Primary Medial Patellofemoral Ligament Repair Versus Reconstruction: Rates and Risk Factors for Instability Recurrence in a Young, Active Patient Population

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Purpose: To comparatively evaluate the clinical outcomes and rates of recurrent instability in young patients with primary medial patellofemoral ligament (MPFL) repair or reconstruction, as well as to assess for radiologic risk factors for worse outcomes. **Methods:** A retrospective review identified all patients with lateral patellar instability who underwent either MPFL repair and/or imbrication or MPFL reconstruction without any additional osseous procedures between 2008 and 2015 at a single center. Demographic variables and preoperative magnetic resonance imaging were analyzed, and Kujala scores were obtained at a minimum 2-year follow-up. Risk factors for worse outcomes were assessed, including the Caton-Deschamps Index (CDI) Insall-Salvati Index, tibial tubercle–trochlear groove distance, and tibial tubercle–posterior cruciate ligament distance. **Results:** We identified 51 knees with isolated MPFL surgery (reconstruction in 32 and imbrication and/or repair in 19) at a mean of 59.7 months' follow-up (range, 24-121 months). The overall rate of recurrent dislocations was significantly greater in the repair group (36.9%) versus the reconstruction group (6.3%, $P = .01$), despite the average CDI being significantly higher in the reconstruction group (1.34 vs 1.23 in repair group, $P = .04$). No significant difference in the rate of return to baseline activity was found between the groups (77.8% in reconstruction group vs 70% in repair group, $P = .62$). The average Kujala score showed no significant difference between the repair and reconstruction groups (84.15 ± 14.2 vs 84.83 ± 14.38, $P = .72$). No imaging measurements were found to be predictive of a worse postoperative Kujala score; however, the average CDI among the MPFL repair failures (1.30 ± 0.05) was significantly higher than among the MPFL repair nonfailures (1.18 ± 0.12, $P = .03$). **Conclusions:** MPFL reconstruction may provide improved midterm clinical outcomes and a decreased recurrence rate compared with MPFL repair. Increased patellar height as measured by the CDI may be a risk factor for recurrent patellar instability in patients who undergo isolated MPFL repair. **Level of Evidence:** Level III, retrospective comparative study.

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Lateral patellar instability (LPI) is a common complaint in young athletes[1-3] that can greatly hinder patient function and athletic participation owing to apprehension or episodic instability.[2,4,5] Patellar stability is provided by a balance of forces,[4,5] and a disruption of these forces can lead to patellar maltracking or secondary instability. This can result in significant morbidity and greatly hinder patient function[2,4,5] and athletic participation owing to apprehension or episodic instability. There are a wide variety of surgical options to treat patellar instability, but the optimal management remains unknown.

As the primary restraint to lateral translation,[6] the medial patellofemoral ligament (MPFL) contributes about 60% of patellar stability from 0° to 30° of knee flexion.[6-8] However, with continued flexion, resistance to lateral translation is provided by engagement in the trochlear groove.[9-13] The MPFL is disrupted in essentially all complete patellar dislocations,[14-17] and when nonoperative management is not successful, this can lead to recurrent instability in adolescents and children.[18] MPFL repair and reconstruction are commonly performed as surgical interventions to address acute[19] and recurrent patellar dislocations,[20] respectively. MPFL repair can be performed by directly repairing patellar or femoral avulsions whereas "imbrication" typically refers to reefing of the midsubstance of the MPFL and medial retinaculum to remove redundancy in the medial patellofemoral complex.[21,22] Although some authors have shown success, several other retrospective series have shown inconsistent outcomes with MPFL repair and relatively higher rates of recurrent dislocation.[20,23,24] By contrast, MPFL reconstruction has resulted in relatively low failure rates[23] and favorable rates of return to preinjury activity, although cases of iatrogenic arthrofibrosis, patellar fracture, and overconstraint continue to be reported.[24] Previous randomized trials have shown improved outcomes with MPFL reconstruction compared with nonoperative management[25]; however, this has not been found to be true for MPFL repair.[26,27]

The objective of this study was to comparatively evaluate the clinical outcomes and rates of recurrent instability in young patients with primary MPFL repair or reconstruction, as well as to assess for radiologic risk factors for worse outcomes. We hypothesized that MPFL reconstruction would yield superior subjective outcomes and a superior failure rate at 2 years' follow-up compared with repair and that patella alta and axial malalignment would not be associated with worse patient outcomes.

Methods

After we obtained approval from the institutional review board, a retrospective review identified all patients with LPI who underwent surgical treatment with either MPFL repair and/or imbrication or MPFL reconstruction from January 2008 to September 2015. The inclusion criteria were patients who had a history of at least 1 confirmed patellar dislocation, had received either MPFL reconstruction or MPFL repair, had available preoperative imaging, and had at least 2 years of follow-up. The exclusion criteria were revision surgery and patients who received a tibial tubercle osteotomy or any concomitant procedure other than lateral retinacular lengthening and/or release, cartilage fragment fixation, chondroplasty, loose body removal, debridement, or plica excision. The medical history, clinical data, preoperative plain radiographs (anteroposterior, lateral, and Merchant views), preoperative magnetic resonance imaging (MRI) scans, and operative reports were collected retrospectively. The clinical data recorded included the circumstances of each patellar dislocation event, participation in competitive sports, previous ipsilateral knee operations, postsurgical complications, physical examination data up to 12 months postoperatively, and subsequent ipsilateral knee operations.

Preoperative MRI scans were used to measure the tibial tubercle—trochlear groove (TT-TG) distance[28] and tibial tubercle—posterior cruciate ligament (TT-PCL) distance,[29] as well as patellar height according to the Insall-Salvati Index (ISI)[30] and Caton-Deschamps Index (CDI).[31] These measurements were made by a trained orthopaedic researcher (W.Z.) and verified by a fellowship-trained orthopaedic surgeon (B.W.).

Surgical Technique

All surgical procedures were performed by 1 of the 4 authors (A.B.Y., N.V., B.F., B.J.C.) at our institution. All patients undergoing surgery had a history of 1 or multiple patellar dislocations. Preoperative examination included assessment of patellar tracking and translation. At the time of the procedures. an arthroscopic examination of the knee assessed for chondral lesions and other concomitant injuries. A lateral release was performed if the patients' patella could not be everted to neutral on examination under anesthesia.

Reconstruction Technique. MPFL reconstructions were performed using hamstring allograft or autograft or tibialis anterior allograft (AlloSource, Centennial, CO). By use of intraoperative fluoroscopy, the femoral insertion was identified and a small incision was made at the Schöttle point, 1 mm anterior to a line extending from the posterior cortex and 2.5 mm distal to the posterior origin of the medial femoral condyle, as well as proximal to the level of the posterior point of the Blumensaat line.[32] Once the position was confirmed on a lateral fluoroscopic image, a 2.4-mm guidewire was placed and a 6.5-mm reamer was advanced over this to ream a unicortical bone socket. The graft was then implanted into this socket and secured using a 6.25-mm PEEK (polyether ether ketone) biotenodesis screw (Arthrex, Naples, FL) or 7-mm Biosure PEEK tenodesis screw (Smith & Nephew, Andover, MA). A small vertical incision was made along the superior aspect of the medial border of the patella. The graft was then shuttled medially toward the patella, traveling between layers 2 and 3 of the medial retinaculum, using looped suture to facilitate passage. Two suture anchors, either 4.75-mm PEEK SwiveLock (Arthrex), 2.4-mm BioComposite SutureTak (Arthrex), or 2.9-mm Osteoraptor (Smith & Nephew) suture anchors, were placed at the midpoint and superomedial aspect of the patella for graft fixation. After tensioning of the graft at 30° of flexion and neutral rotation, the suture limbs were passed through the graft and tied. Care was taken to prevent overconstraint on the knee joint throughout a full arc of motion.

Repair Technique for Disrupted Ligament. Repair of the MPFL was performed if the ligament was avulsed from the femoral or patellar insertion or if the midsubstance of the ligament was partially intact or redundant. If multiple locations of injury were identified, MPFL reconstruction was performed. For MPFL repair in patients who had a disrupted ligament from the patella, the medial patella was prepared using a rongeur, and nonabsorbable No. 2 suture with PEEK suture anchors (Arthrex) or Osteoraptor suture anchors was placed into the anatomic insertion point of the ligament. The knee was placed at 30° of flexion, and the sutures were passed through the native MPFL to provide imbrication and then tied to ensure that the patella was centralized in the trochlea. The knee was cycled through its full range of motion to ensure appropriate patellar tracking and to confirm that the joint was not overconstrained. For MPFL repair in patients with a partially intact but redundant ligament, tightening was performed in an imbrication-type fashion using high-tensile, nonabsorbable No. 0 suture. This was performed with the knee in 30° of flexion, and the knee was subsequently cycled to ensure proper patellar translation without overconstraining the joint.

Rehabilitation

Every patient underwent a standardized rehabilitation program. Patients were discharged with full weight-bearing status as tolerated, with crutches being provided for support for the first 24 to 48 hours. Exercises such as straight-leg raises, single-leg raises, and ankle pumps were encouraged immediately after surgery. Physical therapy began immediately after surgery, and range of motion was allowed without limitation. A long-leg, hinged knee brace locked in extension was used until 6 weeks postoperatively or until the patient was able to obtain full extension without lag. Patients were permitted to return to sport at 4 to 6 months if cleared by the surgeon.

Data Collection

Patient-reported outcomes were collected via telephone contact made at a minimum of 2 years after the operation. Clinical outcomes were evaluated using the Kujala score,[33] return to sport or baseline activity, and recurrence of patellar instability. Return to sport or baseline was evaluated by asking the patient, "Have you regained your ability to perform physical activity or to participate in sports compared to your baseline activity level prior to your first patellar dislocation?" Patients were also asked about any postoperative complications or subsequent procedures. Failure was defined as reoperation on the affected knee or at least 1 instance of postoperative patellar dislocation. Postoperative subluxation events were delineated from dislocation events based on clinical documentation, which was retrospectively reviewed after a patient was noted, during telephone contact, to have had recurrent patellar instability. A single instance of patellar subluxation without dislocation was noted but not considered a failure. Patients with postoperative patellar dislocations but no revision surgery had their Kujala scores included for final analysis, but those who received revision surgery did not have their scores included because their outcomes were impacted by the revision procedure.

Statistical Analysis

All statistical analysis was performed using SPSS software (version 25; IBM, Armonk, NY). The Student t test was used to compare continuous data between the repair group and the reconstruction group, and the Fisher exact test was used to compare categorical data between the groups. Risk factors for surgical failure were analyzed for the combined groups and for MPFL repair alone; these included age, sex, ISI, CDI, TT-TG distance, and TT-PCL distance. This analysis could not be performed for MPFL reconstruction alone because of the low number of failures in this group ($n = 2$). A post hoc power analysis was performed to determine whether there was a sufficient size to detect a statistical difference in the variables of interest. To determine independent predictors for worse subjective outcomes within the combined groups, a multivariate linear regression analysis was performed using a history of more than 1 patellar dislocation, ISI, CDI, TT-TG distance, TT-PCL distance, age, sex, and body mass index as the independent variables and the Kujala score at final follow-up as the dependent variable. $P < .05$ was regarded as being statistically significant.

Results

Patients and Clinical History

We identified 23 patients (24 knees) who underwent isolated MPFL repair and 40 patients (40 knees) who

Table 1. Demographic Variables and Baseline Imaging Measurements of MPFL Repair and Reconstruction Groups

	MPFL Repair (n = 19)	MPFL Reconstruction (n = 32)	*P* Value
Female patients	9 (47.4)	19 (59.4)	.41
Age, yr	21.4 ± 8.0	24.2 ± 10.5	.32
BMI	25.7 ± 6.8	27.7 ± 7.3	.35
Competitive sports	13 (72.2)	19 (59.4)	.52
Multiple dislocations	12 (63)	31 (96.9)	.001*
TT-PCL distance, mm	20.85 ± 4.4	22.93 ± 3.7	.08
TT-TG distance, mm	14.49 ± 6.0	16.65 ± 5.9	.22
CDI	1.23 ± 0.17	1.34 ± 0.16	.03*
ISI	1.27 ± 0.11	1.34 ± 0.20	.17

NOTE. Data are presented as mean ± standard deviation or number (percentage).

BMI, body mass index; CDI, Caton-Deschamps Index; ISI, Insall-Salvati Index; MPFL, medial patellofemoral ligament; TT-TG, tibial tubercle−trochlear groove; TT-PCL, tibial tubercle−posterior cruciate ligament.

*Statistically significant.

underwent isolated MPFL reconstruction from January 2007 through September 2015 and met the inclusion criteria. Of these patients, 18 who underwent MPFL repair (19 knees, 79.1%) and 32 who underwent MPFL reconstruction (32 knees, 80%) were able to be contacted at an average of 59.7 months (range, 24-121 months) after their procedures. For the combined groups, there were 22 male patients (44%) and the average age at the time of the procedure was 23.3 years (range, 13-49 years). No patients had evidence of fractures or advanced osteoarthritis preoperatively, although these were not exclusion criteria. For the combined groups, 32 patients (64%) sustained 1 or more patellar dislocations during competitive sports. No significant difference regarding demographic variables was found between the 2 groups (Table 1). Of the 19 knees that underwent MPFL repair, 12 (63%) had multiple dislocation events prior to operative management compared with 96.9% of knees in the reconstruction group ($P = .001$) (Table 1). No significant differences in age or sex were found between patients with a history of 1 patellar dislocation and those with multiple patellar dislocations (mean age of 23.8 years for those with a single dislocation vs 23.2 years for those with multiple dislocations, $P = .88$; 4 female patients [44.4%] with a single dislocation vs 24 [58.5%] with multiple dislocations, $P = .44$). At the time of surgery, 31.3% of knees in the reconstruction group and 57.9% in the repair group received a lateral retinaculum release ($P = .06$).

Preoperative Imaging Measurements

The average TT-TG distance was 14.5 ± 6.0 mm in the repair group and 16.65 ± 5.9 mm in the reconstruction group ($P = .22$), and the TT-PCL distance was 20.85 ± 4.4 mm and 22.93 ± 3.7 mm, respectively ($P = .08$, Table 1). Although the average CDI in the repair group was significantly greater than that in the reconstruction group ($P = .03$), no significant difference in ISI measurements was found ($P = .14$, Table 1).

Surgical Outcomes

Of the knees that received MPFL repair surgery, 8 (42.1%) sustained 1 or more recurrent postoperative dislocations, 3 of which subsequently underwent revision to MPFL reconstruction. Within the primary MPFL reconstruction group, only 2 knees sustained recurrent dislocations and arthrofibrosis developed in 1 patient, amounting to 3 failures (9.4%), but none underwent revision surgery. Of the patients in the reconstruction group who experienced recurrent dislocations, 1 had received a hamstring autograft and the other, a hamstring allograft. The failure rate of the repair group (42.1%) was significantly higher than that of the reconstruction group (9.4%, $P = .006$). A total of 7 subjects (63.6%) in the MPFL repair group and 21 subjects (72.4%) in the MPFL reconstruction group, not including those with failure or those who underwent revision surgery, were able to return to baseline athletic or physical activity at the time of follow-up; this difference was not statistically significant (Table 2). The Kujala score for patients who had not

Table 2. Comparison of Outcomes Between MPFL Repair and Reconstruction

	MPFL Repair (n = 16)	MPFL Reconstruction (n = 32)	*P* Value
Kujala score, mean ± SD	84.2 ± 13.13*	84.8 ± 14.0	.72
Returned to baseline activity, n (%)†	7 (63.6) (n = 11)	21 (72.4) (n = 29)	.59
Failures, n (%)	7 (36.8)	2 (6.3)	.01‡

MPFL, medial patellofemoral ligament; SD, standard deviation.

*Does not include scores collected after revision operations.

†Does not include failures.

‡Statistically significant.

Table 3. Summary of Characteristics and Imaging Measurements Between Failures and Nonfailures for Combined MPFL Repair and Reconstruction Groups

Variable	Failure (n = 11)	Nonfailure (n = 40)	*P* Value
Age, yr	18.4 ± 4.9	24.1 ± 10.0	.08
Female patients	5 (45.5)	23 (57.5)	.48
TT-PCL distance, mm	20.7 ± 5.4	22.6 ± 3.7	.18
TT-TG distance, mm	15 ± 5.1	16.3 ± 6.2	.53
ISI	1.31 ± 0.2	1.29 ± 0.15	.72
CDI	1.3 ± 0.04	1.3 ± 0.3	>.99

NOTE. Categorical data are presented as number (percentage), and continuous data are presented as mean ± standard deviation. Odds ratios were not calculated for continuous data.

CDI, Caton-Deschamps Index; ISI, Insall-Salvati Index; MPFL, medial patellofemoral ligament; TT-TG, tibial tubercle−trochlear groove; TT-PCL, tibial tubercle−posterior cruciate ligament.

received revision surgery showed no significant difference between MPFL repair and MPFL reconstruction at final follow-up ($P = .53$). Subgroup analysis showed that there was no difference in outcomes regarding the average Kujala score or failure rate between patients with a history of 1 patellar dislocation and those with multiple patellar dislocations (mean Kujala score of 88.8 vs 85.4, $P = .53$; failure rate of 28.6% vs 14%, $P = .32$).

Risk Factor Analysis

Baseline characteristics between the failures and nonfailures for the combined groups did not differ significantly according to any demographic or radiographic variable (Table 3). The average age among the failures was 5.7 years younger than that among the nonfailures, but this was not statistically significant on univariate analysis ($P = .08$). Patellar height as measured by the CDI was the only factor found to be significantly greater in MPFL repair failures compared with MPFL repair nonfailures ($P = .02$) (Table 4). A post hoc power analysis found that the number of samples in each group was adequate to achieve 86% power in the category of CDI. Multivariate linear regression analysis of the combined groups did not find any variable to be significantly associated with a worse postoperative Kujala score.

Surgical Complications

In the repair group, 1 patient continued to have transient patellar subluxations with spontaneous reduction during sports participation. An MRI scan obtained after these events did not show any MPFL damage or loose cartilage fragments; this case was deemed a surgical failure. The patient received injection therapy for resultant pain and swelling, and her symptoms resolved without any further complications. In the reconstruction group, 1 patient underwent arthroscopic debridement and suprapatellar pouch release with open suture removal for arthrofibrosis 2 years after the index procedure; this case was deemed a surgical failure. No additional surgical complications occurred in any patient at final follow-up.

Discussion

The most significant finding of this investigation was that the failure rate after isolated MPFL repair surgery was approximately 6-fold greater than that after isolated MPFL reconstruction at a minimum 2-year follow-up despite the average patellar height, as measured by the CDI, being significantly higher in the reconstruction group. Sex and unaddressed risk factors for patellar instability, such as patella alta and axial rotational malalignment, did not have a significant impact on failure rates when the reconstruction and repair groups were combined. However, the average patellar height was significantly higher among failed MPFL repairs compared with nonfailed repairs. The average age among patients who experienced a surgical failure was 6.8 years lower than that of nonfailures, but this finding did not quite reach statistical significance

Table 4. Summary of Imaging Measurements Between MPFL Repair Failures and Nonfailures

Variable	Failure (n = 8)	Nonfailure (n = 11)	*P* Value
TT-PCL distance, mm	19.4 ± 5.0	21.9 ± 3.8	.26
TT-TG distance, mm	14.6 ± 5.4	17.1 ± 3.8	.32
ISI	1.32 ± 0.18	1.23 ± 0.15	.27
CDI	1.29 ± 0.04	1.17 ± 0.11	.02*

NOTE. Continuous data are presented as mean ± standard deviation. Odds ratios were not calculated for continuous data.

CDI, Caton-Deschamps Index; ISI, Insall-Salvati Index; MPFL, medial patellofemoral ligament; TT-TG, tibial tubercle−trochlear groove; TT-PCL, tibial tubercle−posterior cruciate ligament.

*Statistically significant.

($P = .06$). In addition, a history of more than 1 patellar dislocation, ISI, CDI, TT-TG distance, TT-PCL distance, age, sex, and body mass index were not predictive of a worse postoperative Kujala score.

Although variably defined, patella alta is a known risk factor for patellar instability. Its occurrence is due to delayed engagement of the patella within the trochlea until deeper degrees of knee flexion. There are multiple measures and indices to quantify relative patellar position, patellar height, and overall patellar tendon length. It is interesting to note that, in our study, the average CDI was significantly greater in the reconstruction group than in the repair group; however, there were no significant differences according to the ISI. Similarly, when only MPFL repairs were analyzed, there was a significantly greater CDI among the failures compared with the nonfailures but no significant difference in the ISI. The CDI has previously been described as the most accurate method of assessing patellar height because it relies on readily identifiable landmarks and is easily reproducible.[34] In addition, it does not depend on radiologic enlargement or the degree of knee flexion.[34] On the other hand, the ISI has limitations; the distal landmark for measurement is the tibial tuberosity, which may be difficult to reliability assess on lateral radiographs, and the shape of the patella and its most distal extent can vary. As a result, the ISI is a less sensitive and less practical method of assessing for patella alta compared with the CDI.[35]

Several recent publications have shown analogous outcomes when assessing MPFL repair or MPFL reconstruction alone. Studies by Camp et al.[20] and Arendt et al.[36] reported on isolated MPFL repair at a minimum of 2 years' follow-up and revealed similarly high rates of recurrence (28% and 46%, respectively). It is possible that MPFL repairs show a higher failure rate because the strength and stiffness of the residual ligament after repair are weakened and much less than those of a hamstring or Achilles tendon graft. Unlike in our study, however, patella alta was not found to be a significant risk factor in these previous publications. In addition, they did not analyze for the effect of axial malalignment (i.e., TT-TG distance and TT-PCL distance) because computed tomography or MRI was not consistently used. A recent systematic review by Schneider et al.[23] on the outcomes of isolated MPFL reconstruction showed that there was a pooled risk of recurrent instability of 1.2% and the cumulative reoperation rate was 3.1%. These numbers are only marginally lower than that reported in our study (6.3%), although only 9 of the 14 studies included in this review reported outcomes of patients with 1 or more anatomic risk factors for LPI. Among the studies that included patients with additional risk factors for LPI, patella alta and an increased TT-TG or TT-PCL distance were not found to be significant risk factors for worse outcomes.[23]

Limitations

We acknowledge limitations to this study. This is a retrospective cohort study that obtained follow-up via telephone contact, in lieu of a physical examination component at 2-year follow-up. As such, crepitation, effusion, and radiographic changes could not be evaluated, other than a patient's subjective feelings of crepitation and effusion that are evaluated on the Kujala questionnaire. Furthermore, we did not evaluate our patients' use of nonsteroidal anti-inflammatory drugs or need for a brace, injections, or other nonoperative treatments in the postoperative period. Pain, limping, and instability are all evaluated in the Kujala questionnaire, however. Although risk factors for recurrent instability such as patella alta and axial malalignment were included in this study, trochlear dysplasia was not assessed. In addition, the inclusion of patients who were operated on by several surgeons, as well as the lack of a clear treatment algorithm, introduces the potential for selection bias. However, the bias was likely toward performing reconstruction in higher-risk patients, which would further strengthen the argument that reconstruction is a superior treatment option to repair for these patients. No a priori power analysis was performed to determine the appropriate sample size to make statistical conclusions regarding risk factors for worse outcomes; however, a post hoc power analysis revealed a sufficient sample size to achieve adequate power for the conclusion regarding an increased CDI in MPFL repair failures.

Conclusions

MPFL reconstruction may provide improved short-term to midterm clinical outcomes and a decreased recurrence rate compared with MPFL repair. Increased patellar height, as measured by the CDI, may be a risk factor for recurrent patellar instability in patients who undergo isolated MPFL repair.

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