Medial Patellofemoral Ligament Injury Following Acute Transient Dislocation of the Patella: MR Findings with Surgical Correlation in 14 Patients

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**Purpose:** The purpose of this study was to determine the accuracy of MRI in determining both the extent and the location of injury to the medial patellofemoral ligament (MPFL).

**Method:** MR findings were compared to the surgical results of 14 consecutive patients who experienced transient patellar dislocation. Two musculoskeletal radiologists, blinded to the surgical results, retrospectively reviewed the MR studies, and a consensus reading was obtained.

**Results:** Surgery demonstrated complete disruption of the MPFL in 7 of 14 patients (50%), with stretching or partial tearing of the MPFL in the remaining 7 (50%) patients. MRI was 85% sensitive and 70% accurate in detecting MPFL disruption. Vastus medialis obliquus muscle elevation was present in 12 of 14 (85%).

**Conclusion:** MRI accurately depicts both the extent and the location of MPFL injury following transient patellar dislocation and can therefore play a significant role in directing surgical management of these patients.

**Index Terms:** Magnetic resonance imaging—Ligament, medial patellofemoral—Legs, ligaments.

Acute transient dislocation of the patella is a somewhat common sports-related injury of the young athlete but is frequently misdiagnosed at the time of initial clinical presentation (1). MRI, however, is an accurate method of diagnosing acute transient dislocation of the patella (1). The classic MR findings associated with patellar dislocation are nearly pathognomonic and include bone marrow edema involving the anterolateral aspect of the lateral femoral condyle and the inferomedial aspect of the patella in combination with injury to the medial soft tissues of the knee and hemarthrosis (2). Anatomic studies have demonstrated that the medial soft tissue restraints are composed of several individual structures. These include the medial patellofemoral ligament (MPFL), the medial parapatellar retinaculum, the patellomeniscal ligament, and the medial patellotibial ligament (Fig. 1).

From these medial soft tissue restraints, the MPFL is the primary stabilizer against lateral patellar displacement, providing between 53 and 67% of the medial soft tissue restraint (3).

Although not universally accepted by the orthopedic community, recent literature suggests that following transient dislocation of the patella, patients experiencing disruption of the MPFL may benefit from primary surgical repair of the ligament (4). MRI clearly depicts the normal MPFL on axial images as a low signal band extending from the adductor tubercle of the medial femoral condyle to the medial aspect of the superior pole of the patella (5,6). MRI may be able to play a significant role in directing surgical management if it can accurately depict the extent of injury to the MPFL.

**SUBJECTS AND METHODS**

The study group consisted of 14 consecutive patients (10 males and 4 females; age range 12–60 years, average
age 29.6 years) that were all operated on for acute transient dislocation of the patella in our hospital. All patients were evaluated in the orthopedic department between December 1997 and December 1998; based on either clinical evaluation or MR findings, each was suspected of having had acute transient dislocation of the patella. MRI of the affected knee was performed within 23 days of the time of injury in all patients (range 2–23 days, mean 10.9 days, median 10 days). Surgical exploration of the injured knee was performed within 10 days of imaging in 12 patients; two examinations were significantly delayed (range 0–180 days, mean 21.1 days, median 5 days).

All MR images were acquired on a Signa 1.5 T scanner (GE Medical Systems, Milwaukee, WI, U.S.A.). The MR protocols used a 6.5 in extremity coil for the knee (Quadrapature coil; GE). Oblique sagittal, coronal, and axial fast SE T2-weighted images were obtained with frequency-selective fat saturation (3,100–5,200/51–80 ms range TR/ range effective TE, echo train 8). The field of view was 16 × 16 cm, and the slice thickness ranged from 3 to 4 mm with a 1 mm interslice gap. The matrix size was 256 × 192 with three excitations. Oblique sagittal and coronal T1-weighted images were obtained (400–700/14–16 ms range TR/ range TE). The field of view was 16 × 16 cm, and the slice thickness ranged from 3 to 4 mm, with a 1 mm interslice gap. The matrix was 256 × 192 with two excitations.

Two experienced musculoskeletal radiologists retrospectively reviewed all MR images, and consensus was reached for all findings. The radiologists were blinded to the surgical findings in all cases. MR images were evaluated for MPFL injury and elevation of the vastus medialis oblique (VMO) muscle. For the purposes of this study, the MPFL was defined on axial MR images as the low signal band-like structure extending from the adductor tubercle of the medial femoral condyle to the superior pole of the patella (5,6) (Fig. 2). The structure arising from the medial aspect of the midpole of the patella and distal to the VMO muscle was considered to represent the medial parapatellar retinaculum (Fig. 3). The standard system for grading ligamentous injuries was used, as follows: The MPFL fibers were graded as normal (intact fibers with no adjacent edema), stretched (wavy continuous fibers), or disrupted (no intact fibers

FIG. 1. Line drawing shows the normal anatomic structures of the medial aspect of the knee as well as their relationship to one another. The medial patellofemoral ligament extends from the adductor tubercle on the medial femoral condyle to the superior pole of the patella. Note that it lies deep to the most distal fibers of the vastus medialis oblique muscle. The adductor magnus tendon and medial collateral ligament also attach to the adductor tubercle.

FIG. 2. Normal medial patellofemoral ligament of the knee in an 18-year-old woman with medial joint line pain but no history of patellar dislocation. Axial fat-saturated T2-weighted fast SE MR image of the knee demonstrates a normal-appearing medial patellofemoral ligament (short arrows) extending from the superior pole of the patella (curved arrow) to the adductor tubercle (long arrow). The medial patellofemoral ligament is deep to the vastus medialis oblique muscle (thick arrow).
noted). The pattern of MPFL injury and adjacent edema was recorded.

The VMO muscle was evaluated for edema within the muscle fibers on both oblique sagittal and axial images and was evaluated for uplifting or displacement of the muscle away from the medial femoral condyle on the oblique sagittal images. VMO muscle elevation was defined as the distance between the undersurface of the VMO muscle and the superior aspect of the medial femoral condyle as measured on the oblique sagittal MR images at the level of the adductor tubercle. The extent of VMO muscle uplifting in these 14 patients was compared with the VMO muscle elevation measured retrospectively on 100 consecutive knee MR exams performed on patients without clinical or MR evidence of patellar dislocation or medial collateral ligament injury obtained during the same 12 month period, with statistical evaluation of the difference performed using the Fisher exact test.

A single sports medicine fellowship-trained orthopedic surgeon operated on all 14 patients. Arthroscopic examination of the affected knee was performed to repair osteochondral injuries and to remove any associated loose bodies. Open exploration of the medial soft tissues was performed, and in all cases the MPFL was directly visualized, extent of injury was evaluated, and injured ligaments were repaired.

RESULTS

MPFL

The pattern of edema located within or adjacent to the fibers of the MPFL on MR images was as follows: Edema isolated to the femoral attachment site was noted in 4 of 14 patients (29%). Focal edema isolated to the patellar attachment site was noted in a single patient (1/14; 7%). Focal edema isolated to the midsubstance of the MPFL did not occur. Diffuse edema beginning at the femoral attachment site and extending into the midsubstance of the MPFL occurred in 5 of 14 (36%), and diffuse edema extending the entire length of the MPFL from the femoral attachment to the patellar attachment occurred in 4 of 14 (29%).

The MPFL was identified on axial MR images in 14 of 14 (100%) of cases. Complete disruption of the MPFL was noted on MR images in 8 of 14 (57%). In seven of these eight cases, the discontinuity was located at or near the adductor tubercle of the medial femoral condyle (Fig. 4). In a single case (1/14, 7%), there appeared to be complete disruption of the MPFL fibers adjacent to the patellar attachment site, but this was not confirmed surgically. In the remaining 6 of 14 (43%), MRI demonstrated wavy or stretched MPFL fibers with adjacent soft tissue edema, but in each of these cases, some fibers appeared intact (Fig. 5). When compared with surgical findings, MRI was 85% sensitive and 70% accurate for diagnosing MPFL disruption.

At the time of surgical exploration, the MPFL was identified in all 14 patients, and each patient demonstrated some degree of MPFL injury. It was either completely disrupted near the femoral attachment site or avulsed off the femur (7/14 patients, 50%). All seven disruptions occurred at or near the femoral attachment site. The remaining 7 of 14 (50%) patients demonstrated either stretching or partial tearing of the MPFL with adjacent soft tissue edema, but in each of these cases, some fibers remained intact. At the time of surgery, the MPFL was thought to be intact adjacent to the patellar attachment site in all 14 cases.

VMO Muscle

MRI demonstrated elevation of the VMO muscle away from the medial femoral condyle in 12 of 14 patients (85%). In each of these cases, fluid or hemorrhage was present between the VMO muscle and the medial femoral condyle (Fig. 4B). Edema was present within the fibers of the VMO muscle in 13 of 14 (93%) of dislocators but was absent in all 100 nondislocators. In the
dislocators, VMO muscle elevation ranged from 0.5 to 2.8 cm with a mean of 1.7 cm. This was compared with the 100 control knees in which VMO muscle elevation ranged from 0.0 to 1.6 cm with a mean of 0.18 cm (Fig. 6). The difference between the amounts of VMO muscle elevation in the dislocators versus the nondislocators was significant ($p = 0.001$, Fischer exact test).

**DISCUSSION**

Acute transient dislocation of the patella most commonly occurs in young adult athletes (1,2,7). The injury typically happens while the knee is slightly flexed. The knee undergoes a twisting motion, and as the femur rotates internally on the fixed tibia, the quadriceps tendon contracts, forcing lateral subluxation of the patella out of the trochlear groove (7,8). As the patella relocates, the inferomedial aspect of the patella impacts the anterolateral aspect of the lateral femoral condyle, resulting in the classic bone marrow edema pattern seen on MRI (1,2,7). Other MR findings frequently associated with lateral dislocation of the patella include injury of the medial soft tissue restraints, hemorrhrosis, and osteochondral injury involving the inferomedial patella and lateral femoral condyle (1,7).

The medial soft tissue restraints of the patella are composed of four distinct anatomic structures (Fig. 1), which include the MPFL, the medial parapatellar retinaculum, the medial patellomeniscal ligament, and the medial patellotibial ligament (Fig. 3) (3,4). Studies have shown that the MPFL is the most important soft tissue stabilizer preventing lateral dislocation of the patella, providing between 53 and 67% of the restraining force, whereas the patellomeniscal ligament contributes approximately 22% (3,4). The medial parapatellar retinaculum and the patellotibial ligament contribute little toward the prevention of lateral subluxation of the patella (3,4). Although not agreed upon by all orthopedic surgeons, recent surgical literature suggests that following acute transient dislocation of the patella, those patients with disruption of the MPFL may benefit from primary surgical repair of the ligament and will experience a lower rate of recurrent dislocation (4,9).

From a practical standpoint, the extent and location of MPFL injury are important in planning the location and extent of incision along the medial aspect of the knee for MPFL repair. If the ligament is stretched, then the incision should be located midway between the medial femoral condyle and the medial border of the patella; at this point, the ligament is identified and imbricated. If the ligament is torn, the incision is made directly over the area of disruption and primary repair of the ligament is performed.

Knowledge of the expected anatomic location of these four ligaments as well as their relationships to one another is crucial if one is to differentiate between them on MRI and thereby predict with accuracy which structures have been injured. The MPFL varies in size and thickness but maintains a constant anatomic location (10). It originates from the adductor tubercle of the medial femoral condyle proximal to the origin of the superficial fibers of the medial collateral ligament (Fig. 1). It then extends distally to insert upon the undersurface of the VMO muscle and the upper two-thirds of the medial aspect of the patella (3,4). The MPFL is seen on axial MR images as a low signal intensity band-like structure of variable thickness that is located just deep to the VMO muscle (Fig. 2) (5,6). On axial MR images, the MPFL can be differentiated from the medial parapatellar retinaculum as follows: Anatomically, the MPFL and the medial
The MPFL, however, is located more proximally. On MRI, the MPFL is seen on the same axial images as the VMO muscle and is located just deep to it (Fig. 3). We observed that the MPFL is typically seen best near its patellar attachment site, but as it approaches its femoral attachment site, it blends with the deep fascia of the VMO muscle and may be difficult to separate from the overlying fascia of the VMO muscle. The medial parapatellar retinaculum, on the other hand, is located distal to the VMO muscle at the level of the midpatella and is not seen in the same axial images as the VMO muscle. Therefore, the ligamentous structure seen on axial MR images extending from the superior pole of the patella toward the adductor tubercle and situated deep to the VMO muscle represents the MPFL. Conversely, the structure seen on axial MR images extending from the midpole of the patella but located distal to the VMO muscle represents the medial parapatellar retinaculum.

Evaluation on MR images of soft tissue edema and MPFL injury patterns in this series suggests that the majority of MPFL injuries occur proximally, near or at the femoral attachment site adjacent to the adductor tubercle (Fig. 4). MRI demonstrated disruption of the MPFL near the patellar attachment site in a single case, but this was not confirmed surgically. In 13 of 14 cases, soft tissue edema was present at the femoral attachment site and extended variable distances along the length of the MPFL. In 29% of cases, the edema was isolated to the femoral attachment site; 36% of cases demonstrated extension of edema from the femoral attachment site into the mid-MPFL; and in 29% of cases, the edema extended along the entire length of the ligament. These findings suggest that the weak point of the MPFL is at or near the femoral attachment site, and although disruption may occur near the patellar attachment site, it usually occurs in the proximal portion of the ligament. This contradicts some early studies, which suggested that the majority of soft tissue injuries occurred near the patellar attachment site (11–13), but confirms more recent studies suggesting disruption of the MPFL most commonly occurs in the proximal fibers (9,14).

The VMO muscle is defined anatomically as the relatively small set of fibers located at the inferior aspect of the vastus medialis muscle. These fibers originate from the medial intermuscular septum and the adductor magnus tendon proximal to the adductor tubercle. They then extend distally to insert on the superomedial aspect of the patella (14). Elevation of the VMO muscle off the lateral femoral condyle as seen on oblique sagittal images appears to be a sensitive indicator for acute transient dislocation of the patella and was present in 85% of dislocators in this series (Fig. 6). Although there is overlap in the range of elevation of the VMO muscle between the dislocators and the nondislocators, the MR appearance is quite different between the two groups. The VMO muscle normally sits directly on top of the MPFL as it inserts into the adductor tubercle of the medial femoral condyle, and on oblique sagittal MR images, the VMO muscle appears to be in almost direct contact with the.
underlying medial femoral condyle. As the MPFL tears or stretches, hemorrhage occurs within the soft tissues deep to the VMO muscle, resulting in uplifting of the VMO muscle away from the underlying medial femoral condyle.

Elevation of the VMO muscle in the dislocators therefore results from hemorrhage deep to it, and MR images demonstrate fluid or blood signal between the VMO muscle and the underlying medial femoral condyle. On MR images, the VMO muscle was in direct contact with the superior aspect of the medial femoral condyle in the majority of nondislocators (range 0–1.6 cm, mean 0.18 cm). VMO elevation was present in a few of the nondislocators, but elevation in this group tended to occur in the older patient population rather than in the younger age group. Elevation in the nondislocators was secondary to fat between the VMO muscle and the underlying medial femoral condyle rather than secondary to underlying edema and hemorrhage, as seen in the dislocators.

This study is limited both by its retrospective nature and by the small number of patients included; however, surgical evaluation of the MPFL was available in each case. The study also lacked a normal control group for evaluation of the MPFL. It would have been difficult, however, to have a blinded control group because all patients with prior transient dislocation of the patella had the typical bone bruise pattern, which would have been absent in the control group.

In summary, recent surgical literature suggests that following transient dislocation of the patella, patients experiencing injury of the MPFL will benefit from primary surgical repair of the ligament. MRI accurately depicts both the location and the extent of ligamentous injury and thus can play an important role in directing surgical management. In the majority of cases, MPFL disruption occurs at or near its medial femoral attachment site on the adductor tubercle. Medial patellofemoral ligament disruption is demonstrated on MRI as either discontinuity of the fibers or fluid located between the proximal fibers of the MPFL and the adductor tubercle. Elevation of the VMO muscle off the underlying medial femoral condyle also appears to be a sensitive secondary MR sign for acute transient dislocation of the patella.

REFERENCES