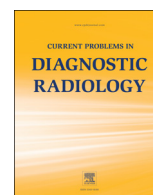




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## The Value of Accurate Magnetic Resonance Characterization of Posterior Cruciate Ligament Tears in the Setting of Multiligament Knee Injury: Imaging Features Predictive of Early Repair vs Reconstruction

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Multiligament knee injury (MLKI) represents a complex set of pathologies treated with a wide variety of surgical approaches. If early surgical intervention is performed, the disrupted posterior cruciate ligament (PCL) can be treated with primary repair or reconstruction. The purpose of our study was to retrospectively identify a critical length of the distal component of the torn PCL on magnetic resonance imaging (MRI) that may predict the ability to perform early proximal femoral repair of the ligament, as opposed to reconstruction. A total of 50 MLKIs were managed at Harborview Medical Center from May 1, 2013, through July 15, 2014, by an orthopedic surgeon. Following exclusions, there were 27 knees with complete disruption of the PCL that underwent either early reattachment to the femoral insertion or reconstruction and were evaluated using preoperative MRI. In a consensus fashion, 2 radiologists measured the proximal and distal fragments of each disrupted PCL using preoperative MRI in multiple planes, as needed. MRI findings were correlated with what was performed at surgery. Those knees with a distal fragment PCL length of  $\geq 41$  mm were capable of, and underwent, early proximal femoral repair. With repair, the distal stump was attached to the distal femur. Alternatively, those with a distal PCL length of  $\leq 32$  mm could not undergo repair because of insufficient length and as such, were reconstructed. If early surgical intervention for an MLKI involving disruption of the PCL is considered, attention should be given to the length of the distal PCL fragment on MRI to plan appropriately for proximal femoral reattachment vs reconstruction. If the distal PCL fragment measures  $\geq 41$  mm, surgical repair is achievable and can be considered as a surgical option.

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### Introduction

Multiligament knee injury (MLKI) is a rare and clinically challenging injury that may occur in the setting of tibiofemoral dislocation.<sup>1</sup> Magnetic resonance imaging (MRI) for MLKI is vital for preoperative planning.<sup>2–5</sup>

Accurate diagnosis and subsequent management of posterior cruciate ligament (PCL) injuries in the setting of MLKI is of central importance owing to the integral function of the PCL in posterior knee stability. Once diagnosed, a common approach to a high-grade PCL injury in the context of MLKI is to delay surgery for several weeks, with more pressing injuries in a patient with polytrauma taking precedence over injury to the knee. If surgery is delayed, it is inevitable that the PCL will be treated with autograft or allograft reconstruction, as delay results in obscuration of tissue planes and loss of tissue integrity with ligament retraction.<sup>1,6–9</sup> However, if early surgical intervention is planned (within 3 weeks from the time of injury) then primary repair of the PCL can be achieved<sup>10–12</sup> and has demonstrated positive clinical outcomes comparable with reconstruction.<sup>13,14</sup>

In MLKI, PCL disruption occurs most frequently at the femoral insertion or midsubstance of the ligament, although distal injury typically involves an attached osseous fragment related to either avulsion or coexistent tibial plateau fracture. In this context, with repair, the torn PCL is reattached to the distal femur. As such, the distal PCL stump must be of sufficient length to allow for reattachment.

The purpose of our study was to retrospectively identify those patients with a documented MLKI, as encountered and recorded by the orthopedic surgeon (B.T.) at Harborview Medical Center, an allied hospital of the University of Washington, over a 1-year period and to separate those with surgically confirmed injury of the PCL for more detailed review. In those with a surgically documented disruption of the PCL, we sought to identify a possible threshold length on the preoperative MRI of the torn distal PCL fragment, which is necessary to allow for successful proximal femoral repair of the PCL, as opposed to reconstruction.

### Materials and Methods

Approval from the Investigational Review Board at the University of Washington was obtained for this study.

During the period of May 1, 2013, through July 15, 2014, 50 knees with MLKI (47 patients, 3 with multiligament injury to both

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the right and the left knee) were encountered and addressed by the same orthopedic surgeon (B.T.) at Harborview Medical Center, using early surgical intervention as part of their primary algorithm of care. The MLKI was defined as surgically confirmed injury of a cruciate ligament, with additional injury to the other cruciate ligament or collateral ligaments or both, with sufficient instability or injury pattern to have warranted surgical intervention and treatment. These patients were prospectively cataloged by the operating orthopedic surgeon (B.T.) into an MLKI database.

Following exclusion of those younger than 18 years at the time of injury (1 patient, with multiligament injury to both the right and the left knee), we retrospectively reviewed each operative report (48 knees from 46 patients) and tabulated the presence or absence of injury to the following structures, as well as the type of repair or reconstruction when applicable: anterior cruciate ligament, PCL, medial collateral ligament or posteromedial corner, and fibular collateral ligament or posterolateral corner.

In the operative report, PCL injury was classified as

1. Grade 1 or partial-thickness sprain.
2. Proximal femoral avulsion.
3. Midsubstance disruption.
4. Distal tibial osseous avulsion or attached to part of a tibial plateau fracture.

In addition, patient demographics including sex, age at the time of injury, and extremity side were recorded.

Those knees with a surgically documented injury of the PCL were identified (41 knees from 40 patients) and were subsequently tabulated separately for more comprehensive operative report and MRI review.

There were 6 knees from 6 different patients with a specified Grade 1 or partial-thickness sprain to the PCL per operative report that were not treated with either repair or reconstruction and were not applicable to the study and were therefore excluded, resulting in 35 remaining knees from 35 different patients.

In 3 of the 35 remaining knees (3 different patients), the exact injury of the PCL was unclear at the time of operative intervention per operative report (1 due to obscuration by the medial head of the gastrocnemius at the time of repair of the collateral structures, and subsequent refusal by the patient for further intervention at the time of planned cruciate repair; 1 related to complete maceration of the PCL; and the last related to poor visualization of the PCL because of adjacent posterior capsule injury collectively repaired using anchors and sutures in the posterior tibial plateau), and as such, these were excluded from the study, resulting in 32 knees from 32 different patients.

There were 4 (4 of 32) knees from 4 different patients with distal tibial osseous avulsion or PCL attached to a part of a tibial plateau fracture. In 1 of these cases of surgically confirmed distal tibial osseous avulsion, there was no accompanying MRI, resulting in 31 knees from 31 different patients. The 3 (3 of 31) remaining knees from 3 different patients with a surgically confirmed distal osseous avulsion from the tibia or PCL attached to a component of a coexistent tibial plateau fracture had an intact PCL and were all treated with bony reattachment, and as such, they were excluded from MRI PCL measurements, resulting in 28 knees from 28 patients.

Finally, in 1 knee with intraoperative confirmation of a mid-substance PCL tear, operative intervention was not pursued, as there was sufficient posterior stability intraoperatively despite the presence of injury, and the patient's age and additional injuries rendered the patient a poor candidate for aggressive intervention. Following this exclusion, there were 27 knees from 27 patients remaining for review. Inclusion and exclusion criteria are demonstrated in Figure 1.

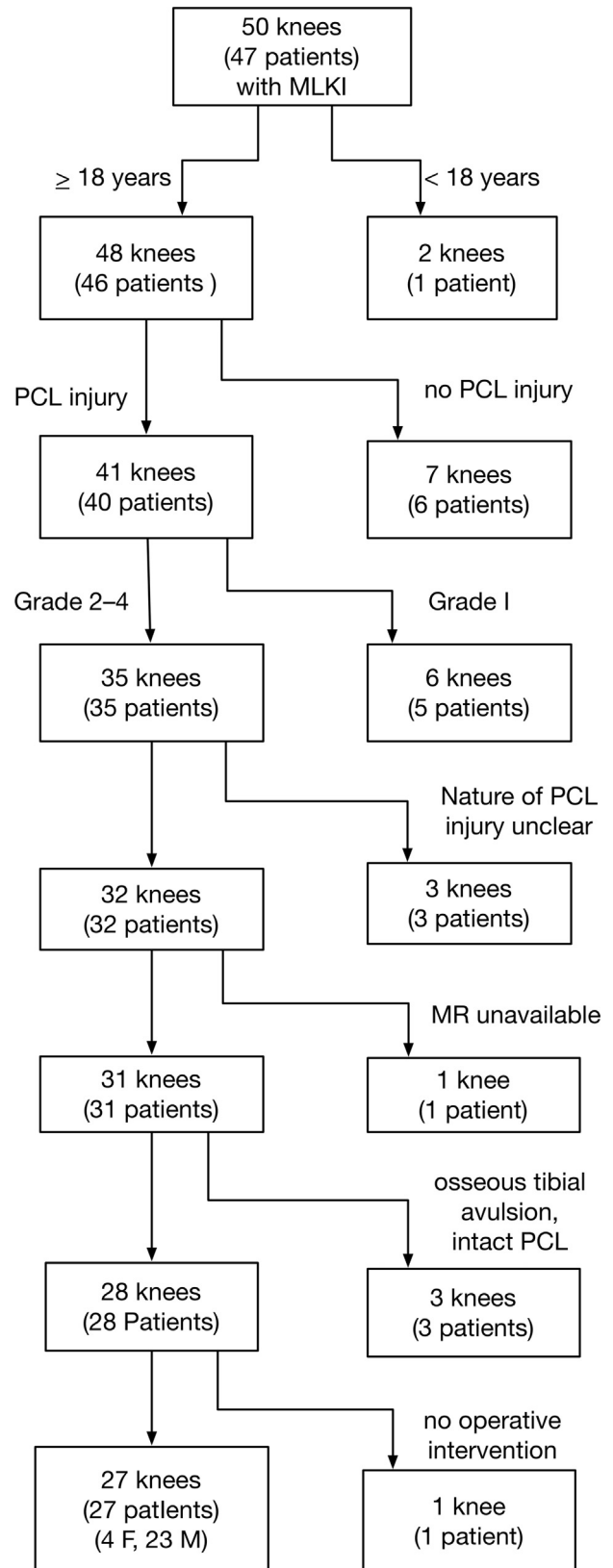


Fig. 1. A flowchart demonstrating stepwise inclusion and exclusion criteria of the study. The left column demonstrates knee and patient inclusions, while the right column demonstrates knee and patient exclusions.

Following exclusions, 2 musculoskeletal trained radiologists (H.M. and J.P.) reviewed the MRI studies in a consensus fashion in an effort to establish the maximal length of the proximal and

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