Anterior Cruciate Ligament Injuries in Children and Adolescents

Peter D. Fabricant, MD, MPH[a],
Mininder S. Kocher, MD, MPH[b,*]

KEYWORDS

• ACL • Anterior cruciate ligament • Youth athlete • Young athlete • Pediatric sports
• Iliotibial band • Hamstring

KEY POINTS

- Youth and adolescent athletes comprise the largest demographic of anterior cruciate ligament (ACL) tears, and the incidence is increasing.
- Growth disturbance is a common concern for those who treat ACL injuries in skeletally immature athletes.
- Nonoperative management leads to high rates of sport dropout; continued instability can result in progressive meniscal and cartilage damage as well as arthritic changes.
- Several physeal-respecting ACL reconstruction techniques exist for use in skeletally immature patients to minimize risk of growth disturbance.

INTRODUCTION

Tears of the anterior cruciate ligament (ACL) were once considered rare in skeletally immature athletes; however, they are now observed with increasing frequency. A dramatic increase in youth competitive athletic activity, early sport specialization, and year-round training and competition, along with increased awareness of ACL injuries in children, have led to a commensurate increase in the frequency of ACL tears in the skeletally immature. A recent epidemiologic analysis of a New York State administrative database revealed that the rate of ACL reconstruction in children less than 20 years of age had increased nearly 3-fold over a 20-year period from 1990 to 2009, and indicated that adolescents and teenagers represent the largest per capita demographic of ACL reconstructions.[1]

Although, historically, nonoperative management until skeletal maturity followed by traditional ACL reconstruction was a popular treatment strategy, recent understanding of the risks of nonoperative treatment and surgical delay have supported a trend toward early operative treatment.[2–7] In light of this, along with the increasing frequency and awareness of ACL injuries in children, surgical methods and instrumentation have evolved, in order to accommodate the unique anatomy of skeletally immature patients.

This article discusses the anatomy of the skeletally immature knee, ACL imaging and physical examination that is unique to children, and treatment strategies for ACL injuries in children and adolescents, including both nonoperative and surgical. The authors also offer their preferred treatment strategy for skeletally immature youth athletes with ACL tears.

ANATOMY

The physes about the knee remain the greatest anatomic concern of surgeons who treat skeletally immature patients with ACL tears.

[a] Pediatric Orthopaedic Surgery Service, Hospital for Special Surgery, Weill Cornell Medical College, 535 East 70th Street, New York, NY 10021, USA; [b] Division of Sports Medicine, Department of Orthopedic Surgery, Boston Children's Hospital, Harvard Medical School, 300 Longwood Avenue, Boston, MA 02115, USA
* Corresponding author.
E-mail address: mininder.kocher@childrens.harvard.edu

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Significant damage to the tibial or femoral physis may lead to growth disturbance and subsequent length or angular deformity of the lower limb. An understanding of this unique anatomy is vital when planning surgery for youth with ACL injuries.

The tibial and femoral physes are the greatest contributors to overall lower limb longitudinal growth. The distal femoral physis contributes 70% of the femoral length and 37% of the overall limb length over the course of skeletal development at an average rate of 10 mm/y. The distance of the femoral physeal plate and perichondral ring from the femoral origin of the ACL remains unchanged from gestational age, and is 3 mm from the over-the-top-position.[8] The proximal tibial physis contributes approximately 55% of the tibial length and 25% of the overall limb length over the course of skeletal development at a rate of 6 mm/y, on average. Furthermore, the tibial tubercle apophysis is subject to injury and can result in recurvatum deformity.[9] Although skeletal maturity occurs around age 14 years in girls and age 16 years in boys, negligible (<1 cm in each limb segment) growth remains around the knee after age 12 to 13 years in girls and 14 years in boys.[10] Until these ages, ACL reconstruction strategies must respect the growing physes. To date, only small case series have reported on growth disturbance after ACL reconstruction,[11–17] so the precise incidence is not known. Experienced surgeons from the Herodicus Society and the ACL Study Group revealed 15 cases of postoperative deformity caused by physeal injury, including distal femoral valgus deformity, tibial recurvatum, genu valgum, and significant leg length discrepancy.[9] More recent case reports and imaging studies show the potential for growth disturbance after transphyseal ACL reconstruction,[18] physeal-sparing all-epiphyseal ACL reconstruction,[19,20] and partial transphyseal reconstruction.[16]

PATIENT EVALUATION AND DIAGNOSIS

Every evaluation should begin with a thorough history and physical examination, as well as ruling out concurrent injury. In adolescents presenting with acute traumatic hemarthrosis, ACL injuries can be present in up to 65% of cases.[21] Reliable physical examination maneuvers to detect ACL insufficiency are similar to those in adult patients and include the Lachman test, anterior drawer test, and the pivot shift. However, pain and swelling can increase guarding and affect patient compliance and subsequent accuracy of these tests; the pivot shift test has been shown to be 98% positive in anesthetized patients compared with only 35% positive in patients who are awake during the examination. It is important to evaluate baseline clinical limb alignment as well as leg length discrepancy. This discrepancy is typically measured with a tape measure (anterior superior iliac spine to medial malleolus), as well as using blocks under the clinically short leg to correct pelvic obliquity and measure functional limb length discrepancy.

MRI is the principal imaging modality used to evaluate for internal derangement of the knee, and is 95% sensitive and 88% specific in detecting ACL tears in children.[22] MRI also allows further evaluation for common associated injuries, including meniscus tears, chondral lesions, and combined ligamentous injury. Traumatic chondral lesions have been observed in up to half of high school athletes with ACL injuries, so careful examination of all cartilage surfaces is important.[23] Identification of these associated injuries may be important in guiding treatment options.

In addition to the standard radiographic evaluation (anteroposterior [AP], lateral, notch, Merchant), surgeons can consider obtaining 130-cm (51-inch) standing AP hip-to-ankle radiographs to quantify any baseline leg length discrepancy and angular deformity noted during the physical examination.[11,24] Skeletal age should be determined for children and adolescents with open physes, and is most frequently assessed using a posteroanterior left hand radiograph[25–27]; however, alternative methods based on pelvis, elbow, and calcaneal radiographs have also been described.[28–31] Clinically, timing of peak growth velocity may be estimated from Tanner staging, as well as onset of menses in female patients.[32] A thorough understanding of preexisting length and angular deformities as well as remaining growth allows surgeons to both document preexisting deformity and consider realignment using an osteotomy or implant-mediated guided growth in more extreme cases.

NONOPERATIVE AND DELAYED SURGICAL TREATMENT

Nonoperative or delayed surgical management were historically appealing options given the increased healing potential of children and the risk of physeal damage with surgical reconstruction.[33] However, subsequent reports have indicated that nonoperative management leads to high rates of sport dropout (up to 94% unable to participate at preinjury level of activity and up to 50% unable to participate at all) because