The Acutely Injured Knee

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The relative explosion of sports participation in
the pediatric and adolescent age groups
includes participation in many running sports
in which injuries to knees are common. Knee injuries
often warrant visits to pediatricians' offices, yet pro-
duce a small enough percentage of office visits to
make it difficult to develop comfort with the assess-
ment. This article will aid the pediatrician evaluating
and managing the youngster with an acute knee
injury with an emphasis on the history and physical
examination.

ANATOMY

No evaluation of the knee can start without an
appreciation of the anatomy of this hinge joint with
many stabilizing structures (Figure 1). The most
important structures that can be injured are the ante-
rior cruciate ligament, the posterior cruciate liga-
ment, the medial (tibial) collateral ligament, the lat-
eral (fibular) collateral ligament, and the medial
and lateral menisci. The two collateral ligaments are
extra-articular, medial and lateral to the joint space,
and prevent excessive valgus and varus stress, respec-
tively. The menisci, which are located on the medial
and lateral tibial plateaus, absorb shock and also lend
stability. The anterior cruciate ligament prevents
excessive anterior motion and internal rotation of the
tibia on the femur. The posterior cruciate ligament
prevents excessive posterior motion and external
rotation of the tibia on the femur.

TELEPHONE TRIAGE

Often, the pediatrician's first contact with the ath-
lete is over the telephone. What questions will help
determine the necessity of a visit to the office or
emergency department? Criteria that warrant early
evaluation include rapid swelling of the knee joint,
inability to bear weight, or any neurovascular com-
promise. A tense and painful effusion within 2 to 4
hours after injury represents a hemarthrosis. The two
most common injuries associated with a hemarthrosis
are an anterior cruciate ligament tear and patellar
dislocation/subluxation.1 Any kind of fracture can cause

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EDUCATIONAL OBJECTIVES

1. Review the immediate historical markers for specif-
ic knee injuries, as well as telephone triage.

2. Discuss specific physical examination parameters
   used to determine the degree and location of a knee
   injury.

3. Provide suggestions for radiographic evaluation
   and management of acute knee injuries.

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T A B L E 1
Mechanisms of Injuries and Associated Injured Structures of the Knees

<table>
<thead>
<tr>
<th>History &amp; Mechanism</th>
<th>Suspected Injury</th>
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<tbody>
<tr>
<td>Blow to outside of knee (valgus stress)</td>
<td>Medial collateral ligament sprain</td>
</tr>
<tr>
<td>Blow to inside of knee (varus stress)</td>
<td>Lateral collateral ligament sprain</td>
</tr>
<tr>
<td>Hyperextension of knee</td>
<td>Anterior cruciate ligament sprain</td>
</tr>
<tr>
<td>Twisting of knee after sudden stop</td>
<td>Anterior cruciate ligament sprain ± meniscus tear</td>
</tr>
<tr>
<td>Knee went &quot;out of joint&quot;</td>
<td>Patellar dislocation/subluxation</td>
</tr>
<tr>
<td>Pivoting after jumping or twisting</td>
<td>Patellar dislocation/subluxation or meniscal tear</td>
</tr>
<tr>
<td>Fall on tibia or dashboard injury</td>
<td>Posterior cruciate ligament</td>
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Immediate swelling, and urgent evaluation is warranted. The younger the athlete, the more likely there will be an osteochondral fracture. One should ask about sensation and extremity color—true neurovascular compromise is rare but requires emergent evaluation if suspected. More subjective criteria for early evaluation include the athlete who cannot bear weight on the injured leg or leave the field on his or her own power. Finally, those athletes who plan to return to practice or competition within 24 to 48 hours and potentially risk further injury often need prompt evaluation before resuming activity.

TAKING A HISTORY

The office evaluation of a knee injury begins with the patient's description of the injury, focusing on the activity and position of the athlete at the time of the injury. Parents, coaches, and other individuals present at the time of injury may be able to help you determine the mechanism of the injury. Was the athlete able to continue playing after the injury? Immediate inability to participate implies a more severe injury than one that produces delayed disability.

The mechanism of injury usually gives the clinician a good idea of what structures have been injured (Table 1). For example, a blow to the outside of the knee of a football lineman often results in sprain of the medial collateral ligament, while a similar stress to the inside of the knee may cause a lateral collateral ligament sprain. An athlete with an anterior cruciate ligament injury may tell you that he or she changed direction suddenly with all the body weight on one leg without contact with another person, or the athlete may have hyperextended the knee. Athletes who complain of a knee going out of joint often are describing patellar dislocation/subluxation, while those who have knee pain with pivoting after jumping or twisting (ie, trying to block an opponent's shot in basketball) are often also describing patellar subluxation or a meniscus tear.

Patients who report instability (giving way or collapsing like "jello") usually are describing a ruptured anterior cruciate ligament or patellar instability. Those who report locking, usually associated with limitations in knee extension, may have an intra-articular loose body due to a torn meniscus, avulsed cruciate ligament fragment, or bony fragment.

An audible pop, especially one heard by others, implies a more serious ligament injury or a fracture. A ripping sensation may represent a meniscal injury or a patellar dislocation. A cracking sound can be caused by bone injury or patellar dislocation.

Evaluation of the knee includes inquiring about any hip pain. One must also ask of any previous injury to either knee since a previous injury may produce an abnormal physical examination. Finally, the clinician must find out what modalities have been used with the current injury; the immediate application of ice or use of a nonsteroidal anti-inflammatory medication can reduce the initial swelling, but should not dissuade the clinician from suspecting intra-articular injury if the history and mechanism of injury are suggestive of such a process.

PHYSICAL EXAMINATION

To ensure an optimal physical examination, the athlete should have both lower extremities fully exposed and wear shorts or an examining gown. The athlete's
gait and balance should be evaluated. Ability to bear weight and take more than four steps on the injured extremity makes a fracture unlikely. After gait is assessed, the athlete should be asked to lie supine on a long table that is not placed up against a wall so that there is ready access to both lower extremities.

The basic sequence of the physical examination includes inspection, range of motion, palpation, and stress testing of both knees. One should always begin with the noninjured knee as this can help reassure and prepare the athlete for what is to come with the injured knee. This also helps the clinician appreciate the physiologic laxity and range of motion of the noninjured knee compared with the injured knee. On the injured knee, it is important to perform maneuvers that are less likely to be painful and to do tests that require relaxation early in the examination.

Inspection begins with noting the general appearance of the knee and lower extremity. Abnormal neurovascular findings call for urgent surgical consultation. An effusion is most likely to be appreciated in the suprapatellar pouches. Placing both knees together and looking for asymmetry in the pouches will help the examiner appreciate an effusion. Localized swelling or ecchymosis, such as over the medial aspect of the knee, may help localize the injury, such as in the case of a medial collateral ligament tear.

Active range of motion should be assessed before any "laying of hands" occurs as palpation often provokes pain and thus may limit movement. Once again, it is important to compare the noninjured and injured sides, so start with the noninjured knee and ask the athlete to flex and extend the knee. If there is a deficit in active range of motion of the injured knee, the examiner should attempt to passively complete the arc of movement. A full, painless range of motion immediately after an injury generally rules out a significant meniscus tear or the presence of an osteochondral fracture. After a few hours, most knee injuries will be accompanied by a loss in the extremes of motion—usually the terminal 10° of extension and 20° to 30° of flexion. These are nonspecific signs due usually to fluid within the joint or quadriceps and hamstring muscle spasm due to pain and thus have little diagnostic value.

Palpation begins with assessing quadriceps bulk and tone and can be appreciated by asking the patient to do an isometric contraction. A reduction in quadriceps bulk and tone usually is seen within several days after injury; hence, one would not expect a decrease in the acute setting unless the athlete had a previous injury. Inability to completely contract the quadriceps muscle may represent an injury to the extensor mechanism such as a quadriceps muscle strain or tear, especially if a focal area of tenderness can be found.

With the knee extended, assess for the presence of an effusion by placing one hand on the inferior aspect of the anterior knee to milk any fluid into the suprapatellar pouches. With the other hand, stroke fluid from the medial suprapatellar pouch into the lateral pouch. While maintaining pressure on the inferior aspect of the knee, push the fluid from the lateral pouch back into the medial suprapatellar region. Even with a small effusion, a fluid wave can be observed in the medial pouch. A less sensitive test for palpating an effusion is the ballottement test in which the knee is extended, the quadriceps muscles are relaxed, and the patella is pushed into the trochlear groove and released. Fluid underlying the patella will be forced first to the sides of the joints and then back to its former position, causing the patella to rebound. These tests help differentiate between a true intraarticular effusion and an extra-articular prepatellar bursitis. If there is a prepatellar bursitis, fluid is easily palpated over the center of the patella.

Palpate the medial patellar facet, medial retinaculum, and above the adductor tubercle because tenderness in any or all of these areas usually represents a patellar dislocation/subluxation (Figure 2). The patellar apprehension test is a more specific test for patellar instability, but by itself is not very sensitive for the diagnosis. With the knee flexed to 20° to 30°, place the fingers on the medial aspect of the patella and try to move it laterally. Distress (ie, apprehension) on the part of the patient represents a positive apprehension sign. If this maneuver produces pain, it also suggests an episode of patellar instability has occurred. Any increased mobility of the patella compared to the uninjured side is consistent with patellar instability.

Tests for ligament injuries involve stretching a ligament and looking for increased motion of the joint when the ligament is stretched. Ligament injuries are graded first, second, or third degree. Pain with no laxity suggests a first-degree sprain. Excessive laxity with a firm endpoint implies a second-degree sprain of the ligament, while absence of an end point indicates a
The most important ligamentous test is the Lachman test to evaluate anterior cruciate ligament integrity. To perform the Lachman test, the knee is flexed to 20° to 30° and one hand is placed above the knee to stabilize the femur, while the other hand is placed around the proximal tibia. It is crucial that the patient relax the hamstring muscles during this portion of the examination for an optimal test. While stabilizing the femur, the second hand pulls the tibia anteriorly. Increased laxity compared to the non-injured side is consistent with an injury to the anterior cruciate ligament (Figure 3). The Lachman test is more sensitive than the classic anterior drawer test done at 90° of knee flexion.9

The posterior cruciate ligament is assessed with the knee flexed to 90°. The physiologic tibial step-off is palpated. Loss of the step-off indicates rupture of the posterior cruciate ligament. One can also compare the front of the tibial plateau with that of the opposite leg by viewing both from the side. If the tibia does not extend beyond the end of the femur, the posterior cruciate ligament is most likely damaged.9 The posterior cruciate ligament also can be tested with the traditional posterior drawer test done at 90° of knee flexion by pushing the tibia posteriorly on the femur.

Medial and lateral laxity should first be tested with the knee in full extension if this position is possible. Laxity in this position is indicative of a combined cruciate ligament and collateral ligament injury and warrants orthopedic consultation. Test for medial laxity by flexing the knee to 20° to 30° over the edge of the examining table, placing a hand over the lateral knee, and providing a valgus stress (pulling the lower extremity away from the other leg). Lateral laxity is done in the same fashion except the hand is placed on the medial joint line and the lower leg is placed in varus stress (toward the other leg). Excessive laxity is felt by the joint “opening.” The clinician looks for both increased laxity and the absence of a firm “end point.”

Examination of the menisci begins with palpation of the tibiofemoral joint line, starting with the medial aspect. Place the knee in 90° of flexion, palpate anteriorly, and move medially. Tenderness medially is indicative of a medial meniscus injury. Other possibilities include a medial collateral ligament sprain that crosses the joint medially. Tenderness along the lateral joint line is suggestive of a lateral meniscus injury. Tenderness just above the fibular head usually represents lateral collateral ligament sprain, especially if there is pain when the ligament is stressed.

Evaluation for meniscal injury involves the McMurray and Apley grind tests. These tests are often difficult to perform in the acute setting and have to wait until the athlete is reexamined 1 or 2 weeks later. The McMurray Test is done with the patient in the supine position. The knee is first flexed completely with the thumb of one hand on the lateral joint line and the first finger on the medial joint line. Then with a valgus stress to the knee and the lower leg externally rotated, the knee is extended and palpated for a click and any pain is noted. Then the lower leg is placed in internal rotation, in varus stress and moved from flexion to extension to stress the lateral meniscal region.9 A positive McMurray test produces pain and a click on extension. In our experience, any pain or crepitus with the maneuver may be significant.

For the Apley grind test, the patient lies prone on the examining table, with one knee flexed and the examiner kneeling on the back of the thigh for stabilization. The examiner leans on the heel to compress the menisci and rotates the tibia internally and externally on the femur. Pain on external rotation suggests medial meniscal damage, while internal rotation pain may indicate lateral meniscal damage.
In our experience, the McMurray test is more sensitive than the Apley test.

**RADIOGRAPHIC EVALUATION**

The next step in the evaluation of the acute knee injury involves the decision to obtain radiographs and which radiographic views to obtain. Indications for radiographs include a large effusion, loss of range of motion, and inability to bear weight. In addition, any patient with an open fracture, penetrating trauma, or history of previous knee surgery requires radiographs with an acute knee injury.

Several recent studies have attempted to determine clinical decision rules for knee radiographs to reduce the number of films obtained in the emergency department. Stiell et al. developed the following criteria for radiographs in adults >18 years old: age ≥55 years old, tenderness at the fibular head, isolated tenderness of the patella without other bony tenderness, inability to flex to 90°, and inability to bear weight (four steps) immediately and in the emergency room. Seaberg added two additional criteria: those patients who suffer a fall or blunt trauma and patients younger than 12 years due to the presence of immature bone with nonossified growth plates.

Both studies found 100% sensitivity with their criteria; no clinically significant fracture was missed in patients who would not have received radiographs due to the criteria developed above. Further studies involving more children will help to further assess the accuracy of these decision rules.

Once the decision has been made to obtain radiographs, four different views should be considered for complete evaluation. The anteroposterior and lateral views give a good impression of patellar integrity, femorotibial alignment, and also will show most suprapatellar or intra-articular fractures. Two unique films are the tunnel and patellar views. The tunnel (or notch) view is done with the knee flexed to 45° and is the best view to look for loose bodies and osteochondritis dissecans. A patellar view evaluates patellar alignment and evaluates for patellar fracture and patellar osteochondritis dissecans (Figure 4).

Many orthopedists do not order sunrise views, but order a view with less flexion, eg, 30° to 45°, to look for evidence of patellar subluxation.

**MANAGEMENT**

Conditions that require immediate orthopedic referral include intra-articular fractures and appreciable ligamentous laxity in the fully extended knee (which implies injury to more than one ligament). Neurovascular compromise warrants vascular surgical consultation in addition to orthopedic evaluation. Since the treatment of anterior cruciate and posterior cruciate ligament injuries is controversial, consultation of an orthopedic surgeon is indicated when these injuries are suspected. Surgery will not be indicated for most first episodes of patellar instability, and if there is uncertainty, an orthopedic surgeon should be consulted. Isolated collateral ligament sprains, even third degree, do not require surgery and can be managed with rehabilitation.

Some injured knees will appear stable on initial examination, yet show instability on repeat examination. There are several criteria for the reevaluation of a stable knee. Any mechanism of injury that suggests more severe injury than initially found should be reexamined within 2 to 3 days, eg, an audible snap or pop at the time of injury. The presence of an effusion on initial examination is another finding that
deserves reexamination, as does any patient with severe symptoms and a stable initial examination. An effusion implies an intra-articular injury. Because the collateral ligaments are extra-articular, injuries to them rarely produce more than a trace effusion. Any grade II ligamentous injury needs to be rechecked to ensure that it is not a "masked" grade III injury. Inadequate muscle relaxation is common in the immediate post-injury period, making the examination difficult. This warrants reevaluation 2 to 3 days later once the spasm has relented.

Initial management of knee injuries includes immediate utilization of the RICEM principle (see "General Principles in Treating Soft-Tissue Injuries," by D.T. Bernhardt on pages 20-25). Immobilizing a knee is warranted in cases of instability and also helps for pain control. The position of comfort is usually 10° to 15° of flexion. A knee immobilizer can be used for this purpose if there is no instability. The immobilizer should be removed several times a day for icing and range-of-motion exercises, which include attempts at both full extension and flexion. It can be discarded within 3 to 4 days when the effusion is gone, and the patient can reach full extension and at least 100° of flexion. We have been using a knee immobilizer less frequently because many youngsters use it too long and do not do their rehabilitative exercises frequently enough. Crutches can be used for 2 to 3 days unless a serious injury has occurred since immediate return to weightbearing is a key component in the rehabilitation process. If there is significant ligamentous laxity, an orthopedist should be consulted and a brace for more stability should be used. A persistent effusion is due to patellar instability or an intra-articular problem and warrants close follow-up and further evaluation.

Exercises are a crucial aspect of the recovery from injury and should begin in the immediate post-injury period as described above. Quadriceps strengthening exercises also can begin within hours of injury and involve muscle tightening with the knee in full extension. This position is held for 8 to 10 seconds, followed by a rest period of a few seconds. This activity should be repeated at least several times a day. Once range-of-motion has returned, the patient can further increase flexion and extension with hamstring flexion with standing and quadriceps extension while sitting. It is often helpful to involve a certified athletic trainer or physical therapist in this process whenever possible.

Nonsteroidal anti-inflammatory medications are commonly used for anti-inflammatory and analgesic properties, although no study has shown definitive efficacy in acute soft-tissue injuries. The most important goal is analgesia in the immediate post-injury period.

The return to activity begins with resumption of walking, and when full range of motion and strength return, then completion of a gradual running program. This program starts with running straight forward progressing from 50% to 100% speed, then adds runs with changing directions before a return to competitive sport is allowed (Table 2). During all phases of rehabilitation, sport-specific drills should be incorporated; initially, activities that do not involve the injured knee can be selected (i.e., shooting free throws) while more challenging activities can be incorporated as the recovery advances. It is especially important to include the injured child in team activities as much as possible to reduce feelings of inadequacy and isolation due to the inability to participate.

The use of bracing or taping for knee stabilization has few indications—McConnell taping or the Palumbo knee brace are effective in the management of patellar instability. Many competitive athletes have used lateral knee-stabilizing braces, especially in contact sports such as football, but current evidence does not show efficacy for prophylaxis and actually shows potential for causing harm. Use of derotational braces is controversial and should be discussed with the consulting orthopedic surgeon.

SUMMARY

Determining the mechanism of injury is often helpful in making the diagnosis during the evaluation of the acutely injured knee. A few injuries require immediate orthopedic referral such as fractures, evidence of more than one sprained ligament, or neurovascular compromise. Most patients with acute knee injuries can be treated initially with crutches, ice, and analgesics. The key to rapid recovery of most injuries is a diligent rehabilitation program.

REFERENCES