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Posterior Cruciate Ligament: MR Imaging[1]

The authors reviewed 610 consecutive magnetic resonance (MR) examinations of patients with suspected internal derangements of the knee, paying special attention to the posterior cruciate ligament (PCL). The normal PCL shows a low MR signal intensity and an arcuate shape. An accessory anterior or posterior meniscofemoral ligament was identified in 58.5% of examinations. Among 202 patients who underwent arthroscopy or arthrotomy, MR imaging depicted 11 PCL injuries: eight complete or incomplete ligament disruptions and three avulsions. All were confirmed by means of arthroscopy or arthrotomy. MR findings of PCL injury were anatomic disruption, increased signal intensity in the ligament, and redundancy of an avulsed ligament. Of the 11 PCL injuries, four were not detected at initial clinical examination. In none of the 202 patients in whom arthroscopy or surgery was performed was an abnormal PCL identified in the presence of a normal MR examination. MR imaging is a reliable method for the detection of PCL injuries.

Index terms: Knee, injuries, 4526.4857 • Knee, ligaments and menisci, 4526.4857 • Knee, MR studies, 4526.1214

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THERE has been increasing awareness of the clinical importance of early detection and treatment of posterior cruciate ligament (PCL) injuries (1–3). These injuries result in posterior instability of the knee, manifested by discomfort and a feeling of unsteadiness and insecurity when the knee is in the semiflexed position, as when descending stairs (4,5). PCL insufficiency may result from either a tear of the ligament or an avulsion of the ligament with attached bone from the tibial insertion (2). While there is general agreement that avulsions of the ligament from the tibia require operative repair, surgical treatment of disruptions in the substance of the ligament has been controversial (2,4,6). The current recommendations favor repair of acute disruptions to prevent chronic posterior instability and osteoarthritis (7,8). Therefore, early detection of PCL injuries has significant clinical implications.

Magnetic resonance (MR) imaging has proved to be an excellent diagnostic tool for identifying the normal anatomy and internal derangements of the knee (9–12). Previously, attention has been focused on the value of MR imaging for the evaluation of the menisci and the anterior cruciate ligament (ACL). To determine the role of MR imaging in the detection of injuries of the PCL, we reviewed all MR imaging examinations performed over a 4-year period for suspected internal derangement of the knee.

MATERIALS AND METHODS

To observe variations in the contour of the normal PCL, we acquired sagittal T1-weighted MR images of a normal volunteer with the position of the knee ranging from 90° of flexion to 5° of hyperextension.

We reviewed 610 consecutive MR examinations of the knee performed between May 1984 and April 1989. There were 360 male and 250 female subjects ranging in age from 14 to 86 years (mean, 36 years). All examinations were performed with either a permanent or hybrid permanent-resistive 0.3-T imaging system. The imaging protocol was specifically designed to evaluate the cruciate ligaments and menisci. All knees were examined with the patient supine and the knee in 0°–15° of flexion and 15° of external rotation; a relatively T1-weighted spin-echo pulse sequence was used (repetition time msec/echo time msec = 500/30 or 800/30). Four- to-five-millimeter-thick sections were acquired at 5–7-mm intervals, followed by a second set of interleaved images with a 2–3-mm offset. Additional T2-weighted spin-echo images (2,000/80 or 2,000/85) in the sagittal plane were acquired in 26 cases.

In all patients, we recorded the presence or absence of the meniscofemoral ligaments of Humphry and Wrisberg, which lie anterior and posterior, respectively, to the PCL.

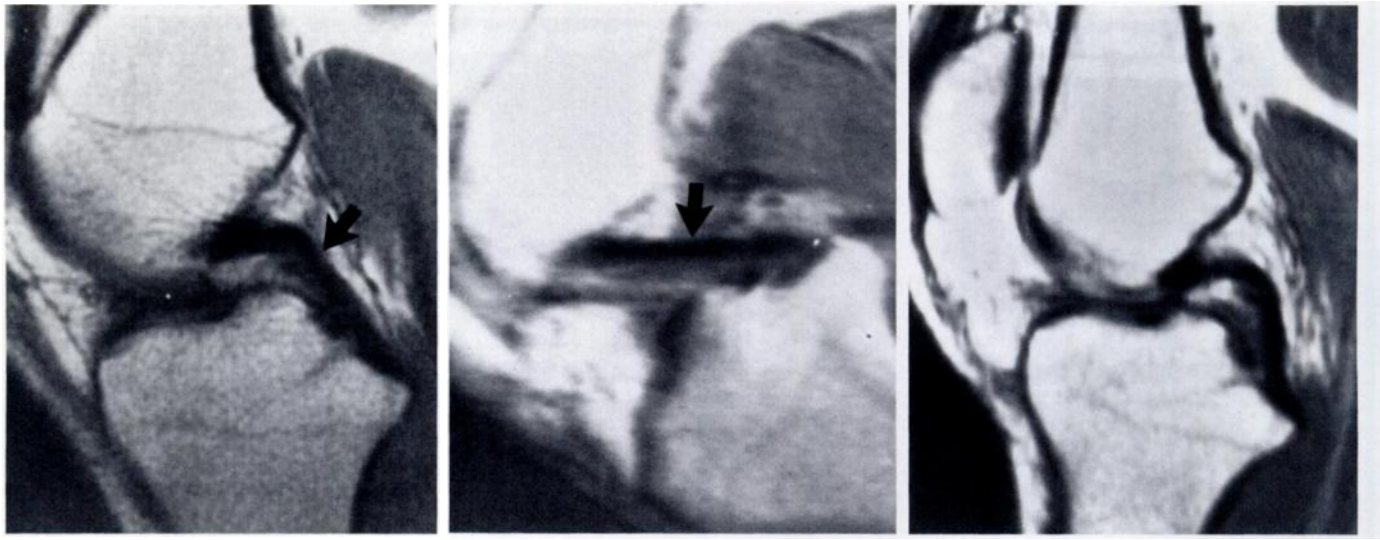
In our retrospective evaluation of these cases, attention was focused on 202 patients who underwent arthrotomy or arthroscopy. We evaluated the configuration, signal intensity, and anatomic integrity of the PCL. Radiographs, clinical history, and physical findings at the time of presentation were reviewed in all patients with abnormal MR findings.

RESULTS

Normal Anatomy

The PCL was identified in all of the examinations, as a complete structure in a single MR section or in the composite of two consecutive sections. The normal PCL has a very low signal intensity. It is arcuate in shape when the knee is in a neutral position or mild flexion (Fig 1a), the position for routine examinations. The ligament becomes increasingly taut with flexion (Fig 1b) and shows lax-

Abbreviations: ACL = anterior cruciate ligament, PCL = posterior cruciate ligament.



a. b. c.

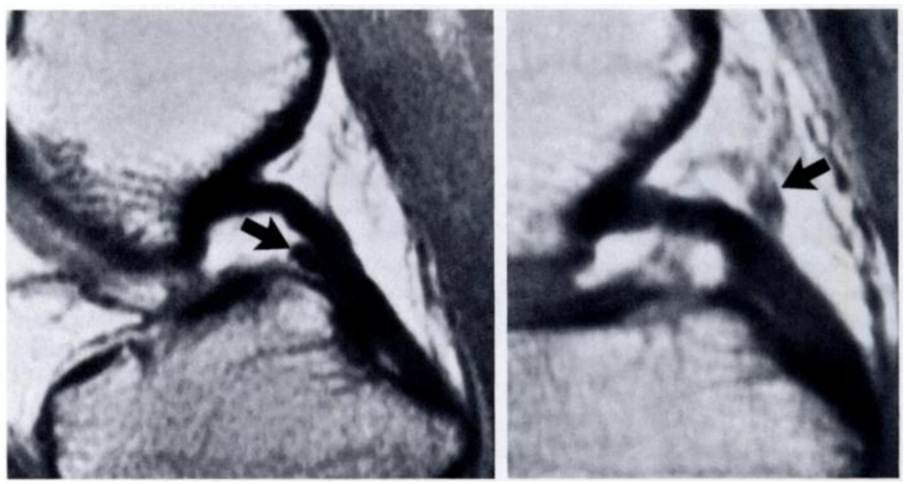
Figure 1. Sagittal T1-weighted images of PCL of a normal 23-year-old volunteer. **(a)** Knee relaxed in 10° of flexion and 15° of external rotation, as for routine imaging. The PCL (arrow) is arcuate and has uniform low signal intensity. **(b)** In 90° of flexion the PCL (arrow) is taut. **(c)** In 5° of hyperextension the PCL shows laxity. Note redundancy of the patellar ligament.

ity in hyperextension (Fig 1c).

Among the 610 MR examinations, an anterior meniscofemoral ligament (Fig 2a) was depicted in 147 cases (24.1%), a posterior mensicofemoral ligament (Fig 2b) in 139 (22.8%), and both in 71 (11.6%).

Tears of the PCL

Of 202 cases with surgical correlation, 11 showed, at MR imaging, visible disruption of the PCL or detachment of the ligament from its osseous insertion. Of these 11 PCL injuries, seven were tears in the midsubstance of the ligament (Fig 3), one was a tear near the femoral origin, and three were avulsions from the tibial insertion (Fig 4). All of the PCL injuries were identified on T1-weighted images, but tears were more obvious on T2-weighted images. T2-weighted images were useful in establishing that the PCL was normal when the T1-weighted image was equivocal (Fig 5), thus preventing false-positive interpretations. In seven of the 11 patients with PCL injuries, the injury was detected at initial physical examination by the demonstration of a positive posterior drawer or posterior sag sign. Three others had normal initial clinical examination results but demonstrated positive physical findings when examined under general anesthesia before arthroscopy. One patient with a complete tear through the midportion of the ligament on the MR examination (Fig 3) demonstrated no abnormal physical findings attributable to the PCL even under general anesthesia, but a tear of the PCL was confirmed at arthroscopy.



a. b.

Figure 2. Meniscofemoral ligaments. **(a)** Anterior ligament of Humphry (arrow). **(b)** Posterior ligament of Wrisberg (arrow).

Of the 11 patients with surgically proved PCL injuries, 10 had other significant internal derangements: ACL tear in four patients, medial collateral ligament tear in four, and one or more meniscal tears in five.

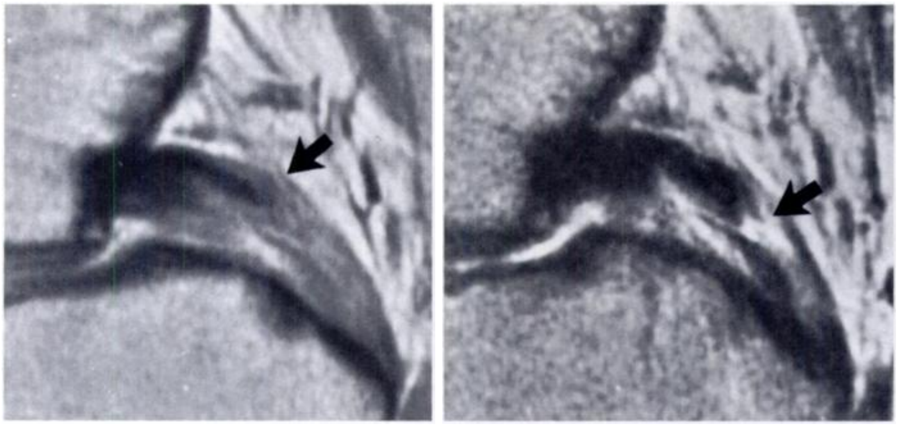
In two knees, abnormal signal intensity was present in the PCL on T1-weighted images, without definite evidence of anatomic disruption (Fig 5). Neither of these patients had clinical evidence of PCL insufficiency. Arthroscopic evaluation was performed for other suspected internal derangements, and at arthroscopy neither had a PCL tear.

Of the 202 patients in whom arthroscopy or arthrotomy was performed, none had an abnormal PCL identified in the presence of a normal MR examination.

DISCUSSION

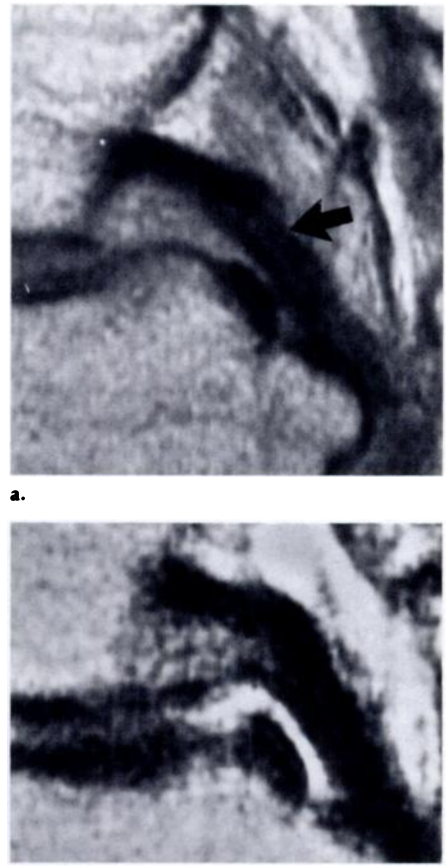
Tears of the PCL are less common than tears of the ACL, and in the past PCL tears have often been considered of little clinical significance (13). Major mechanisms of injury to the PCL include forceful posterior translation of the tibia in a flexed knee (dashboard injury) (14), forced hyperextension (8), continued valgus angulation after rupture of the ACL and medial collateral ligament (8,15), and hyperflexion (16). PCL injuries most often occur as a result of sports-related or motor vehicle accidents.

The PCL is 30% larger than the



a. b.

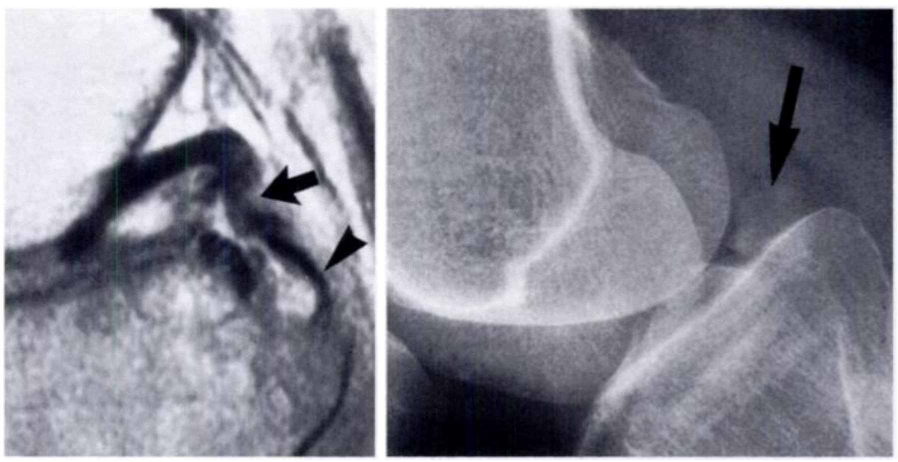
Figure 3. MR images of a 19-year-old man injured in a baseball game show a tear at the midportion of the PCL. There were no clinical findings of posterior laxity at either initial physical examination or at examination with the patient under general anesthesia. **(a)** Sagittal T1-weighted image shows an anatomic disruption of the ligament (arrow) and abnormally high signal intensity in the ligament. **(b)** Sagittal T2-weighted image shows high signal intensity fluid traversing the tear (arrow) in the ligament. A tear of the midportion of the PCL was confirmed at arthroscopy.



a.

b.

Figure 5. MR images of a 37-year-old man with knee pain and anteroposterior instability following a basketball injury. **(a)** Sagittal T1-weighted MR image shows possible distortion of the ligament (arrow) and higher signal intensity in the distal portion of the ligament. **(b)** Sagittal T2-weighted image shows an intact PCL. Clinical examination revealed no evidence of PCL tear, and the patient is doing well at 6-month follow-up.



a. b.

Figure 4. Images of a 38-year-old man whose knee struck a buoy during a waterskiing accident. He had no evidence of posterior instability at initial clinical examination but demonstrated a posterior drawer sign when examined under general anesthesia. **(a)** T1-weighted sagittal MR image shows redundancy of the PCL (arrow), which is attached to an avulsed fragment of bone (arrowhead). **(b)** Radiograph shows only the avulsed osseous fragment (arrow). Findings were confirmed at the time of surgical repair of the avulsion.

ACL (14), and cadaveric studies have shown it to be twice as strong as the ACL or medial collateral ligament when subjected to unidirectional tensile forces (17). Therefore, disruption of the PCL implies a severe injury. There is increasing evidence that insufficiency of the PCL may have more clinical significance than previously thought. Untreated PCL deficiency may lead to early degenerative arthritis due to instability (8,18). Since the extensor mechanism acts as the dynamic counterpart to the PCL against posterior tibial subluxation, increased stresses due to PCL insufficiency may lead to inflammation of the patellar ligament and quadriceps tendinitis (7). In addition, increased stresses at the patellofemoral joint may lead to patellar grinding and chondromalacia patellae (8).

Reported injury rates for the PCL range from 3.4% (19) to 20% (20) of knee ligament injuries. However, some investigators believe that the true rate is greater than that reported in the literature because PCL insufficiency can elude clinical detection (2,21). The most commonly employed clinical examination is the posterior drawer test: Placing the relaxed knee in 90° of flexion, the examiner grasps the lower leg with the hand over the anterior proximal tibia and pushes the tibia posteriorly in the sagittal plane (20). The reported accuracy for this test ranges from 31% to 85% (15,18). When anteroposterior instability is detected, it may be difficult to distinguish ACL disruption from PCL disruption. When both ligaments are torn, PCL insufficiency may be overlooked (18). Hughston (21) suggests that a false-negative posterior drawer test may be related to resistance from an intact arcuate complex, the combined posterolateral corner ligaments. A second commonly recognized clinical finding associated with PCL insufficiency is the posterior sag sign, which is recognized as a concavity in the anterior profile of the proximal tibia when the patient is supine and the knee is flexed 90° (14). The abduction stress test for PCL insufficiency evaluates for varus/valgus instability in extension (21). Despite the variety of physical signs that may be elicited to detect a PCL tear, swelling, hemarthrosis, muscle spasm, and pain may preclude a reliable physical examination in the aftermath of an acute knee injury. Our findings concur with those of other authors who have reported that PCL injuries are usually part of multiligamentous knee trauma (6,15). Of 11 patients with surgically confirmed PCL injuries, 10 had other significant internal knee derangements. Thus, detection of a PCL injury at MR imaging should alert the radiologist to the possibility of additional internal derangement.

In this series, MR imaging was superior to physical examination in the detection of PCL injuries. Four of the 11 PCL injuries detected with MR imaging were not appreciated at the time of initial physical examination. Furthermore, MR imaging depicted one PCL tear that was not evident even during physical examination under anesthesia.

Although the PCL is intraarticular, it is extrasynovial. Therefore, an unsuspected PCL injury may be overlooked during routine arthroscopy or during an arthrotomy performed with an incision that does not permit adequate visualization of the PCL. This occurred in one of our cases in which MR imaging was not performed at the time of initial injury: At arthroscopy for medial meniscectomy, a clinically occult PCL tear was not appreciated. When the patient presented 8 months later with progressive posterior instability, MR imaging revealed a tear in the PCL, which was subsequently reconstructed.

The arthrographic diagnosis of a PCL tear depends on the demonstration of an intact ACL in order to exclude poor technique as the basis for nonvisualization of the ligament (22). The accuracy of arthrography for the diagnosis of PCL tears has not been reported.

MR imaging may be the most reliable method for detection of a PCL injury. MR imaging depicted all 11 tears or avulsions of the PCL proved by means of surgery. Among 202 patients who underwent arthroscopy or arthrotomy, no PCL injuries had been missed with MR imaging. The PCL tears were identified on sagittal T1-weighted images by anatomic disruption of the ligament or detachment of the ligament from its insertion (Fig 3a). Tears were more obvious on T2-weighted images due to the high signal intensity of fluid within the tear (Fig 3b). All of the avulsions of the PCL from its tibial insertion were identified on MR images by detachment and redundancy of the ligament (Fig 4a). However, radiographs were required to confirm the presence of an avulsed fragment of bone (Fig 4b). All of the injured PCLs manifested abnormally high signal intensity on T1-weighted images. However, abnormal signal intensity on a T1-weighted image without anatomic disruption was not sufficient evidence for a PCL tear, and the cause of this increased signal was not determined. In equivocal cases, a T2-weighted image should be employed to show whether the PCL is normal (Fig 5).

The meniscofemoral ligaments are anatomic variants that should not be confused with posttraumatic intraarticular fragments in the MR examination (23). These accessory ligaments extend from the posterior horn of the lateral meniscus to the lateral aspect of the medial femoral condyle, one meniscofemoral ligament passing in front of, and one behind, the PCL (Fig 2). They are believed to play a role in bringing the lateral meniscus forward when the knee is flexed, thus protecting the meniscus from impaction between the femoral and tibial condyles (24). Cadaveric studies have shown that the size and presence of these ligaments is variable (24,25). A meniscofemoral ligament—the anterior ligament of Humphry (Figure 2a) or the posterior ligament of Wrisberg (Figure 2b)—was identified in 58.5% of the MR examinations. The meniscofemoral ligaments are of little clinical significance since injuries to these structures are not treated.

Tears of the PCL are repaired by primary suturing with or without graft augmentation (7). Avulsions from the tibial insertion are treated by reimplantation of the tendon and attached fragment with screw fixation or pull-through sutures (2). Failure to identify and repair PCL injuries may result in chronic posterior instability and eventual tricompartmental degenerative changes (7,8). ■

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