Arthroscopic Suture Bridge Fixation of Tibial Eminence Fractures: A New Surgical Technique and Biomechanical Analysis

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Introduction
Fractures of the tibial eminence (spine) occur most frequently in the pediatric and early adolescent ages, although it can be seen in the adult population. Fracture classification consists of three types: Type I is minimally displaced, type II consists of proximal displacement of the anterior 1/3 of the spine with an intact posterior hinge, and type III involves complete displacement of the fracture fragment from its bony bed.1,2 Displaced tibial eminence fractures often require surgical intervention, either open or arthroscopic. Multiple arthroscopic techniques have been described in the literature, including suture and screw fixation.3 Arthroscopic suture bridge fixation with Pushlock anchors (Arthrex; Naples, FL) is a new surgical technique. The purpose of this study is to describe this novel surgical technique and perform a biomechanical comparison with suture and screw fixation.

Methods
Surgical Technique: A standard knee arthroscopy is performed with anterolateral and anteromedial working portals. The displaced tibial eminence fracture is identified and both the fragment and its bed are debrided. Definitive fracture fixation is performed using a Pushlock anchor preloaded with two strands of No. 2 Fiberwire (Arthrex; Naples, FL) and placed into the posterior wall of the fracture bed. The sutures are shuttled through and around the anterior cruciate ligament (ACL) in a crossing fashion and secured using Pushlock anchors on the anteromedial and anterolateral edges of the fracture line to complete the suture bridge (Figure 1). The anchors are best placed in an angled position to avoid damage to the physs. Post-operatively patient is placed into a knee immobilizer with partial weight bearing with crutches for 2 weeks. Gradual range of motion is allowed after this period to regain full motion. Non-impact activities are allowed between six and eight weeks.

Biomechanical Testing: Twenty-four porcine knees were dissected, leaving only the ACL as a soft tissue attachment between the femur and tibia. A fracture of the tibial eminence was created using an osteotome. Specimens were randomly assigned to one of three fixation techniques: suture fixation, screw fixation, or suture bridge fixation with Pushlock anchors (Figure 2). Following fixation, the specimens underwent biomechanical testing using a method similar to that described by Mahar et al., to assess initial stiffness (N/mm), displacement at failure (mm), and failure load (N). The authors would like to acknowledge Ryan Rich and Sarath Koruprolu for their hard work and dedication in completing the biomechanical testing.

Results
Data from each fixation group was averaged and compared using one-way ANOVA. Statistical significance was defined a priori as p<0.05. The Pushlock fixation group had a statistically significant higher failure load in comparison to screw and suture fixation (p<0.05) (Figure 3). The comparison of screw and suture fixation showed no significant difference (p=0.99). Initial stiffness comparison between the three fixation groups showed no significant difference (p=0.396). The displacement change after 200 cycles showed no statistically significant difference between the three groups (p=0.18), although there was a trend toward less displacement for the Pushlock compared to both screw and suture fixation (Figure 3). The displacement at failure showed a statistically significant larger displacement for suture fixation (14.1 mm) than screw fixation (5.62 mm, SD 3.68 mm). There was no significant difference between Pushlock fixation (8.36 mm, SD 2.9 mm) and screw or suture fixation.

Discussion
Suture bridge fixation of displaced tibial eminence fractures using Pushlock anchors is an effective, growth-plate sparing technique that allows for rigid fixation of the fracture fragment. Biomechanical testing revealed a statistically significant higher failure load in comparison to suture and antegrade screw fixation. Similar to other studies in the literature, there was no significant difference for failure load in comparing screw and suture fixation. There was also a trend toward less displacement after 200 cycles for Pushlock fixation, but the sample size was not large enough (n=24). Appropriately, in all three fixation groups the initial stiffness was not statistically different, indicating that the quality of the initial fixation was adequate.

Significance
The rigid fixation of the Pushlock technique may allow for more aggressive rehabilitation protocols and decreased post-operative laxity, residual instability, and need for re-operation.

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References