Tibial Eminence Fractures: A Review and Algorithm for Treatment

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Background

Fractures of the tibial eminence, first described by Poncet in 1875,[1] are bony avulsions of the ACL from its insertion on the intercondylar eminence of the tibia (Figure 1). Tibial eminence fractures are relatively rare with an incidence of approximately 3 per 100,000 per year,[2] and account for 2 to 5% of knee injuries in the pediatric pediatric population.[3,4] While most commonly seen in children between 8 and 14 years of age,[5] recent literature suggests that the incidence of tibial eminence fractures in adults is higher than previously thought.[6] Hayes *et al* found that 40% of tibial eminence fractures reported in the literature occurred in adults.[7]

Arthroscopic reduction of tibial eminence fractures has gained popularity due to its successful outcomes, decreased invasiveness, and improved recovery time.[8-11] However, controversy still exists regarding the optimal method of arthroscopic surgical fixation. The risk of arthrofibrosis, which can diminish range of motion (ROM) of the affected knee, particularly extension, is of primary concern when treating tibial eminence fractures both surgically and non-surgically.[12]

Figure 1. T2-weighted sagittal MRI demonstrating a displaced tibial eminence fracture.

Anatomy

The tibial eminence is anatomically divided into four distinct regions by the medial and lateral intercondylar spines and anterior and posterior recesses. It serves as the insertion point for the anterior and posterior cruciate ligaments and the menisci. The ACL inserts on the tibial eminence at the anterior intercondylar area in a recess anterior to the medial tibial spine. The anterior attachment of the medial meniscus is anterior to the ACL insertion, and the anterior attachment of the lateral meniscus is posterior to the ACL insertion.[8] The intermeniscal ligament traverses between the medial and lateral menisci anterior to the tibial eminence where it is vulnerable to entrapment within these fractures, thereby blocking reduction.

Classification

In 1959, Meyers and McKeever published a system for classifying tibial eminence fractures.[13] They recognized three main types based on the amount of displacement and the fracture pattern seen on the initial radiographs. Type I fractures display minimal elevation of the anterior margin of the fragment. Type II fractures show anterior lifting of one-third to one-half of the tibial eminence from the epiphyseal bed through a posterior hinge (i.e. a trap-door configuration). Type III fractures have completely displaced from the osseous bed in the intercondylar eminence. These can be broken down into type IIIA fractures, which have no rotational malalignment, and type IIIB fractures, which have rotated such that the cartilaginous surface of the fracture fragment faces the exposed bone at the fracture site.

The classification system was updated by Zaricznyj in 1977 to include Type IV fractures, or comminuted fractures of the tibial eminence.[14] Lateral plain radiographs are the most helpful basic imaging modality to assess which fracture type is present. Thetreatment modality is

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highly dependent on fracture type, so a good quality lateral radiograph is of paramount importance.

Treatment

Type I fractures are best managed by immobilization in a long-leg cast or fracture brace. The amount of flexion recommended varies by author and can range from 10-40 degrees,[15-17] with some advocating for immobilization in full extension[18,19] or hyperextension.[20] Immobilization in hyperextension is poorly tolerated[15] and puts posterior structures such as the popliteal artery under tension, potentially resulting in the development of compartment syndrome.[21] The decision to evacuate the hematoma is at the discretion of the treating physician. Healing occurs rapidly in skeletally immature patients and most physicians treat type I fractures with 4-6 weeks of immobilization.[18,22-24] In older children, adolescents, and adults, long periods of immobilization may cause development of significant knee stiffness and muscle atrophy.[25] Therefore, the shortest period of immobilization possible to maintain reduction is recommended,[26-28] often 2-3 weeks, followed by protected ROM activity. Isometric quadriceps exercises are prescribed throughout the immobilization period to minimize the effects of disuse. Interval radiographs are obtained to ensure maintenance of fracture reduction.[8]

Many have promoted closed reduction by knee extension under anesthesia followed by knee immobilization for type II fractures of the tibial eminence.[29-31] However, the ability of manipulation under anesthesia to achieve reduction is controversial.[16,29,30,32] Reduction is most likely caused by femoral notch and sulcus pressures during knee extension. Importantly, a minimal amount of fragment elevation (less than 4mm) does not appreciably affect subjective outcomes.[24,33] However, if an acceptable reduction cannot be achieved or maintained by closed manipulation, operative treatment is indicated.The inability to achieve reduction is often secondary to entrapment of the intermeniscal ligament in the fracture.[34,35]

Surgical reduction and fixation is standard of care in type III and IV fractures because soft tissue entrapment, which occurs in 65-100% of these fractures,[34,35] must be resolved for adequate reduction. Several arthroscopic techniques have been reported including metal screw,[36-41] staple,[42] Kirschner wire,[43-46] and suture fixation.[42,46-51] The optimum fixation technique remains controversial;[52] some surgeons favor suture fixation[51] while others prefer screw fixation.[53]

The success of surgical intervention is dependent on prompt treatment,[20,54] secure fixation, and early mobilization.[55] Biomechanical studies have reported that the strength of suture fixation is higher than that of screw fixation.[56,57] However, Mahar*et al* found that both suture and screw fixation had increased fracture separation during cyclic physiologic loads which could cause loss of fracture reduction.[58] Recent reports have indicated that the use of a hybrid technique, using both suture and screw fixation, may achieve a more stable reduction allowing early return to ROM, thereby decreasing risk of arthrofibrosis.[59] The authors' preferred treatment algorithm is presented in Figure 2.

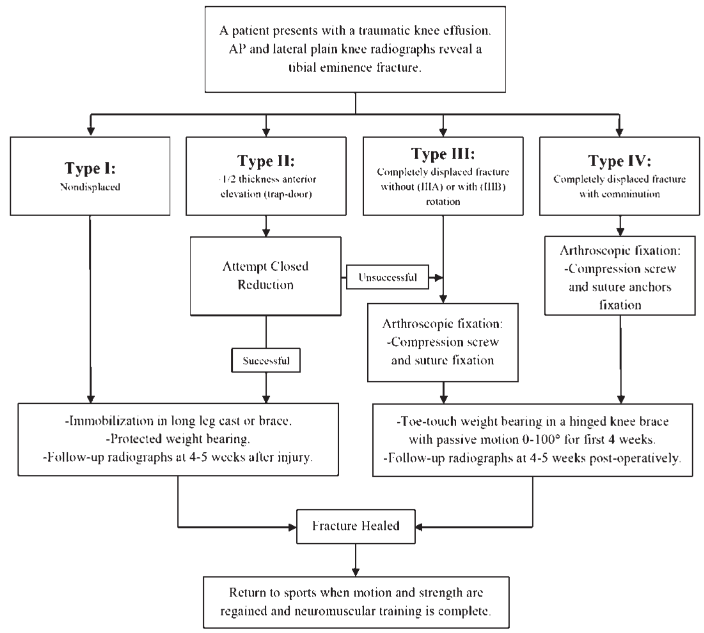

Figure 2. The authors' preferred algorithm for the treatment of tibial eminence fractures.

Keys to Avoid Pitfalls

- To avoid misdiagnosis of fracture classification, a true lateral radiograph is necessary.
- Early treatment, secure fixation, and early mobilization can help avoid complications such as arthrofibrosis with loss of knee extension.
- Mid-patellar portals allow good visualization and easy placement of screws perpendicular to the fracture site
- Provisional fixation of the fracture fragment with Kirschner wires before final fixation can help maintain reduction

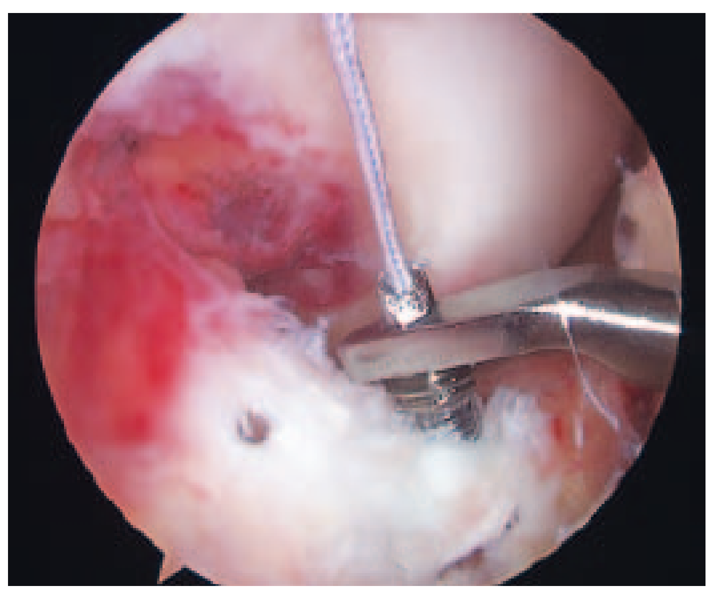

Figure 3. When attempting suture fixation of tibial eminence fractures, use of a cannulated ACL guide allows for passage of sutures from distal to proximal through the tibial tunnel into the joint.

- Fixation can be aided by use of a washer when the tibial eminence fracture is thin or has slight comminution
- The use of cannulated ACL guides may assist passage of sutures from distal to proximal into the joint (Figure 3)
- In comminuted (type IV) fractures, use arthroscopic shoulder fixation techniques for the knee: pass the sutures through the base of the ACL (as one would secure the capsule and labrum for a shoulder) and secure with shoulder anchors on the proximal tibia anterior to the fracture site.

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