Systematic Review

Return to Activity After Medial Patellofemoral Ligament Repair or Reconstruction

George T. Matic, B.S., Robert A. Magnussen, M.D., Gregory P. Kolovich, M.D., M.P.H., and David C. Flanigan, M.D.

Purpose: This study aimed to determine the ability of patients to return to activity after medial patellofemoral ligament (MPFL) reconstruction or repair for patellar instability. **Methods:** A systematic review was performed using multiple databases. Studies reporting outcomes with Tegner scores after repair or reconstruction of the MPFL were included. Surgical technique, Tegner scores, and episodes of recurrent patellar instability were recorded. **Results:** Ten articles with a total of 402 patients were included. The mean preoperative Tegner score was 4.7 (2.9 to 7.5). The mean postoperative Tegner score was 5.8 (4.0 to 7.7). Forty-nine patients (12.2%) had a recurrent episode of instability, 11 of whom required additional corrective procedures. There was a statistically significant larger failure rate among those who underwent MPFL repair (26.9%) than those who underwent reconstruction (6.6%) or medial retinacular repair/plication (16.5%). **Conclusions:** Recurrent dislocation was higher in patients who underwent MPFL repair rather than reconstruction. However, repair and reconstruction had similar Tegner scores. Repair or reconstruction of the soft tissue structures contributing to patellofemoral instability is successful in returning patients to preinjury activity levels. **Level of Evidence:** Level IV, systematic review of Level II, III, and IV studies.

Patellar instability, including dislocation and subluxation, tends to affect a young athletic population.[1-3] Recurrent patellar instability appears to be multifactorial, affecting individuals with patella alta, increased quadriceps angle, excessive tibial tubercle-trochlear groove (TT-TG) distance, trochlear dysplasia, and ligament hyperlaxity.[1,4-7] The mechanisms most commonly associated with patellar dislocation include twisting with a valgus stress on a planted foot and direct trauma.[5,6,8,9]

It is widely acknowledged that the medial patellofemoral ligament (MPFL) is an important structure in patellar instability and is frequently injured with patellar dislocation.[10,11] With a tensile strength of 208 N,[12] the MPFL is shown to be the primary soft tissue stabilizer to lateral patellar displacement, providing 50% to 60% of the restraining force.[13-15] The MPFL originates superior and posterior to the medial femoral epicondyle, distal to the adductor tubercle, and fans out to attach to the superomedial edge of the patella. It is found within layer II, deep to the medial retinaculum, positioned deep to the vastus medialis.[12,16-18]

Nonoperative management of traumatic dislocations is still recommended as the first line of therapy, except in patients with osteochondral fractures, a recurrent dislocation, or those who do not improve with conservative management.[19] When performing a surgical intervention for patellar instability, one must take into account the soft tissue stabilizers disrupted during dislocation, as well as anatomical abnormalities that may predispose to chronic dislocations. Specific indications for isolated MPFL reconstruction or repair are trochlear dysplasia type A or normal trochlea, a TT-TG distance less than 20 mm, and patella alta less than 1.4 (Insall-Salvati ratio).[20] Reconstruction of the MPFL can be augmented by bony procedures in the setting of specific anatomical abnormalities. A trochleoplasty can be performed to address trochlear dysplasia, excessive TT-TG may warrant medialization of the tibial tubercle, and correction of patella alta can be done with a distal tibial tubercle transfer.[20,21]

Despite MPFL reconstruction gaining in popularity, the literature is sparse on outcomes in the athletic

From the Department of Orthopaedics, The Ohio State University, Columbus, Ohio, U.S.A.

The authors report the following potential conflict of interest or source of funding in relation to this article: D.C.F. receives support from Smith & Nephew and Sanofi.

Received February 4, 2014; accepted February 25, 2014.

Address correspondence to David C. Flanigan, M.D., Department of Orthopaedics, The Ohio State University Sports Medicine Center and Cartilage Restoration Program, 2050 Kenny Road, Suite 3100, Columbus, OH 43221, U.S.A. E-mail: david.flanigan@osumc.edu

0749-8063/1489/$36.00

http://dx.doi.org/10.1016/j.arthro.2014.02.044

population. The purpose of this systematic review was to determine the ability of patients to return to activity after MPFL reconstruction or repair for patellar instability. We hypothesized that surgical reconstruction or repair of the MPFL would result in return to the same or higher level of preoperative activity.

Methods

To determine return to preoperative activity after an MPFL procedure for patellar instability, a systematic review of the literature was performed. Return to preoperative activity was defined by the ability to return to the same activity level or better postoperatively measured by the Tegner score.[22] The search was performed on March 13, 2013 and again on March 19, 2013. The following databases were used: PubMed, MEDLINE, SPORTDiscus, and Scopus. The search terms were *patellar instability*, *treatment*, *outcome*, and *sport*. All studies with Level I to Level IV evidence (according to the Oxford Centre for Evidence-Based Medicine used by the American volume of *The Journal of Bone and Joint Surgery*)[23] that met criteria were included. All potential articles were manually reviewed and discussed among the authors. If there was a disagreement among authors regarding inclusion of an article, the senior author made the final decision. In addition, references of selected studies were reviewed for potentially inclusive articles missed by the initial search.

The inclusion criteria included (1) acute or chronic patellar instability defined as dislocation or subluxation, (2) surgical reconstruction or repair of the MPFL or medial retinaculum, (3) studies evaluating return to activity with use of the Tegner score, (4) Level I to Level IV evidence, (5) minimum duration of follow-up of 12 months, (6) English-language studies, and (7) all ages and both sexes.

The exclusion criteria included (1) patellofemoral arthritis seen radiographically, (2) arthroplasty procedures, (3) congenital syndromes associated with ligamentous laxity, (4) a duration of follow-up of less than 12 months, and (5) non—English-language studies.

The initial search of the literature yielded 312 articles. After elimination of articles based on our inclusion and exclusion criteria, a total of 10 articles describing reconstruction or repair of the MPFL or medial retinaculum with return to activity evaluated by the Tegner score as the clinical outcome were reviewed (Fig 1).[24-33]

Paired *t* tests were used to compare preoperative and postoperative mean Tegner scores. The Pearson χ-square test was used for comparisons of dichotomous variables. Comparisons among the preoperative mean Tegner scores for each surgical technique were done using a one-way analysis of variance (with Tukey's post hoc test). This test was repeated to compare mean postoperative Tegner scores. $P < .05$ was considered significant for all comparisons. All statistical analysis was performed using Stata/IC13 (Stata, College Station, TX).

Results

Of the 10 studies examined, there were a total of 402 patients who underwent MPFL repair, MPFL reconstruction, or medial retinacular repair/plication for patellofemoral instability (Table 1). The overall mean age of the patients reviewed was 22.1 years (range, 10 to 52 years). Two hundred forty-four patients had the MPFL reconstructed (60.7%), 91 patients had medial retinacular repair/plication (22.6%), and 67 patients had the MPFL repaired (16.7%). Of those who underwent reconstruction, 177 (72.5%) used an autologous semitendinosus (ST) tendon graft for reconstruction (Table 2). Procedures concomitant with the MPFL reconstruction, MPFL repair, or retinacular repair/plication included 273 knees (67.9%) that underwent lateral retinacular release (LRR), 152 (37.8%) knees that underwent anteromedialization of the tibial tuberosity, 11 knees that had tibial tubercle distalization, 20 knees that had imbrication of the vastus medialis obliquus to the medial retinaculum and MPFL grafts, 14 knees that had loose body removal, and 38 knees that underwent chondral procedures, including chondroplasty and microfracture of full-thickness chondral lesions.

There was no statistical difference ($P = .0773$) between the overall preoperative Tegner score (mean 4.70; 95% confidence interval, 3.61 to 5.79) and postoperative Tegner score (mean, 5.76; 95% CI, 5.10 to 6.42). There was a statistically significant difference ($P = .0077$) in preoperative mean Tegner scores among the 3 treatment groups, with the MPFL repair group having a higher mean score (8.1) than the other 2 groups (MPFL reconstruction, 4.2; medial retinacular repair/plication, 4.2). There was no statistical difference between the postoperative Tegner scores across the 3 treatment groups ($P = .148$). The largest decrease in preoperative to postoperative Tegner score of −2.7 (Table 3) used an MPFL repair technique. The largest increase of 3.5 used an autologous ST tendon graft for MPFL reconstruction.

Three studies reported the mean duration of return to athletic participation, which averaged 5.1 months. Ahmad et al.[24] reported that all patients returned to their previous preoperative athletic participation, with an average return at 4 months after MPFL reconstruction. Drez et al.[27] reported that 14 of 15 patients participated in athletics at the time of injury. Eleven patients returned to the same preinjury activity levels, one of the patients increased their Tegner score by 2 levels, and 2 patients decreased their Tegner score by one level postoperatively. The average return to activity

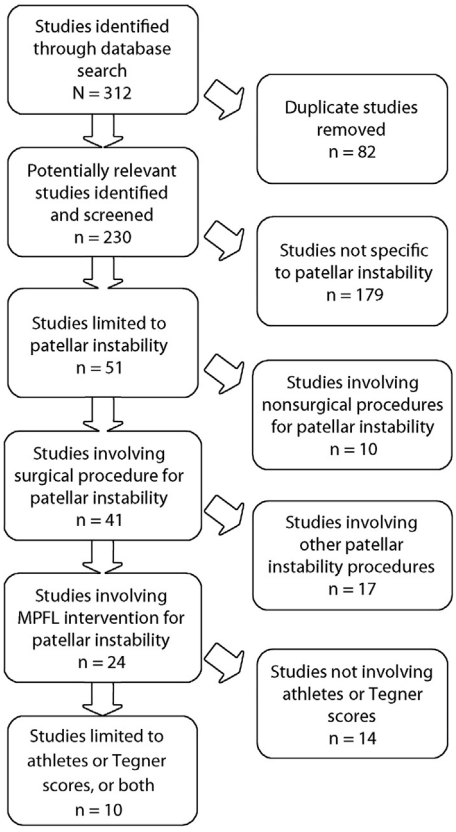

Fig 1. Article exclusion criteria flow chart. (MPFL, medial patellofemoral ligament.)

was 6 months postoperatively. Of the 21 patients in the study of Nelitz et al.,[28] 3 returned to sports at a higher level, 14 returned to their preoperative level, and 4 returned at a lower level than preoperatively. The average time for return to sport was 5.3 months. Ninety percent of patients in the Camp et al.[26] study participated in athletics at the time of injury and all were able to return to sport, although no data were given as to the duration until return to sport.

Forty-nine patients had recurrent instability postoperatively, yielding a 12.2% failure risk. Sixteen patients who underwent MPFL reconstruction had recurrent instability, resulting in a failure risk of 6.6%. Eighteen patients who underwent MPFL repair had recurrent postoperative instability, generating a failure risk of 26.9%. A total of 15 patients who underwent medial retinacular repair/plication reported recurrent instability, producing a failure risk of 16.5%. This difference was statistically significant ($P < .0001$), showing that MPFL reconstruction yielded a lower risk of postoperative instability. Buchner et al.[25] found that patients younger than 15 years of age had a significantly higher redislocation rate than did those older than 15 years. Although not statistically significant, the average age of patients with repeated dislocations after MPFL repair in the study by Camp et al. was 16 years, with a range of 15 to 18 years. The only patient in the study of Drez et al. who had a repeated dislocation was 17 years of age at the time of surgery, with the redislocation occurring 8 months after MPFL reconstruction while the patient was playing basketball. The other studies in this review that reported patients with repeated patellar instability after surgical correction did not specifically report the ages of those who experienced repeated dislocations.

Twenty-five of the 402 knees (6.2%) had complications (other than recurrent patellar instability on the operated knee), as described in Table 3. These complications included patellar fracture, reduced knee flexion, wound complications, removal of screws causing symptoms, hematoma, and pain. Two patellar fractures occurred; one author used a 7.5-mm blind-ended patellar tunnel and another used a 2.5-mm transverse patellar tunnel. Of the 5 patients with limited knee flexion, 3 required a return to the operating room, one for arthrofibrosis necessitating manipulation under anesthesia and 2 with suprapatellar adhesions. The other 2 patients required a more prolonged and aggressive physical therapy regimen. Other causes for return to the operating room were evacuation of a postoperative hematoma (n = 1) and removal of screws causing symptoms from the medial epicondyle (n = 3).

Discussion

Patellar dislocations are common in the young athletic population. This review sought to determine the return to preinjury activity after a surgical procedure on the MPFL or medial retinaculum. The most important finding of this review is that athletes tend to return to preprocedural activity levels after surgical intervention on the MPFL for patellar instability. Furthermore, recurrence is 4 times more common with MPFL repair and 2.5 times more common in medial retinacular repair/plication compared with MPFL reconstruction. The current evidence shows that there is no difference between preoperative and postoperative Tegner activity scores for those undergoing either MPFL reconstruction or repair, indicating these patients return to their previous activity level. Both surgical approaches are effective in returning patients to their previous activities, although failure rates, defined as recurrent patellar instability, are higher among those undergoing repair.

There was no statistical significance when preoperative and postoperative Tegner scores were compared, indicating return to activity near the same level before surgery. Most athletes (90%) returned to a preinjury level of activity or better by an average of 5.1 months. This shows that surgical intervention on the MPFL is effective for patients resuming their previous activities, even those as demanding as athletics. However, given that only 3 of the studies assessed definitive time points for an athlete's return to sport, there is a need for

Table 1. Demographics

Author (Year)	Study Design; Evidence Level	No. of Knees (Male/Female)	Mean Age at Surgery, yr (range)	Mean Follow-up Period (range)	Acute or Recurrent Instability*	Previous Surgery to Correct Patellar Instability†
Ahmad et al.[24] (2009)	Case series; Level IV	21‡ (6/15)	23 (11-43)	31 mo (24-39 mo)	Recurrent (21)	None
Buchner et al.[25] (2005)	Retrospective, comparative; Level III	37 (21/16)	19.9 (10-56)	7.8 yr (2-13 yr)	Acute (37)	None
Camp et al.[26] (2010)	Retrospective, case series; Level IV	29 (14/13)	18.5 (11.3-32.1)	4 yr (2.1-7 yr)	Recurrent (29)	1. LRR (1) 2. LRR with MRR (1) 3. MRR with loose body removal (1)
Drez et al.[27] (2001)	Retrospective, case series; Level IV	15 (10/5)	22 (14-52)	31.5 mo (24-43 mo)	Recurrent (15)	1. Arthroscopic LRR (1)
Nelitz et al.[28] (2013)	Prospective, case series; Level IV	21 (15/6)	12.2 (10.3-13.9)	2.8 yr (2.0-3.6 yr)	Recurrent (21)	1. Medial reefing (2) 2. LRR and medial reefing (2)
Panagopoulos et al.[29] (2008)	Level IV	25 (19/6)	26.9	13 mo	Recurrent (25)	None reported
Schöttle et al.[30] (2006)	Retrospective, comparative; Level III	48 (22/26)	20.7 (13-34)	12 mo	Acute (30) Recurrent (18)	None reported
Steiner et al.[31] (2006)	Retrospective; case series; Level IV	34 (12/22)	27	66.5 mo (24-130 mo)	Recurrent (34)	None
Xie et al.[32] (2012)	Prospective, comparative, randomized; Level II	85 (13/72)	26.4 (16-48)	60 mo	Recurrent (85)	None
Zhao et al.[33] (2012)	Prospective, comparative, randomized; Level II	88 (15/73)	24.5 (16-43)	60 mo	Recurrent (88)	None

LRR, lateral retinacular release; MRR, medial retinacular repair.
*Defined as recurrent dislocations or subluxations.
†Number of patients undergoing procedure in parentheses.
‡One patient lost to follow-up.

further literature to define rehabilitation and time to return to activity in athletes.

Medial patellofemoral ligament reconstruction was used 1.5 times more often than MPFL repair and medial retinacular repair/plication in the included studies, likely resulting from MPFL reconstruction being the more popular technique currently. Of patients undergoing reconstruction, the vast majority had an autologous ST tendon graft. The studies by Panagopoulos et al.[29] and Xie et al.[32] had the largest increase in Tegner scores from preoperatively to postoperatively by using an ST autograft during reconstruction. The largest decrease in Tegner scores reported by Buchner et al.[25] used an MPFL repair technique. This large decrease may result from the characteristics of the study participants; all patients in the study had acute traumatic patellar dislocation. Twenty-seven percent of these patients had recurrence of instability. This is in contrast to the study of Mäenpää and Lehto,[34] who found significantly higher recurrence rates in nontraumatic (38.6%) compared with traumatic (2.4%) patellar dislocations during athletic activity.

The rate of recurrent dislocation in athletes was found to be higher than previously thought and was worse with MPFL repair. Nonoperative management is commonly thought to have a recurrence rate of 15% to 50% after acute patellar dislocations.[35] In a recent systematic review, Shah et al.[36] found that 3.7% of knees experienced redislocation or subluxation after MPFL reconstruction. In contrast, the current review yielded a failure rate of 6.6% in athletes after reconstruction. The higher failure rate may be caused by the more active patient population selected by our inclusion criteria. The recurrence rate for arthroscopic medial retinacular repair/plication was 16.5%. Reports of recurrent instability in the literature based on similar techniques range from 0% to 19%.[37-39] Arendt et al.[40] found that 46% of patients who experienced repeated dislocation after MPFL repair were an average of 4 years younger at the time of surgery than those who did not suffer a redislocation event. The studies in this review are similar in that failure rates tend to occur in the younger population. This may be the result of increased demand on the repair or reconstruction because this patient population tends to be very active.

A large percentage of patients (38%) underwent an anteromedialization procedure in addition to the intervention on the MPFL. Given that this procedure is very different from an isolated MPFL reconstruction, Tegner scores and recurrent instability data would have been valuable to report. Unfortunately, individual data for those undergoing this additional procedure were not provided. However, there is evidence reported by Ebied and El-Kholy[41] showing that anteromedialization performed concomitantly with MPFL reconstruction produces no difference in International Knee Documentation

Table 2. Operative Data

Author (Year)	Surgical Technique	Concomitant Procedures	Postoperative Rehabilitation
Ahmad et al.[24] (2009)	MPFL reconstruction using the docking technique ST allograft (2) Tibialis anterior allograft (2) ST autograft (16)	1. Chondroplasty (7) 2. LRR (12) 3. Imbrication of the VMO to medial retinaculum and MPFL graft (20)	1. Weight bearing with knee brace locked in full extension for 6 wk 2. Quadriceps muscle strengthening initiated immediately 3. Active and passive ROM exercises at 2 wk postoperatively 4. Quadriceps, hamstring, and hip muscle strengthening at 6 wk 5. Running and agility training after 12 wk 6. Return to full athletic participation 4 mo postoperatively
Buchner et al.[25] (2005)	MPFL repair medial patellar ligament complex with realignment of the patella (37)	1. LRR (37) 2. Osteochondral fragment removal (8) 3. Chondral fragment removal (2)	1. Mobilized with patella-stabilizing orthosis for 4 wk 2. Full axial weight bearing and free ROM as soon as tolerated
Camp et al.[26] (2010)	Isolated MPFL repair Reattachment with suture anchors into femoral origin (7) Repair with 2 suture anchors at avulsed patellar insertion site (8) Anchors placed in both the patellar and femoral attachment sites (7) Ligamentous reefing without the use of anchors (7)	1. LRR (1) 2. Debridement of partial-thickness chondral lesion (13) 3. Microfracture for full-thickness chondral lesion (6) 4. Loose body removal (14)	First 6 wk: 1. Partial weight bearing using knee immobilizer and crutches 2. Active flexion and passive extension knee ROM 3. Straight leg raises and quadriceps sets After 6 wk: 1. Crutches and immobilizer discontinued 2. Progressive resistance quadriceps strengthening
Drez et al.[27] (2001)	MPFL reconstruction IT band autograft (3) ST tendon autograft (6) ST and gracilis tendon autograft (5) MPFL repair (1)	1. LRR (15)	1. Knee in compression dressing and knee immobilizer for first 2 wk 2. Straight leg raises and quadriceps sets at 2 wk 3. ROM exercises and weight bearing as tolerated at 3 wk 4. Full activity permitted with return of full ROM and normal quadriceps strength (about 6 mo postoperatively)
Nelitz et al.[28] (2013)	Anatomical, physeal-sparing MPFL reconstruction using autogenous gracilis tendon (21)	1. Microfracture for full-thickness chondral lesion (2)	1. Partial weight bearing using crutches 2. Daily PT with active and passive flexion and extension exercises, strengthening of vastus medialis muscle, and straight leg raises for 15 min 4 times/d 3. Full weight bearing at 2 wk 4. Return to sport allowed at 3 mo postoperatively 5. Average return to sports was 5.3 mo (4-12) postoperatively
Panagopoulos et al.[29] (2008)	MPFL reconstruction using ST tendon autograft fixed to the superomedial pole of the patella (25)	None reported	1. Hinge knee brace with partial weight bearing for 6 wk except when brace locked in full extension 2. Continuous passive ROM of knee by first postoperative visit 3. Knee flexion limited to 45° for first 3 wk postoperatively 4. Knee flexion progressed to 90° over next 3 wk 5. Neoprene patellar brace applied for another 4-6 wk 6. Rehabilitation with a physiotherapist aims to return patient to preinjury level of activity 16-20 wk postoperatively

(continued)

Table 2. Continued

Author (Year)	Surgical Technique	Concomitant Procedures	Postoperative Rehabilitation
Schöttle et al.[30] (2006)	Arthroscopic medial retinacular repair with reefing of the capsule to the periosteum of the medial patellar edge	1. Arthroscopic LRR (35)	1. Partial weight bearing with crutches for first wk 2. Progressive mobilization 3. ROM restricted to flexion of 60° 3 wk postoperatively 4. ROM restricted to flexion of 90° for an additional 3 wk 5. Soft brace (lateral "J") worn for 6 wk to remove stress from sutures and prevent premature scarring of the LRR
Steiner et al.[31] (2006)	MPFL reconstruction Adductor magnus tendon autograft (23) Bone–quadriceps tendon autograft (6) Bone–patellar tendon allograft (5)	None	1. Continuous passive motion machine from 0° to 60° 2. Full weight bearing and active exercises 3. Knee immobilizer during gait for 4 wk until quadriceps function and knee motion returned to normal
Xie et al.[32] (2012)	MPFL reconstruction using ST tendon autograft With polyester suture augmentation (42) Without polyester suture augmentation (43)	1. Anteromedial TT transfer* (74) 2. TT distalization† (4) 3. LRR (85)	1. Partial to full weight bearing immediately after operation 2. ROM exercises with knee flexion restricted to 45°, 90°, and 120° in the first, second, and third 2-wk periods postoperatively 3. Hinged brace used for 6 wk and locked in extension while walking 4. Straight leg raises, vastus medialis muscle exercises, and proprioception training at 6 wk postoperatively 5. Running and agility training at 4 mo postoperatively
Zhao et al.[33] (2012)	Arthroscopic medial retinaculum plication (43) MPFL reconstruction using ST tendon autograft (45)	1. Anteromedial TT transfer* (78) 2. TT distalization† (7) 3. LRR (88)	1. Partial to full weight bearing immediately after operation 2. ROM exercises with knee flexion restricted to 45°, 90°, and 120° in the first, second, and third 2-wk periods postoperatively 3. Hinged brace used for 6 wk and locked in extension while walking 4. Straight leg raises, vastus medialis muscle exercises, and proprioception training at 6 wk postoperatively 5. Running and agility training at 4 mo postoperatively

IT, iliotibial band; LRR, lateral retinacular release; MPFL, medial patellofemoral ligament; PT, physical therapy; ROM, range of motion; ST, semitendinosus; TT, tibial tubercle.

*Indications were TT-TG distance greater than 15 mm.

†Indications were patellar-trochlear distance greater than 5 mm.

Committee scores postoperatively when compared with isolated MPFL reconstruction.

Limitations

A marked limitation of the current review is the small number of high-level evidence studies included. Only 2 studies reported Level II evidence with randomized controlled trials,[32,33] 2 studies were retrospective comparative studies of Level III evidence,[25,30] and the remaining 6 studies reported case series of Level IV evidence.[24,26-29,31] Other limitations to this review exist because of lack of homogeneous reporting among studies. Some of the studies reported failures as redislocations only, whereas other studies included multiple episodes of instability, including subluxations, as failures. This may result in more failures than expected across these studies. Although Tegner scores were used as a functional outcome measure in all included studies, only a few reported the actual activities patients were participating in at the time of injury and the ones they returned to postoperatively. This would be useful to report in future studies because rehabilitation can be tailored to the activities that result in higher dislocation rates. Also, preinjury Tegner scores are reflective and subjective measures that may not be completely accurate.

Conclusions

Contrary to our hypothesis, recurrent dislocation was higher in patients who underwent MPFL repair rather

Table 3. Outcomes

Author (Year)	Mean Tegner Scores		Recurrent Episodes of Instability*/Repeated Surgery	Other Postoperative Complications
	Preoperative	Postoperative		
Ahmad et al.[24] (2009)	3.6	5.6	0/0	1. Knee stiffness that resolved after 4 mo of aggressive PT (1)
Buchner et al.[25] (2005)	7.5	4.8	10/2	None reported
Camp et al.[26] (2010)	6.9	6.6	8/5	None reported
Drez et al. (2001)	6.8	6.7	1/0	1. Arthrofibrosis requiring MUA/remaining flexion loss (1) 2. Superficial wound dehiscence (1)
Nelitz et al.[28] (2013)	6.0	5.8	0/0	1. Prolonged rehabilitation because of reduced flexion 6 wk postoperatively (1) 2. Pain during vigorous activities (4)
Panagopoulos et al.[29] (2008)	4.2	7.7	0/0	1. Patellar fracture (1)
Schöttle et al.[30] (2006)	5.5	4.8	4/2	1. Suprapatellar adhesions that limited full flexion, requiring reoperation (2)
Steiner et al.[31] (2006)	3.1	5.1	0/0	1. Evacuation of a postoperative hematoma (1) 2. Graft advancement after loosening in an MVA (1) 3. Elective removal of a screw causing symptoms at the medial epicondyle (3)
Xie et al. (2006)	3.3, 3.5†	6.8, 5.5†	1, 10†/0, 1†	1. Operation for ankle instability (1) 2. Patellar instability of contralateral leg (4)
Zhao et al.[32] (2012)	2.9, 3.1‡	4.0, 5.7‡	11, 4‡/1, 0‡	1. Patellar fracture from drill hole (1) 2. ACL injury requiring reconstruction (1) 3. Patellar instability of contralateral leg (2)

ACL, anterior cruciate ligament; MPFL, medial patellofemoral ligament; MUA, manipulation under anesthesia; MVA, motor vehicle accident; PT, physical therapy.

*Defined as recurrent episode of dislocation or subluxation, or both.

†Augmentation group, nonaugmentation group.

‡Medial retinaculum plication, MPFL reconstruction.

than reconstruction. However, repair and reconstruction had similar Tegner scores. Repair or reconstruction of the soft tissue structures contributing to patellofemoral instability is successful in returning patients to preinjury activity levels.

References

1. Atkin DM, Fithian DC, Marangi KS, Stone ML, Dobson BE, Mendelsohn C. Characteristics of patients with primary acute lateral patellar dislocation and their recovery within the first 6 months of injury. *Am J Sports Med* 2000;28:472-479.
2. Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute patellar dislocation. *Am J Sports Med* 2004;32:1114-1121.
3. Waterman BR, Belmont PJ Jr, Owens BD. Patellar dislocation in the United States: Role of sex, age, race, and athletic participation. *J Knee Surg* 2012;25:51-57.
4. Arendt EA, Fithian DC, Cohen E. Current concepts of lateral patella dislocation. *Clin Sports Med* 2002;21:499-519.
5. Cash JD, Hughston JC. Treatment of acute patellar dislocation. *Am J Sports Med* 1988;16:244-249.
6. Hinton RY, Sharma KM. Acute and recurrent patellar instability in the young athlete. *Orthop Clin North Am* 2003;34:385-396.
7. Nikku R, Nietosvaara Y, Kallio PE, Aalto K, Michelsson JE. Operative versus closed treatment of primary dislocation of the patella. Similar 2-year results in 125 randomized patients. *Acta Orthop Scand* 1997;68:419-423.
8. Abramov M, Stock H. Lateral patellar dislocation: Mechanism of disease, radiographic presentation, and management. *Conn Med* 2013;77:235-238.
9. Nikku R, Nietosvaara Y, Aalto K, Kallio PE. The mechanism of primary patellar dislocation: Trauma history of 126 patients. *Acta Orthop* 2009;80:432-434.
10. Bicos J, Fulkerson JP, Amis A. Current concepts review: The medial patellofemoral ligament. *Am J Sports Med* 2007;35:484-492.
11. Philippot R, Chouteau J, Wegrzyn J, Testa R, Fessy MH, Moyen B. Medial patellofemoral ligament anatomy: Implications for its surgical reconstruction. *Knee Surg Sport Traumatol Arthrosc* 2009;17:475-479.
12. Amis AA, Firer P, Mountney J, Senavongse W, Thomas NP. Anatomy and biomechanics of the medial patellofemoral ligament. *Knee* 2003;10:215-220.
13. Conlan T, Garth WP Jr, Lemons JE. Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee. *J Bone Joint Surg Am* 1993;75:682-693.
14. Desio SM, Burks RT, Bachus KN. Soft tissue restraints to lateral patellar translation in the human knee. *Am J Sports Med* 1998;26:59-65.
15. Hautamaa PV, Fithian DC, Kaufman KR, Daniel DM, Pohlmeyer AM. Medial soft tissue restraints in lateral

patellar instability and repair. *Clin Orthop Relat Res* 1998: 174-182.
16. Feller JA, Feagin JA Jr, Garrett WE Jr. The medial patellofemoral ligament revisited: An anatomical study. *Knee Surg Sport Traumatol Arthrosc* 1993;1:184-186.
17. Nomura E, Inoue M, Osada N. Anatomical analysis of the medial patellofemoral ligament of the knee, especially the femoral attachment. *Knee Surg Sport Traumatol Arthrosc* 2005;13:510-515.
18. Smirk C, Morris H. The anatomy and reconstruction of the medial patellofemoral ligament. *Knee* 2003;10:221-227.
19. Stefancin JJ, Parker RD. First-time traumatic patellar dislocation: A systematic review. *Clin Orthop Relat Res* 2007;455:93-101.
20. Arendt EA. MPFL reconstruction for PF instability. The soft (tissue) approach. *Orthop Traumatol Surg Res* 2009;95: S97-S100.
21. Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: An anatomic radiographic study. *Knee Surg Sport Traumatol Arthrosc* 1994;2:19-26.
22. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res* 1985: 43-49.
23. Obremskey WT, Pappas N, Attallah-Wasif E, Tornetta P III, Bhandari M. Level of evidence in orthopaedic journals. *J Bone Joint Surg Am* 2005;87:2632-2638.
24. Ahmad CS, Brown GD, Stein BS. The docking technique for medial patellofemoral ligament reconstruction: Surgical technique and clinical outcome. *Am J Sports Med* 2009;37:2021-2027.
25. Buchner M, Baudendistel B, Sabo D, Schmitt H. Acute traumatic primary patellar dislocation: Long-term results comparing conservative and surgical treatment. *Clin J Sport Med* 2005;15:62-66.
26. Camp CL, Krych AJ, Dahm DL, Levy BA, Stuart MJ. Medial patellofemoral ligament repair for recurrent patellar dislocation. *Am J Sports Med* 2010;38:2248-2254.
27. Drez D Jr, Edwards TB, Williams CS. Results of medial patellofemoral ligament reconstruction in the treatment of patellar dislocation. *Arthroscopy* 2001;17: 298-306.
28. Nelitz M, Dreyhaupt J, Reichel H, Woelfle J, Lippacher S. Anatomic reconstruction of the medial patellofemoral ligament in children and adolescents with open growth plates: Surgical technique and clinical outcome. *Am J Sports Med* 2013;41:58-63.
29. Panagopoulos A, van Niekerk L, Triantafillopoulos IK. MPFL reconstruction for recurrent patella dislocation: A new surgical technique and review of the literature. *Int J Sports Med* 2008;29:359-365.
30. Schöttle PB, Scheffler SU, Schwarck A, Weiler A. Arthroscopic medial retinacular repair after patellar dislocation with and without underlying trochlear dysplasia: A preliminary report. *Arthroscopy* 2006;22:1192-1198.
31. Steiner TM, Torga-Spak R, Teitge RA. Medial patellofemoral ligament reconstruction in patients with lateral patellar instability and trochlear dysplasia. *Am J Sports Med* 2006;34:1254-1261.
32. Xie G, Zhao J, Huangfu X, He Y. Medial patellofemoral ligament reconstruction using semitendinosus tendons: Polyester suture augmentation versus nonaugmentation. *Am J Sports Med* 2012;40:1365-1374.
33. Zhao J, Huangfu X, He Y. The role of medial retinaculum plication versus medial patellofemoral ligament reconstruction in combined procedures for recurrent patellar instability in adults. *Am J Sports Med* 2012;40: 1355-1364.
34. Mäenpää H, Lehto MU. Surgery in acute patellar dislocation—evaluation of the effect of injury mechanism and family occurrence on the outcome of treatment. *Br J Sports Med* 1995;29:239-241.
35. White BJ, Sherman OH. Patellofemoral instability. *Bull NYU Hosp Jt Dis* 2009;67:22-29.
36. Shah JN, Howard JS, Flanigan DC, Brophy RH, Carey JL, Lattermann C. A systematic review of complications and failures associated with medial patellofemoral ligament reconstruction for recurrent patellar dislocation. *Am J Sports Med* 2012;40:1916-1923.
37. Halbrecht JL. Arthroscopic patella realignment: An all-inside technique. *Arthroscopy* 2001;17:940-945.
38. Sillanpaa PJ, Mäenpää HM, Mattila VM, Visuri T, Pihlajamaki H. Arthroscopic surgery for primary traumatic patellar dislocation: A prospective, nonrandomized study comparing patients treated with and without acute arthroscopic stabilization with a median 7-year follow-up. *Am J Sports Med* 2008;36:2301-2309.
39. Haspl M, Cicak N, Klobucar H, Pecina M. Fully arthroscopic stabilization of the patella. *Arthroscopy* 2002;18:E2.
40. Arendt EA, Moeller A, Agel J. Clinical outcomes of medial patellofemoral ligament repair in recurrent (chronic) lateral patella dislocations. *Knee Surg Sport Traumatol Arthrosc* 2011;19:1909-1914.
41. Ebied AM, El-Kholy W. Reconstruction of the medial patello-femoral and patello-tibial ligaments for treatment of patellar instability. *Knee Surg Sport Traumatol Arthrosc* 2012;20:926-932.