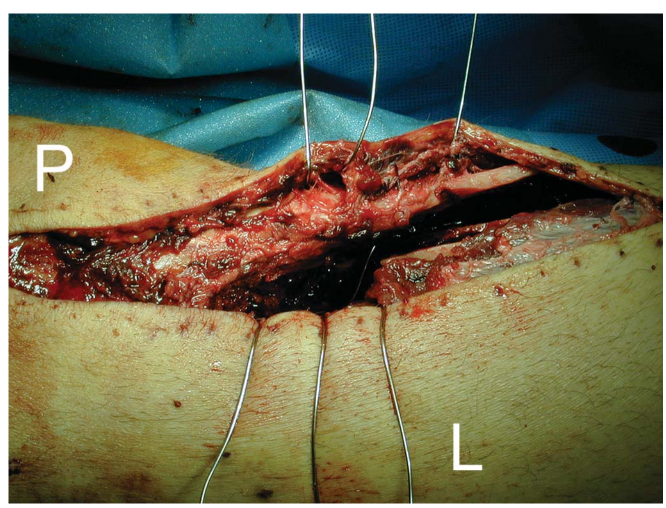

FIGURE 3. Three 16-gauge wires are looped around the tibial tubercle fragment, avoiding extensive soft-tissue stripping. P, proximal; L, lateral.

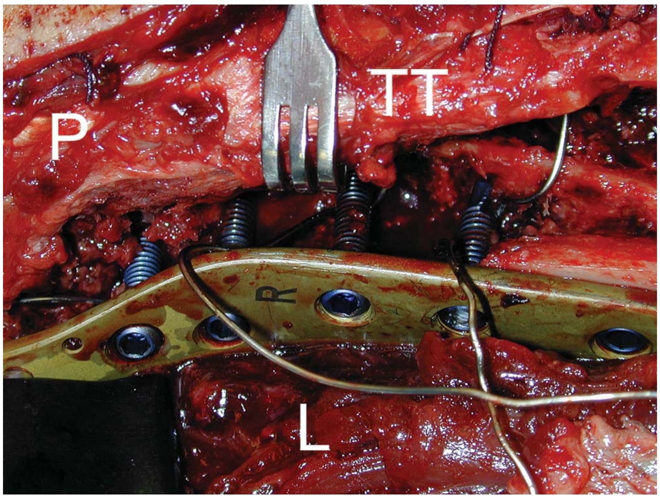

FIGURE 4. The wires are then each passed around one of the locking screws or through a free hole in the locking plate. P, proximal; L, lateral.

CASE SERIES

We performed a retrospective review of all the patients treated with this technique at our institution. Patients were identified by query of our institution's electronic orthopaedic trauma database: Ortho DUDE (Data Utility of Documentation and Education). Over the 5 years, from January 1, 2002, through December 31, 2006, 16 patients were treated with this technique. Data were gathered through review of the electronic patient notes and radiographs. Patient demographics and injury characteristics are presented in Table 1.

Patient outcomes are presented in Table 2. At a mean follow-up of 15 months (2–40 months), the average extension was 1 degree (±4.1 degrees) and the average flexion was 113 degrees (±22.1 degrees). All but 1 fracture went onto radiographic and clinical union (94%). Although there was a significant complication rate, there were no complications specifically related to the tibial tubercle fixation.

Figures 6 and 7 depict the preoperative and postoperative radiographs of a typical patient treated with this technique. This patient was an 18-year-old gentleman who was injured when he was hit by a car while rollerblading. He sustained a type I open fracture of his right tibial plateau. He was taken urgently to the operating room for irrigation, debridement, and surgical fixation of his fracture. Postoperatively, he was placed in a hinged knee brace and a continuous passive motion machine. Touchdown weight bearing was continued until there was evidence of bone healing. At 5-month follow-up, he had returned to school, had 0–120 degrees of active knee motion, had similar strength to the contralateral side, and had only occasional discomfort related to the implant.

TABLE 1. Patient Characteristics After Proximal Tibial Fixation and Tibial Tubercle Wiring

Patients	16
Age (yrs)	47 (18–81)
Sex (male), %	9/16 (56)
Bony injury (%)*	
41A	3 (19)
41B	1 (6)
41C	12 (75)
Soft tissue injury (%)†	
Closed	13 (82)
Type I	1 (6)
Type II	1 (6)
Type IIIA	0 (0)
Type IIIB	1 (6)

*Fractures classified according to the AO classification.[1]
†Soft tissue injury associated with the proximal tibial fracture was graded according to the Gustillo–Anderson grading system.[2]

TABLE 2. Outcomes After Proximal Tibial Fixation and Tibial Tubercle Wiring at Final Follow-up

Follow-up (mo)	15 (2–40)
Range of motion (degrees)	
Extension	1 (±4.1)
Flexion	113 (±22.1)
Radiographic union (%)	15/16 (94)
Complications (%)*	5/16 (31)

*Complications included 1 amputation for an infected nonunion of the tibial shaft, 1 case of implant removal for persistent infection, 1 case of implant removal for irritation from the plate and wires, 1 nonunion of an associated tibial shaft fracture requiring bone grafting, and 1 arthroscopy for a loose body. There were no complications directly related to the wires or extensor mechanism.

DISCUSSION

Fracture of the tibial tubercle and extensor mechanism disruption in conjunction with a tibial plateau fracture are uncommon. The operative management of this injury pattern has not been well defined in the orthopaedic literature. These injuries are difficult to treat and plagued with a high rate of complication.[3]

Cortical lag screw fixation of the tubercle to the posterior tibial cortex is the traditional surgical option available.[2] Stable fixation can be limited both by poor bone quality or by significant comminution of the proximal tibia. Ricci et al[4] in their review of 28 patients treated with the "less invasive stabilization system" for complex proximal tibial injuries

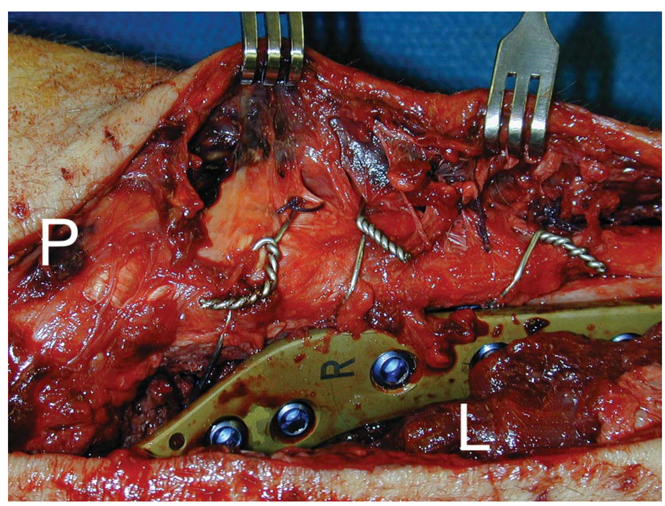

FIGURE 5. The tibial tubercle fragment is then reduced and the wires sequentially twisted, compressing the fragment against the tibia and maintaining the reduction. Stability is tested by ranging the knee. P, proximal; L, lateral.

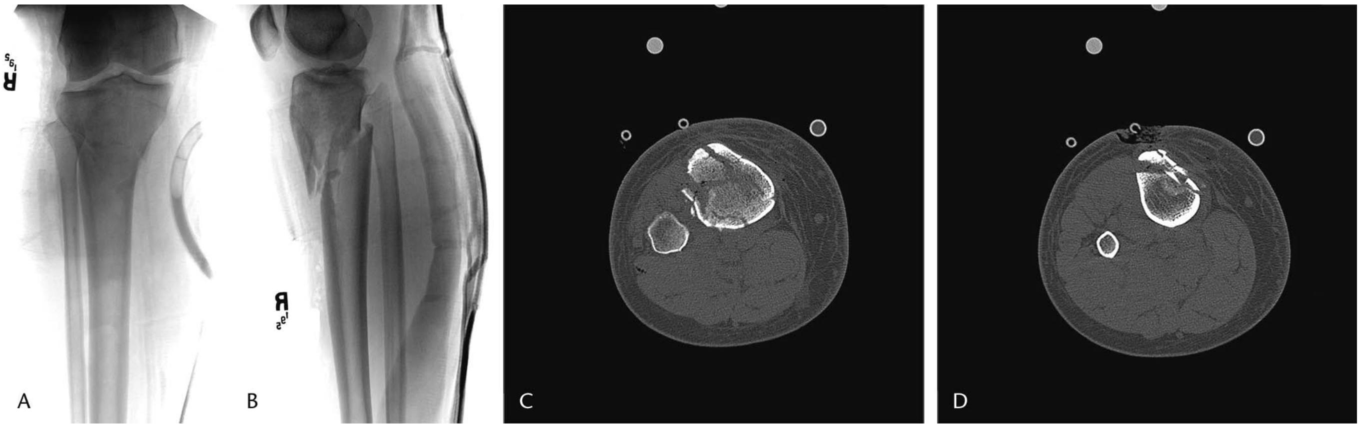

FIGURE 6. A–D, Anteroposterior and lateral radiographs demonstrating a C-type tibial plateau fracture. Representative axial computed tomography images demonstrate the tibial tubercle fragment.

describe the placement of interfragmentary lag screws to reduce a tibial tubercle fragment in 3 patients. The authors acknowledge the difficulty in positioning screws as to avoid the locking screws of the less invasive stabilization system plate.

Circular fixators and thin wires using the Ilizarov method have also been described for the treatment of comminuted proximal tibial fractures.[6–8] A transverse wire placed through the avulsed tibial tubercle fragment and held using an arch wire can be used to stabilize the extensor mechanism. Although the overall success rate is good, the technique precludes early mobilization and is frequently associated with pin tract infections and frame-related discomfort.[9,10] Circular fixators can also be supplemented with a hook plate as described by Watson and Coufal.[10] They reported the successful use of a hook plate in their treatment of 5 individuals with lateral tibial plateau fractures associated with avulsion of the tibial tubercle and loss of the extensor mechanism. They described burying the hook of the plate into the tubercle fragment with or without supplementary monocortical screw fixation. The distal plate is then fixed to the tibia with eccentrically placed screws, leading to compression of the tubercle fragment. The hook plate was then neutralized with an Ilizarov frame. This construct provided enough stability to allow early mobilization but is also dependent upon thin wires and a circular frame.

Our approach to fixation of the tibial tubercle fracture with use of a locking plate and wires offers several advantages over previously described techniques. First, fixation is independent of bone quality or fracture comminution. Issues with "screw traffic," when large numbers of screws are used to fix the primary fracture, are avoided. Enough stability can be achieved to allow immediate postoperative mobilization. The technique involves internal fixation, avoiding the morbidity associated with external fixation. The additional implants required to achieve fixation are minimal. Finally, the simplicity of the technique makes it easy to learn and apply.

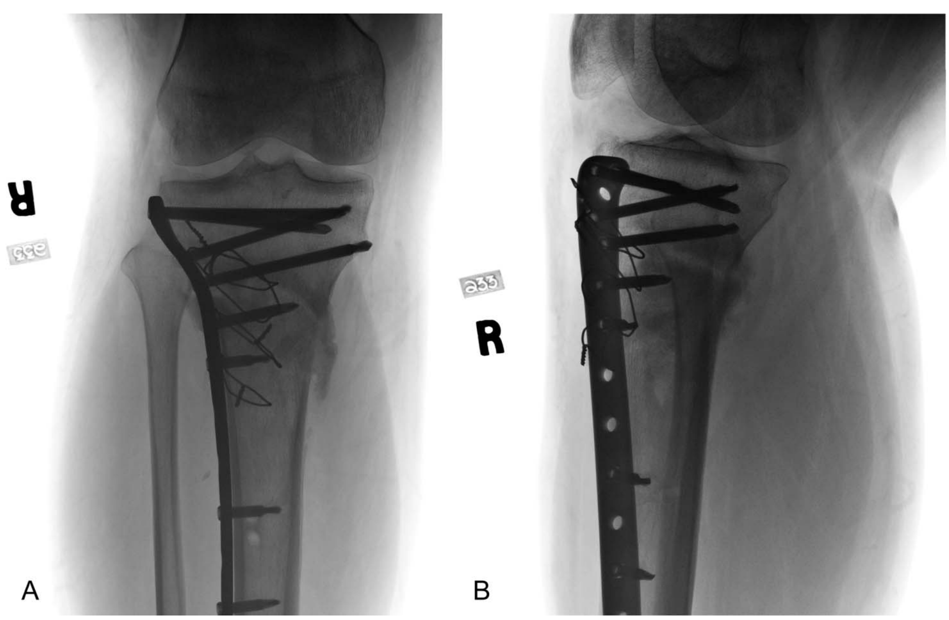

FIGURE 7. A, B, Anteroposterior and lateral radiographs of this same patient taken 5 months after fixation with an LISS plate and wiring of the tibial tubercle. Radiographic union is evident. LISS, less invasive stabilization system.

We have applied this surgical technique using titanium plates and screws coupled with stainless steel wires and with all stainless steel constructs. When 2 different metals contact each other, there is a theoretical possibility of a galvanic reaction, leading to early corrosion or wear. We have not had a problem with wear or wire failure in our limited series. Recently, Høl et al studied the use of various combinations of plates and screws composed of titanium and stainless steel. They determined that there was no increase in corrosion or wear with combinations of titanium and stainless steel as opposed to constructs made entirely of titanium or stainless steel.[12] A similar study of spinal instrumentation systems also found no increase in corrosion or wear with a combination of titanium and stainless steel components.[13]

Our experience with this technique has shown it to be a reliable way of successfully reconstructing a stable extensor mechanism in complex proximal tibial fractures associated with a free tibial tubercle fragment.

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