Case Reports

Pediatric PCL Insufficiency from Tibial Insertion Osteochondral Avulsions

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Abstract Posterior cruciate ligament (PCL) insertion-site osteochondral avulsions in children, particularly from the tibia, are not commonly seen by orthopaedic surgeons. Because of the rarity of these injuries, careful attention to the specific physical examination and imaging findings seen with these injuries is necessary so that the proper diagnosis can be made. Osteochondral avulsions of the PCL can be missed on plain radiographs in skeletally immature patients, and therefore magnetic resonance imaging is necessary for proper diagnosis. With this knowledge, clinicians can formulate treatment plans which can return their patients to activities while avoiding potential morbidity resulting from missed diagnoses or improper treatment. We report two rare cases of PCL insufficiency stemming from tibial insertion osteochondral avulsions. Both patients underwent subsequent open reduction and internal fixation of the avulsion using two

different fixation methods (bioabsorbable anchors versus cannulated screw and washer) and have returned to full sporting activities.

Introduction

Injuries to the PCL are uncommon, especially compared with its counterpart, the anterior cruciate ligament (ACL) [1, 14]. In adults, injuries to the PCL typically are limited to the substance of the ligament [30]. Bony avulsions, in which an osteochondral fragment is detached from the PCL insertion site, also have been reported in adults [5, 8, 11, 17, 22, 23, 29, 33, 35, 39]. In the pediatric population, PCL injuries are rare, likely as a result of the elasticity of the ligament [9, 10, 28]. Furthermore, the relative weakness of the physis and bone in comparison to the ligament more commonly results in osteochondral avulsions rather than ligamentous substance tears as seen in adults [2, 6, 9, 13, 19, 21, 22, 26–28]. However, femoral avulsions of the PCL are reported more frequently than those of the tibial insertion site in children [10, 12, 13, 19, 21, 25, 26, 28] (Table 1), and clinicians may not be as aware of the specific history, physical examination, and radiographic findings of these tibial-sided injuries as compared with those of the femur such as the need for specific imaging.

We present two pediatric patients with PCL insufficiency. Both had avulsion injuries of a fragment from the tibial insertion site of the PCL seen on MRI, although plain radiographs were negative in one of the cases. Both injuries were treated surgically using different fixation techniques based on the risk of potential disturbance to the physis. Intraoperatively in both cases, the detached fragments were primarily cartilaginous with a small, thin wafer of subchondral bone attached to the cartilaginous piece (which

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Each author certifies that his or her institution has approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Table 1. Known case reports of skeletally immature patients with tibial insertion PCL avulsion injuries

Case report	Year
Frank and Strother [9]	1989
Goodrich and Ballard [10]	1988
Ross and Chesterman [26]	1986
Ugutmen et al. [36]	2006
Quintart and Elbaum [25]	1999
Meyers [22]	1975

was attached to the PCL), representing osteochondral avulsions from the tibial insertion site.

Case Reports

Patient 1

A 14-year-old boy presented to our clinic with left posterior-medial knee pain for 11 days after falling while playing soccer. Physical examination showed the patient walked with an antalgic gait. Examination revealed a knee effusion and range of motion from 25° to 115°. The patient had a positive posterior drawer sign of +2 cm, posterior tibial sag sign, and quadriceps-active test. The patient's knee was otherwise stable, and his neurovascular examination was normal. A lateral radiograph of the left knee was normal (Fig. 1). However, MRI studies showed

Fig. 1 A lateral radiograph of the injured knee of Patient 1 was unremarkable for an osteochondral fragment. **Fig. 2** An MR image in the sagittal plane shows the PCL injury with an avulsed tibial osteochondral fragment (black arrow) in Patient 1.

complete avulsion of the tibial attachment site of the PCL with the ligament substance intact (Fig. 2).

We scheduled the patient for open reduction and internal fixation of the PCL avulsion 2 days after presentation to the clinic. An examination with the patient under anesthesia showed a positive posterior drawer sign (A supplemental video is available with the online version of CORR), and that the posterolateral corner of the knee was intact via the dial test. The patient then was placed prone. A posterior knee approach was used. The intact capsule of the posterior knee was incised, and the loose osteochondral fragment of the posterior tibia, which was noncomminuted and attached to the intact PCL, was identified. The fragment was mostly cartilaginous with a small, thin wafer of subchondral bone attached to the cartilaginous piece (which was attached to the PCL). The bed from which the osteochondral fragment emanated was freshened. The PCL was not retracted, which allowed us to easily bring the avulsed fragment down to the bed. We placed two bioabsorbable Mitek Panalok anchors (Mitek Surgical Products, Inc, Raynham, MA) in the proximal tibia, and the avulsed fragment was sutured down to the posterior aspect of the tibia. During final tensioning, the knee was held in 15° to 20° flexion while prone to allow the PCL avulsion to easily reapproximate to its tibial origin. All other soft tissue, ligamentous, and cartilaginous structures were intact. The normal posterior drawer and sag were reestablished at the conclusion of the case.

Postoperatively, the patient wore a hinged knee brace locked in full extension with the tibia reduced on the femur

clinically and radiographically. The patient was able to bear weight as tolerated. The patient was allowed to begin gentle range of motion activities 3 weeks postoperatively and by 6 weeks was able to discontinue wearing the hinged knee brace completely. In addition, at this time, the patient began strengthening exercises of the knee with emphasis on quadriceps strength recovery.

At the patient's postoperative followup at 6 months, he had no subjective complaints. He had full flexion and extension of the knee, no posterior sag, and a negative quadriceps active test. Biodex (Biodex Medical Systems, Shirley, NY) isokinetic testing showed only minimal strength deficits (22.5% extension and 13.2% flexion deficits at 180° per second; 17.9% extension deficit and 5.9% flexion enhancement at 300° per second) of the left leg compared with the right. The patient returned to sporting activities at this time, and radiographs verified healing. Twenty-four months after operative repair, the patient had returned to full sporting activities, and his physical examination showed symmetric stability tests.

Patient 2

A 12-year-old girl presented to our clinic with right knee pain and inability to bear weight for 7 days after blunt trauma to the knee while it was flexed. Examination revealed bruising about the anterior aspect of the knee with a moderate effusion. Knee range of motion was limited secondary to pain. In addition, the patient had a positive posterior drawer sign with a soft end point of approximately +1 cm, a posterior tibial sag sign, and a positive

quadriceps-active test. The patient's knee was otherwise stable, and her neurovascular examination was normal.

Radiographs showed a proximal tibial avulsion fracture. Magnetic resonance imaging confirmed a complete avulsion of the tibial attachment of the PCL with the ligament substance intact. Seven days after examination, the patient underwent open reduction and internal fixation of the PCL avulsion. Examination under anesthesia revealed a positive posterior drawer and the posterolateral corner of the knee was intact via the dial test. We used a surgical approach in the popliteal fossa similar to that in the prior case.

The loose osteochondral fragment of the posterior tibia, which was noncomminuted and attached to the intact PCL, was located. As with the prior case, the fragment was mostly cartilaginous with a small, thin wafer of subchondral bone attached to the cartilaginous piece (which was attached to the PCL). The bony bed from which the fragment emanated was freshened. We then anatomically reduced and fixed the fragment with a 4.0-mm cannulated screw and washer (Synthes, Paoli, PA). Intraoperative fluoroscopy confirmed the reduction and screw placement. All other soft tissue, ligamentous, and cartilaginous structures were intact. The normal posterior drawer and sag were reestablished at the conclusion of the case.

Postoperatively, the patient wore a hinged knee brace locked in full extension with the tibia reduced on the femur clinically and radiographically. The patient was able to bear weight as tolerated. Six weeks postoperatively the patient was allowed to begin gentle range of motion activities and discontinue wearing the hinged knee brace; the patient also began strengthening exercises with an emphasis on the quadriceps.

Fig. 3A–B (A) Anteroposterior and (B) lateral radiographs of the left knee of Patient 2 show maintenance of reduction with no injury to the physis 7 months postoperatively.

Four months postoperatively, Biodex isokinetic testing showed moderate strength deficits (44.8% extension and 25.6% flexion deficits at 180° per second; 32.6% extension and 14.2% flexion deficits at 300° per second) of the right leg when compared with the left. Aggressive physical therapy was continued at this time. At the patient's postoperative followup at 7 months, she had full flexion and extension of the knee, a negative posterior drawer, no posterior sag, and a negative quadriceps-active test. Plain radiographs showed maintenance of reduction and no disturbances to the physis (Fig. 3). The patient returned to sporting activities 9 months after surgery. Twelve months after operative repair, she had returned to full sporting activities, and physical examination of her knee showed symmetric stability.

Discussion

Diagnosis of PCL insufficiency resulting from avulsion of the tibial insertion site depends largely on radiographic analysis. Although clinical findings such as a posterior tibial sag and provocative physical examination maneuvers such as the posterior drawer and quadriceps-active test are hallmarks of PCL insufficiency, no physical examination maneuvers can differentiate a substance tear from an avulsion injury [6, 7, 11, 14, 20, 32, 34, 36]. Therefore, radiographic analysis is critical for proper diagnosis and treatment. Plain radiographs can be useful to detect an avulsed fragment if it is mostly osseous [20, 22, 32, 34, 36]. However, avulsion cannot be ruled out by unremarkable plain films, especially in skeletally immature patients, as was the case in one of our patients [9, 22]. As a result, we believe MRI is important in pediatric patients presenting with physical examination signs of PCL insufficiency to detect avulsion injuries which cannot be ruled out with unremarkable plain films.

Treatment options for avulsions of the PCL depend on the nature of the injury. If the avulsed fragment is non-displaced or minimally displaced, nonoperative treatment may be successful with a concentration on quadriceps strengthening [14, 32]. If the avulsed fragment is displaced or nonoperative treatment fails, surgical reduction and fixation may be considered [2, 14, 26, 32, 36, 38]. Controversy exists regarding proper treatment (ie, nonoperative versus operative) for these injuries, particularly since there is a paucity of published material regarding the natural history of PCL insufficiency in the pediatric population. We believe that in an athletic, skeletally immature individual who desires to return to sports with theoretically greater demands on his or her lower extremity, operative repair of the avulsed PCL better achieves the goal. We realize good outcomes in two cases do not document better

outcomes in general. However, with the trend of increasing athletic demands in younger age groups, we think it is a natural progression to strongly consider the benefits of surgery (and its risks) versus the potential risks of nonoperative treatment.

Using studies of the adult patient population, conservative treatment of PCL insufficiency has been linked to an increased risk of articular cartilage degeneration (particularly in the medial and patellofemoral compartments) with subsequent development of arthritis, meniscal tears, and quadriceps atrophy [3, 31, 34, 37]. Acute repair of PCL injuries reportedly prevents these changes [37]. Owing to the risk of knee degeneration stemming from abnormal knee biomechanics in the PCL-deficient knee, we believe a more aggressive approach in treating PCL injuries in the pediatric population is warranted through surgical intervention to restore normal knee kinematics and prevent degenerative changes.

If surgery is performed, the fixation method used is largely dependent on the quality of the avulsed fragment and the risk to the patient's physis. The patient's age, skeletal maturity, and physiologic age must be used to determine the amount of growth remaining in the proximal tibia and the subsequent risk of length and angular growth disturbances. The rate of proximal tibial growth is 0.9 cm per year until the last 2 years before maturity (14 years for females; 16 years for males) when the rate decreases to 0.5 cm per year [24]. In our patients (assuming both were 2 years from maturity), there was a possible risk (if the physis was violated) of 1.0 cm growth discrepancy. However, closer examination of the radiographs of both patients (Figs. 1, 3) shows our 12-year-old female patient is closer to physal closure than the 14-year-old boy. As a result, the amount of growth remaining from the proximal tibial physis in the 12-year-old girl can be presumed to be somewhat less than 1.0 cm and in the case of the 14-year-old boy, somewhat greater than 1.0 cm. As a result, if the physis were violated in either patient, the risk was greater to the male than the female.

Some would argue even with a potential growth disturbance less than 1.0 cm in our female patient, the risk of using a cannulated screw, which crosses the physis, should warrant consideration of other fixation options. One study examining a centrally placed hole using a small drill bit (6 mm or smaller) in an open physis for ACL reconstruction showed no growth disturbances [18]. However, a study by Kocher et al. examining transphysal ACL reconstruction showed growth disturbances when the tunnel used was 12 mm or greater across the physis [16]. The size of the cannulated screw used in our female patient was within this safe size for possible physal damage and also was centrally placed. As a result, we presumed a cannulated screw crossing the physis provided minimal risk to physal

growth disturbances in this patient who was nearing proximal tibial physal closure.

In the 14-year-male patient who had a lesser degree of skeletal maturity than the 12-year-old female patient, suture anchor fixation was used. This method provides the advantage of not violating the physis based on placement of the anchor proximal to the physis and is useful for small or comminuted pieces, which cannot be captured by a cannulated screw [4, 15]. In a patient with a larger degree of growth remaining and/or a small or comminuted fragment, suture anchor fixation is a viable option.

Although much has been published on injuries to the PCL in the adult population, pediatric PCL injuries remain a challenge to the orthopaedic surgeon. We report two rare cases of PCL tibial avulsions that were treated successfully with surgery in pediatric patients. Owing to skeletal immaturity of pediatric patients, avulsion of the PCL with an attached osteochondral fragment can exist with negative plain films, therefore, MRI may be useful in establishing the correct diagnosis. If surgery is performed, one must consider the potential risk of crossing the physis based on implant geometry and size and the size and quality of the avulsed fragment when choosing the fixation method. Orthopaedic clinicians must be aware of the fact that pediatric patients presenting with a physical examination consistent with PCL insufficiency may have tibial insertion-site avulsions. If there is a high clinical suspicion for a PCL injury, MRI should be obtained. In addition, surgical fixation based on the potential disturbance to the physis should be a consideration for the surgeon.

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