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Tibial Eminence Fractures in Children: Prevalence of Meniscal Entrapment

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Background: Meniscal entrapment under a displaced tibial eminence fragment may be a rationale for arthroscopic or open reduction in type 2 and 3 tibial eminence fractures.
Purpose: To determine the prevalence of meniscal entrapment in children with type 2 and 3 tibial eminence fractures.
Study Design: Case series.
Methods: Records of a consecutive series of 80 skeletally immature patients (mean age, 11.6 years; range, 5 to 16) who underwent arthroscopic (71), open (5), or combined arthroscopic and open (4) reduction and internal fixation of type 3 tibial eminence fractures (57) or type 2 fractures that did not reduce in extension (23) from 1993 to 2001 were reviewed.
Results: Entrapment of the anterior horn of the medial meniscus (36), intermeniscal ligament (6), or anterior horn of the lateral meniscus (1) was seen in 26% (6 of 23) of type 2 fractures and 65% (37 of 57) of type 3 fractures. An associated meniscal tear was seen in 3.8% of patients (3 of 80).
Conclusions: Meniscal entrapment is common in patients with type 2 and 3 tibial eminence fractures. Arthroscopic or open reduction should be considered for type 3 fractures and for type 2 fractures that do not reduce in extension to remove the incarcerated meniscus, allowing for anatomic reduction.

Fractures of the tibial eminence occur because of chondroepiphyseal avulsion of the ACL insertion on the anteromedial tibial eminence.[21,27] Meyers and McKeever[17,18] classified three types of tibial eminence fractures: nondisplaced (type 1), partially displaced or hinged (type 2), and completely displaced (type 3). Tibial eminence fractures are seen relatively frequently in children and were once thought to be the pediatric equivalent of midsubstance ACL tears in adults.[2,3,7,9,10,12–14,22,23,25,26]

The appropriate treatment of tibial eminence fractures in children is controversial, with techniques advocated that include cast immobilization,[12,19] closed reduction with immobilization,[22,23] open reduction with immobilization,[19] open reduction with internal fixation,[20,22] arthroscopic reduction with immobilization,[18] arthroscopic reduction with suture fixation,[11–14] and arthroscopic reduction with wire[1] or screw fixation.[3,12,16]

Meniscal entrapment under the displaced tibial eminence fragment has been reported, and its presence may be a rationale for considering arthroscopic or open reduction in cases of type 2 and 3 tibial eminence fractures.[5,6,8,13] The purpose of this study was to determine the prevalence of meniscal entrapment in children with type 2 and 3 tibial eminence fractures.

MATERIALS AND METHODS

A consecutive series of 80 skeletally immature patients who underwent surgical reduction and fixation of type 2 or 3 tibial eminence fractures from 1993 to 2001 at the Sports Medicine Division of Boston Children's Hospital was reviewed. The average patient age was 11.6 years (range, 5 to 16). There were 45 male (56%) and 35 female (44%) patients. Injuries occurred as a result of sports or active play (76) or pedestrian-vehicle accidents (4). Lachman examination under anesthesia identified International Knee Documentation Committee (IKDC) Score grade A laxity (normal) in none of the patients, grade B laxity (nearly normal) in 6.3% (5 of 80) of the patients, grade C (abnormal) laxity in 51.3% (41 of 80) of the pa-

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tients, and grade D laxity (severely abnormal) in 42.5% (34 of 80) of the patients. Pivot shift examination under anesthesia was recorded for 54 patients and identified IKDC grade A laxity (normal) in none, grade B laxity (nearly normal, pivot glide) in 38.9% (21 of 54), grade C laxity (abnormal, clunk) in 57.4% (31 of 54), and grade D laxity (severely abnormal, gross) in 3.7% (2 of 54).

During this period, 30 type 1 fractures, 49 type 2 fractures, and 57 type 3 fractures were treated overall. All type 1 fractures were managed closed. For type 2 fractures, 26 patients were treated with a closed technique because they had fracture reduction with knee extension, and 23 patients were treated operatively because they did not have fracture reduction with knee extension. We managed all type 3 fractures operatively. Thus, in this series, there were 23 type 2 fractures and 57 type 3 fractures; 71 patients underwent arthroscopic reduction and internal fixation, 5 patients underwent open reduction and internal fixation, and 4 patients underwent attempted arthroscopic reduction followed by open reduction and internal fixation. Fixation was performed with wires in 1 patient, sutures in 15 patients, and screws in 61 patients (Fig. 1). Postoperatively, the patients' legs were placed in a long leg or cylinder cast (66) or a locked hinged knee brace (14), and they were allowed protected weightbearing for 3 to 6 weeks. Patients were then mobilized with physical therapy emphasizing range of motion followed by strengthening and functional activities. Arthroscopic screw removal was performed between 6 weeks and 3 months postoperatively. Return to activities was allowed between 3 and 4 months after fixation if there was evidence of radiographic healing, clinical stability of the knee (IKDC grade A or B Lachman and pivot shift examination with a firm endpoint), absence of symptoms of instability or pain, and nearly symmetric motion and strength.

Operative reports and intraoperative arthroscopic photos were reviewed to determine the presence of meniscal entrapment. Operative reports, preoperative radiographs, and intraoperative arthroscopic photos were reviewed to determine Meyers-McKeever[17,18] tibial eminence classification: nondisplaced (type 1), partially displaced or hinged (type 2), and completely displaced (type 3). The proportion of cases with meniscal entrapment was determined and compared between type 2 and type 3 fractures by using 95% confidence intervals determined by Pratt's approximation for binomial proportions.[4]

RESULTS

Fifty-four percent of patients (43 of 80) had an incarcerated anterior horn of the medial meniscus (36), intermeniscal ligament (6), or anterior horn of the lateral meniscus (1). Entrapment was observed in 26% (6 of 23) of type 2 fractures and 65% (37 of 57) of type 3 fractures. Type 3 fractures had a significantly higher proportion of meniscal entrapment (95% confidence interval for type 2 fractures, 0.102 to 0.484; 95% confidence interval for type 3 fractures, 0.511 to 0.771).

An associated meniscal tear was seen in 3.8% (3 of 80) of patients, all of whom had a type 3 tibial eminence frac-

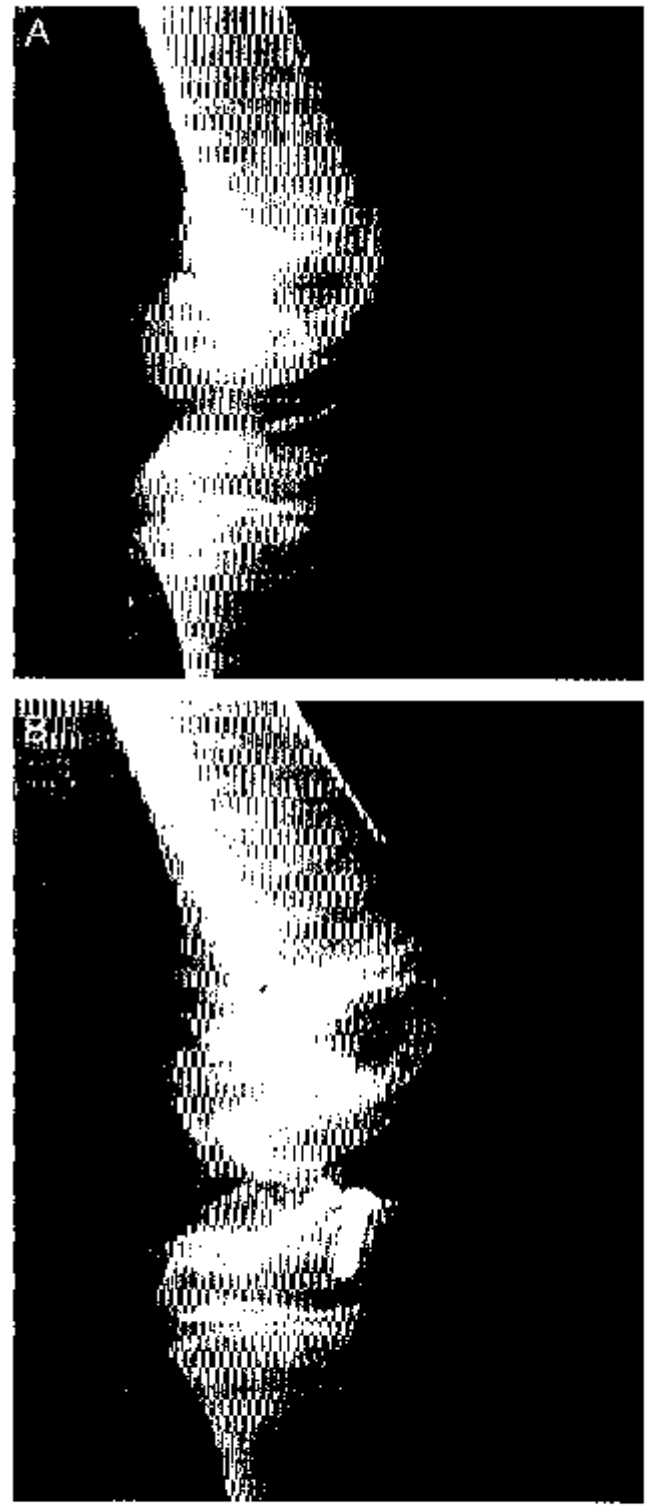

Figure 1. Preoperative (A) and 3-month postoperative (B) lateral radiographs of a type 3 tibial eminence fracture in an 11-year-old male patient treated with arthroscopic reduction and internal fixation.

ture. There were two tears of the posterior horn of the medial meniscus and one tear of the posterior horn of the lateral meniscus. Tear patterns were longitudinal in two patients and horizontal in one patient. All three patients were treated with meniscal repair, and two of the three patients had incarceration of the intermeniscal ligament.

DISCUSSION

Arthroscopic or open reduction with internal fixation of type 2 and 3 tibial eminence fractures has been advocated because of the potential for meniscal entrapment under the fractured tibial eminence, which prevents anatomic closed reduction,[5,6,9,13] the potential for instability and loss of extension associated with closed reduction and immobilization,[9,10,15,22] the ability to concurrently evaluate and treat associated intraarticular meniscal or osteochondral injuries, and the resulting opportunity for early mobilization. For displaced fractures, Wiley and Baxter[25] found a correlation between fracture displacement at healing and knee laxity and functional outcome. However, some studies have found no difference in the outcome of displaced tibial eminence fractures treated closed versus those treated with an open or arthroscopic technique.[3,9,19,25,26] Furthermore, persistent anterior knee laxity despite anatomic surgical reduction and fixation has been frequently reported and may be related to elongation of the ACL associated with the tibial eminence fracture.[1,3,11,16,19,20,24,26]

Entrapment of the anterior horn of the medial meniscus or the intermeniscal ligament under the avulsed anterior tibial eminence fragment has been reported. Falstie-Jensen and Sondergard Petersen,[8] Burstein and colleagues,[6] and Chandler and Miller[6] have all reported cases of meniscal incarceration blocking reduction of type 2 or 3 tibial eminence fractures in children. The prevalence of meniscal entrapment in patients with tibial eminence fractures has not been established but may be common in those with displaced fractures. During arthroscopic treatment, Mah and colleagues[13] found medial meniscal entrapment preventing reduction in 8 of 10 children who had type 3 fractures.

In this study, we found meniscal entrapment preventing reduction in 65% of type 3 fractures and 26% of type 2 fractures that did not reduce in extension. The prevalence of meniscal tears associated with tibial eminence fractures was rare (3.8%, 3 of 80) and therefore does not appear to be commonly associated with anterior meniscal or intermeniscal ligament entrapment. The prevalence estimate of meniscal entrapment for type 2 fractures may be high because of selection bias, because only those type 2 fractures that did not reduce in extension were treated surgically. Nevertheless, meniscal entrapment appears commonplace in cases of type 3 fractures and relatively common in cases of type 2 fractures, particularly those that do not reduce in extension. Meniscal entrapment prevents anatomic reduction of the tibial eminence fragment, which may result in increased anterior laxity or a block to extension.[9,10,16,22,25] Furthermore, meniscal entrapment itself may cause knee pain after fracture healing.[6]

We found that approximately half (47%, 23 of 49) of type 2 tibial eminence fractures that we treated did not reduce adequately with knee extension. Of the 23 patients with type 2 fractures that did not reduce in extension and who thus underwent arthroscopic or open reduction, meniscal entrapment was seen in 26% (6 of 23). The obstacle to reduction in the remaining 17 patients was not clearly identified. Fluid from hemarthrotic knees was aspirated in 6 of these 17 patients; however, adequate reduction was still not obtained. These patients may have had smaller tibial eminence fragments that theoretically would not contact the femoral condyles during extension, thereby affecting reduction. However, we were unable to document this hypothesis because many of the original injury radiographs were returned to the patients or to the referring hospitals. Other authors have suggested that trochlear impingement, not femoral condyle shape, results in reduction of the intercondylar eminence.[5,6,9,13,14]

For type 3 fractures and for type 2 fractures that do not reduce in extension, we perform arthroscopic reduction and internal fixation with cannulated 3.5-mm or 4.5-mm epiphyseal screws (Fig. 1). If the eminence fragment is too small or comminuted for screw fixation, we use suture fixation. The entrapped anterior horn of the medial meniscus or intermeniscal ligament can be extracted by using an arthroscopic probe. We have often found it useful to place a temporary suture around the anterior horn of the medial meniscus from the anteromedial portal to retract it during reduction and fixation (Fig. 2).

In conclusion, we recommend consideration of arthroscopic or open reduction of type 3 tibial eminence fractures and type 2 fractures that do not reduce in extension because of relatively common meniscal entrapment preventing anatomic reduction.

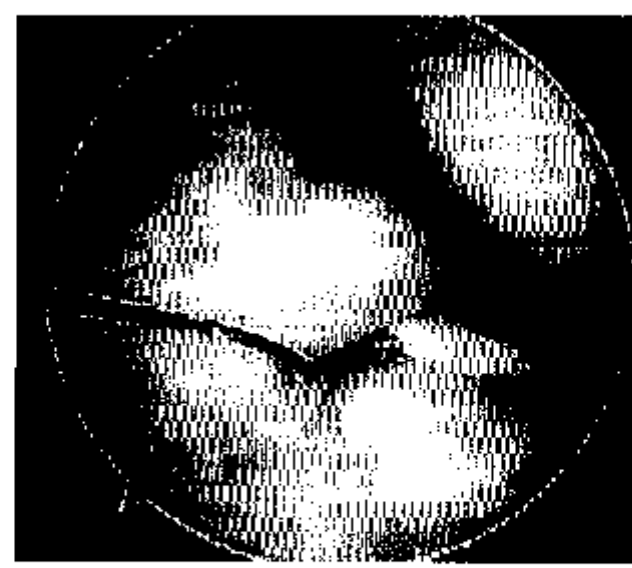

Figure 2. Arthroscopic photo demonstrating retraction of the anterior horn of the medial meniscus with a temporary suture placed through the anteromedial portal after reduction of a type 3 tibial eminence fracture in a 7-year-old male patient.

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