

Associated Injuries in Pediatric and Adolescent Anterior Cruciate Ligament Tears: Does a Delay in Treatment Increase the Risk of Meniscal Tear?

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Purpose: To evaluate the incidence of associated injuries and meniscal tears in children and adolescents with anterior cruciate ligament (ACL) tears, we performed a retrospective review of patients, age 14 and younger, who were treated surgically at our institution. **Type of Study:** Retrospective review. **Methods:** We reviewed 39 patients (30 girls, 9 boys) with an average age of 13.6 years (range, 10 to 14 years) who underwent surgical treatment of the ACL; 24 right knees and 15 left knees were treated. Of the injuries treated, 24 occurred by a twisting mechanism, 10 were the result of contact, and 5 occurred from hyperextension. Thirty-five injuries occurred during sports activities, and 2 were sustained in motor vehicle accidents. The mean duration from injury to operative treatment was 101 days (range, 7 to 696 days). Injuries were classified as acute ($n = 17$) if surgery was performed within 6 weeks of injury and chronic ($n = 22$) if surgery was performed after 6 weeks from injury. Relationships between medial and lateral meniscal injuries and the time from injury to surgery were analyzed, and the 2 groups, acute and chronic, were compared. Finally, the patterns of meniscal injury were compared. **Results:** Twenty-six patients had associated injuries (10 medial meniscal tears, 15 lateral meniscal tears, 3 medial collateral ligament tears, and 1 fractured femur). The association between medial meniscal tears and time from injury to surgery was highly statistically significant ($P = .0223$). There was no statistical significance between the incidence of lateral meniscal tears and time. Medial meniscal tears were more common in the chronic group (36%) than in the acute group (11%), whereas lateral meniscal tears were found with equal frequency. Medial meniscal tears that required surgical treatment (either partial excision or repair) were more common in the chronic group, and lateral meniscal tear patterns were equally distributed. **Conclusions:** Evidence from this study supports the contention that associated injuries are common in young individuals with ACL tears. Furthermore, the data also show that a delay in surgical treatment was associated with a higher incidence of medial meniscal tears. **Key Words:** Anterior cruciate ligament—Meniscus—Pediatric—Adolescent—Skeletally immature.

The incidence of associated injuries with anterior cruciate ligament (ACL) tears in adolescents is not well studied. Furthermore, the appropriate man-

agement of these associated injuries remains controversial. We know from cadaveric studies that the medial meniscus is a secondary restraint to anterior tibial translation that plays an important role in the ACL-deficient knee. In chronic ACL-deficient knees in adults, tears of the medial meniscus are common.¹⁻³ Children and adolescents with ACL-deficient knees may be at risk for subsequent meniscal injuries from repetitive episodes of instability.

Additional soft tissue and bony damage can occur either at the time of injury or subsequently if the knee remains unstable. Although the association between ACL injuries and other soft tissue and bony injuries is well studied in adults, relatively little is known about

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associated injuries in children and adolescents. Failure to recognize an associated injury, such as a medial meniscal injury, may lead to premature articular degeneration and early-onset arthrosis.

The timing of intervention in skeletally immature individuals is also a subject of contention. There are advantages and disadvantages to delaying surgery in skeletally immature patients. Advantages of delaying treatment include the closure of the growth plates and better rehabilitation potential with a more mature individual. Disadvantages include the potential for recurrent episodes of instability with subsequent injury to the menisci or articular cartilage.

The purpose of this study is to report the incidence of associated injuries after ACL tears in children and adolescents and to test the hypothesis that a delay in treatment of the ACL-deficient knee results in an increased incidence of meniscal pathology.

METHODS

To evaluate the incidence of associated injuries and meniscal tears in children and adolescents with ACL tears, we performed a retrospective review of patients age 14 and younger who underwent surgical ACL treatment at our institution. Data including age, gender, mechanism of injury, operative findings, method of treatment, and associated injuries were recorded and evaluated.

The relationships between medial and lateral meniscal injuries and the time from injury to surgery were analyzed by 1-way analysis of variance and $P < .05$ was considered statistically significant. For analysis, the patients were further stratified into 2 groups, those with acute injuries and those with chronic injuries, based on the interval from injury to surgery. Injuries were classified as acute if the patients underwent surgery within 6 weeks of injury and chronic if patients underwent surgery more than 6 weeks after the injury. The various parameters were then compared between the 2 groups. Finally, the patterns of meniscal injury and their treatment were compared.

RESULTS

We identified 39 patients age 14 or younger who underwent surgical treatment for ACL injury (Table 1). There were 30 girls and 9 boys. The average age was 13.6 years (range, 10 to 14). There were 24 right knees, and 15 left knees. Of the injuries, 24 occurred from a twisting mechanism, 10 were the result of contact, and 5 occurred from hyperextension. Of these

TABLE 1. Patient Demographics

Characteristic	Study Population
No. of Patients	39
Mean age (range)	13.6 (10-14)
Gender	30 girls, 9 boys
Side affected	24 right, 15 left
Mechanism of injury	24 twisting, 10 contact, 5 hyperextension
Sport's injury	35
Motor vehicle accident	2
Mean time to surgery (days)	101 (range, 6-696)

injuries, 35 occurred during sports, and 2 were sustained in motor vehicle accidents. The mean duration from injury to surgery was 101 days, with a range from 7 days to 696 days.

Examination under anesthesia revealed all knees to have at least a grade 2B Lachman test (5-10 translation without a firm endpoint) and a grade 2 pivot shift. Two patients had grade 3 Lachman examinations (> 10 mm translation) and 2 had grade 3 pivot shifts. There were no significant differences in laxity between the acute and chronic groups.

Of the 39 ACL injuries, 3 were repaired primarily; 8 were repaired primarily and augmented with hamstrings (7 autograft, 1 allograft); 28 were fully reconstructed, 7 with hamstrings and 21 with bone-patellar tendon-bone (BPTB) autografts. Four procedures were performed using open techniques, and 35 were arthroscopically-assisted (16 two-incision, 19 one-incision).

To avoid the femoral physes, the grafts or native ligament were fixed in the "over-the-top" position in 15 cases. Femoral tunnels were drilled in 24 cases. The average drill size was 10 mm (range, 8 to 12). Staples were used in 16 cases; a button in 4 cases; suture only in 1, and an interference screw in 18 cases.

The tibia was drilled in 38 cases. Average drill size was 10 mm (range, 7 to 12 mm). In 12 cases, the medial hamstring insertions were maintained distally. In 19 cases, an interference screw was used for fixation (all BPTB). Six staples and 3 buttons were used. As far as we are aware, there were no angular deformities or growth arrests.

Overall

Of the 39 patients included in our study, 26 patients (67%) had 30 associated injuries. These included medial meniscal tears (10 of 39), lateral meniscal tears (16 of 39), medial cruciate ligament (MCL) tears (3 of

39), and femur fracture (1 of 39). There were no patients with chondral injuries noted at the time of initial surgical treatment of the ACL.

Of the 26 patients with associated injuries, 19 (48.7%) required additional surgical treatment to address the associated injuries. The additional procedures included 7 medial meniscal repairs, 3 partial medial meniscectomies, 6 partial lateral meniscectomies, and 1 lateral meniscal rasping. Two patients with MCL tears underwent reconstruction with autogenous hamstring grafts (Bosworth); another patient with an MCL injury required reefing of the lax ligament. The 1 patient who suffered a concomitant, ipsilateral femur fracture was treated with open reduction and internal fixation prior to ACL reconstruction.

Overall complications included 1 case of stiffness with motion loss that required manipulation of the knee under anesthesia to restore motion, 1 recurrent lateral meniscal tear, 1 reinjury of a repaired ACL and MCL that required revision of the ACL and plication of the MCL, and 1 patellar chondral defect that required arthroscopic debridement. Of note, there were 2 patients, both girls, who suffered contralateral ACL injuries.

Association Between Time From Injury and Meniscal Pathology

Ten patients had medial meniscal tears. The average time from injury to surgery was 201 days for patients with medial meniscal tears and 68.9 days for patients without medial meniscal tears. The association between medial meniscal tears and time from injury to surgery was highly statistically significant ($P = .0223$). Sixteen patients had concomitant lateral meniscal tears, although with the numbers available there was no statistically significant association between the incidence of lateral meniscal tears and time.

Acute Versus Chronic Injuries

The incidence of associated injuries in the acute and chronic groups are summarized in Table 2.

TABLE 2. Incidence of Meniscal Tears

	Overall (n = 39)	Acute (n = 17)	Chronic (n = 22)
Associated injuries	26 (67%)	10 (58%)	16 (73%)
Medial meniscus	10 (26%)	2 (11%)	8 (36%)
Lateral meniscus	16 (41%)	8 (47%)	8 (36%)

TABLE 3. Patterns of Meniscal Tears

Treatment	Medial Meniscus Tear (n = 10)		Lateral Meniscus Tear (n = 16)	
	Acute	Chronic	Acute	Chronic
None	0	1	3	6
Partial Excision	0	3	2	4
Repairable	2	4	1	0
Total	2	8	6	10

Acute Group: Seventeen patients underwent surgical stabilization of their knee within 6 weeks; 10 (58%) of these patients had associated injuries. The mean duration from injury to surgery was 17 days (range, 7 to 34). There were 8 patients (47%) with meniscal injuries, 8 (47%) with lateral meniscal injuries, and 2 (11%) with medial meniscal injuries. Three patients in this group had MCL injuries.

Chronic Group: Twenty-two patients underwent surgery more than 6 weeks after the injuries; 16 patients (72%) had associated injuries. The mean duration from injury to surgery was 166 days (range, 47 to 696). In this group, 15 patients (68%) had meniscal injuries, 8 (36%) had lateral meniscal injuries, and 8 (36%) had medial meniscal injuries. One patient had a femur fracture that was treated previously.

Patterns of Meniscal Injury

The patterns of meniscal injury in ACL-deficient knees are reported in Table 3. There were more medial meniscal tears that required surgical treatment (partial excision or repair) in the chronically ACL-deficient knees. On the lateral side, meniscal tears that required surgical treatment were equally distributed between the two cohorts.

DISCUSSION

ACL injuries are being diagnosed more commonly in children and adolescents, but the incidence of associated injuries is currently not well documented. Skeletally immature patients present a unique set of diagnostic and treatment challenges.⁴ Improvements in imaging have facilitated the recognition of these injuries in skeletally immature individuals.^{5,6} The timing of surgical intervention, however, has remained the subject of debate. Potential advantages of delaying surgery include better psychological preparation, which facilitates adherence with rehabilitation protocols, and greater skeletal maturity, which increases the

options for surgical reconstruction. Conversely, a long delay in surgical stabilization may predispose the patient to further episodes of instability with increased meniscal and chondral injuries that obviously do not portend well for the long-term health of the joint.⁷

Our data document a significant number of associated injuries (64%) in skeletally immature individuals with ACL tears. In our study, meniscal tears were the most common associated injury. An important strength of our study is its size of 39 patients. Our work substantiates previous series that have shown similar results with smaller sample sizes. Angel and Hall⁵ reported 9 associated meniscal tears in 13 patients with ACL injuries. In addition, our study demonstrates that the incidence of medial meniscal tears increased as the interval between injury and surgery increased, with medial meniscal tears 4 times more common in chronically reconstructed knees. Lateral meniscal injuries were about equal across groups. Graf et al.⁸ previously reported on 12 skeletally immature patients with intrasubstance ACL tears. In this series, 6 of the patients had 8 meniscal tears, with medial and lateral tears being equal (4 medial and 4 lateral). These authors found that, in patients not treated with reconstruction initially and for whom activity modifications were not prescribed, a significant number of new meniscal tears (7 tears in 8 patients) occurred during the mean follow-up period of 15 months. Although both studies show a higher incidence of medial meniscal tears in chronically ACL-deficient knees, because of the retrospective nature of these studies, we can only infer that the cause is due to persistent recurrent functional instability.

McCarroll et al.⁹ also reported on ACL injuries in 40 young athletes with open physes. These authors also found a high rate of associated meniscal tears in skeletally immature individuals with ACL-insufficient knees. They found 18 meniscal injuries (12 medial and 6 lateral) in the 24 patients who underwent surgical treatment for their ACL, and they found 6 meniscal tears (4 medial and 2 lateral) in 4 of the 6 patients who were treated nonsurgically. Although patients were classified as having either acutely or chronically ACL-deficient knees, the authors did not correlate this with the associated injuries.

Fortunately, 6 of the 10 medial meniscal tears in our series were repairable. Three required partial meniscectomies, and 1 was not treated. In contrast, the lateral meniscal tears tended to be less severe, with only 7 of the 16 (44%) requiring treatment. Only 1 lateral meniscal tear was amenable to additional treatment (rasping); 6 required partial excision, and 9 were

deemed stable tears that did not require any further treatment.

To our knowledge, the patterns of meniscal injury in children with ACL deficiency have not been reported previously. Our findings are the first to demonstrate that meniscal damage in association with an ACL tear in the young patient is indeed similar to that seen in adults.^{1,2} We found a predominance of lateral meniscal tears with an acute ACL rupture (Table 2). The mechanism of injury in the majority of our patients was a twisting injury. It has been postulated that lateral meniscal injury is more common after a twisting injury because the mobile lateral meniscus is more susceptible to the combination of compressive and shear forces that result from this type of injury.²

The incidence of lateral meniscal tears increased only slightly over time in our patient population. This is probably because the lateral meniscus is more mobile and is able to translate more freely in the sagittal plane. Our data support the contention that the lateral meniscus does not act as a significant secondary restraint in the ACL-deficient knee in this patient population.

The incidence of medial meniscal tears, however, increased significantly with chronic ACL insufficiency. This result is consistent with the hypothesis that there is continued injury to the medial meniscus from persistent instability. Unfortunately, we have no data about the number or severity of instability episodes in the group with chronically reconstructed knees.

In general, we found that more medial meniscal tears were repairable (6 of 10) in contrast to lateral meniscal tears (1 of 10) (Table 3). However, as we expected, the percentage of repairable tears decreased with the chronicity of ACL insufficiency. We speculate that in children, as in adults, the medial meniscus serves as a significant restraint to anterior tibial translation in the ACL deficient knee.³ Increased demand on the medial meniscus may account for the increased incidence of medial meniscal tears in the chronically ACL deficient knees in this population as well. We believe that a reduction of these forces on the menisci over time is important in preserving meniscal integrity. Early knee stabilization and attention to meniscal injury may prevent further injury and foster healing of small tears or repaired menisci, ultimately preventing premature degenerative arthrosis.

Our study is limited by its retrospective nature and lack of documentation of associated injuries at the time of initial injury. Unfortunately we did not have imaging studies for enough patients to draw meaning-

ful conclusions. Furthermore, because of the referral nature of our facility and the retrospective nature of this study, we have no record of the number or severity of giving-way episodes. Finally, the argument could be made that the study was subject to surgeon bias because there was some judgment used in determining which menisci were amenable to treatment. Nevertheless, we believe the data demonstrate important new findings that support the contention that associated injuries are common in young individuals with ACL tears. Additionally, our data also show that a delay in treatment is associated with a higher incidence of medial meniscal tears.

We know from natural history studies that untreated ACL-deficient knees in children and adolescents do poorly, with persistent instability, symptoms, and joint arthrosis.¹⁰ Therefore, we advocate early surgical stabilization of the ACL-deficient knee before further meniscal damage occurs. Although many variables influence the timing of surgical intervention, we believe that in young patients with high activity levels, early stabilization may prevent further meniscal injury. We agree with other authors⁷ who advocate early surgical treatment of ACL injuries in skeletally immature individuals.

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