Postoperative Bracing after Medial Patellofemoral Ligament Reconstruction

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Abstract

It is unclear if bracing is necessary after isolated medial patellofemoral ligament reconstruction (MPFLr) for recurrent patellar instability. We hypothesize that patients who did not use a brace will have similar outcomes to those who were braced postoperatively. A retrospective review of patients who underwent isolated MPFLr from January 2015 to September 2020 at a single institution was performed. Those with less than 6 weeks of follow-up were excluded. The braced group was provided a hinged-knee brace postoperatively until the return of quadriceps function, which was determined by the treating physical therapist (brace, "B"; no brace, "NB"). Time to straight leg raise (SLR) without lag, recurrent instability, and total re-operations were determined. Univariate analysis and logistic regression were used to evaluate outcomes (statistical significance, $p < 0.05$). Overall, 229 isolated MPFLr were included (B: 165 knees, 146 patients; NB: 64 knees, 58 patients). Baseline demographics were similar (all $p > 0.05$). Median time to SLR without lag was shorter in the NB group (41 days [interquartile range [IQR]: 20–47] vs. 44 days [IQR: 35.5–88.3], $p = 0.01$), while return to sport times were equivalent (B: 155 days [IQR: 127.3–193.8] vs. NB: 145 days [IQR: 124–162], $p = 0.31$). Recurrent instability rates were not significantly different (B: 12 knees [7.27%] vs. NB: 1 knee [1.56%], $p = 0.09$), but the re-operation rate was higher in the brace group (20 knees [12.1%] vs. 0 [0%], $p = 0.001$). Regression analysis identified brace use (odds ratio [OR]: 19.63, 95% confidence interval [CI]: 1.43–269.40, $p = 0.026$) and female patients (OR: 2.79, 95% CI: 1.01–7.34, $p = 0.049$) to be associated with needing reoperation. Recurrent instability rates and return to sport times were similar between patients who did or did not use a hinged knee brace after isolated MPFLr. Re-operation rates were higher in the braced group. Retrospective Comparative Study, Level III

Keywords
- patellar instability
- MPFL reconstruction
- bracing
- rehabilitation

Patellofemoral instability (PFI) often occurs in the setting of symptomatic deficiency or laxity of soft tissue constraints that, when combined with a displacing force, causes the patella to subluxate or dislocation laterally out of the trochlear groove.[1] Patellar subluxation and dislocations are some of the most common knee injuries among skeletally immature athletes.[2–4] Medial patellofemoral ligament reconstruction (MPFLr) may be indicated in patients with either first-time or recurrent PFI events (more than one dislocation) who fail nonoperative treatment and have evidence of MPFL injury.[5,6] A recent

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systematic review and meta-analysis of patients who underwent isolated MPFLr demonstrated that patients achieve good outcomes, with high pooled Kujala pain scores (85.8, 95% confidence interval [CI]: 81.6–90.0) and return-to-play rates (84.1%) and a low pooled rate of recurrent instability (1.2%).[3]

Achieving successful postoperative outcomes not only depends on meticulous surgical technique but also adherence to an appropriate postoperative rehabilitation protocol.[7] Reviews of clinical outcomes after MPFLr demonstrate that there is wide variability in rehabilitation protocols with respect to early postoperative knee bracing, range of motion (ROM), and weight bearing.[7–11] The majority of surgeons prefer the use of a postoperative knee brace combined with an assistive device for early ambulation.[12] Knee bracing protocols range from the use of a compressive bandage for 1 to 2 weeks to the use of a hinged knee brace (HKB) locked in extension for 6 weeks.[9,12] To protect the MPFLr graft early after surgery, activities that risk axial rotation of the knee, specifically valgus forces with femoral internal rotation, need to be avoided. However, since the MPFL is unaffected by axial loading, some authors suggest that there is no evidence for weight-bearing limitations.[9,13]

Given the variability in rehabilitation protocols and unclear evidence for postoperative bracing after MPFLr, studies comparing outcomes of patients who did or did not use a brace after surgery are needed. The purpose of this study is to compare early postoperative recovery in patients who did or did not use a HKB after MPFLr. We hypothesize that patients who did not use a brace will have similar outcomes to patients who were braced postoperatively.

Materials and Methods

This study was approved by the Institutional Review Board at the University of Iowa. A retrospective review of all patellar-stabilizing procedures from a single institution between January 2015 and September 2020 was performed. Patients were identified from a prospectively collected patellofemoral instability registry and separate medical record review. Those who underwent isolated MPFLr and had a minimum 6 weeks of follow-up were included. Patients who underwent concomitant cartilage resurfacing, tibial tubercle osteotomy, lateral retinacular release, or MPFL repair and those with less than 6 weeks of follow up were excluded (►**Fig. 1**).

MPFLr was performed by four board-certified orthopaedic surgeons fellowship trained in sports medicine. Two groups were created based on the use of postoperative bracing, which was assigned per the treating surgeons' preference—three staff surgeons routinely braced all MPFLr, while the remaining surgeons did not use a brace in the setting of an isolated MPFLr. When utilized, bracing consisted of a standard HKB initially locked in extension during ambulation with either full ROM or 0 to 90 degrees of motion when seated. Patients were permitted to weight bear as tolerated immediately after surgery. Range of motion during ambulation was progressed after 2 weeks postoperatively at the discretion of the treating physical therapist based on evaluation of quadriceps control. The brace was discontinued by the treating physical therapist after patients regained quadriceps function. All patients who did not use a brace were allowed to fully weight bear with unrestricted range-of-motion allowed immediately after surgery. Bracing was categorized as brace, "B," and no brace, "NB" (►**Table 1**).

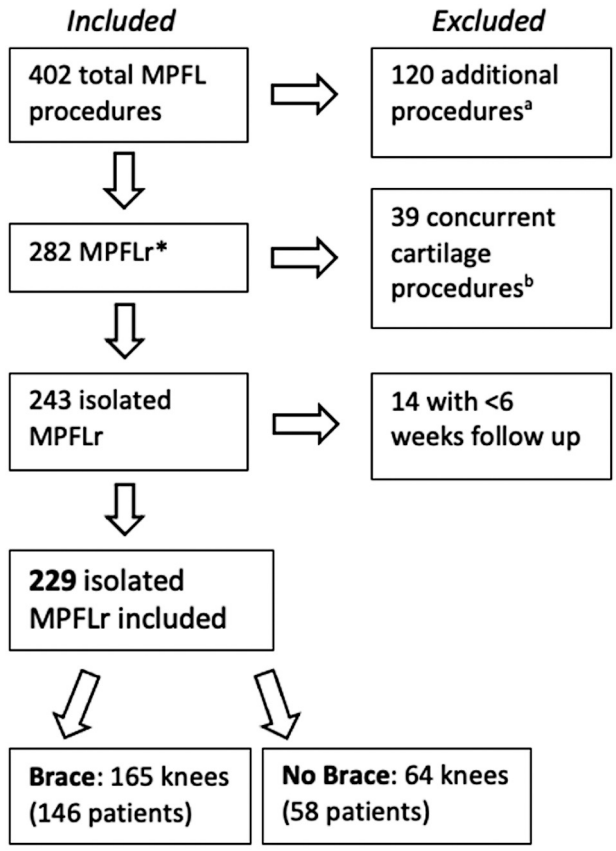

Fig. 1 Flowchart of included patients. MPFLr, medial patellofemoral ligament reconstruction.
[a]Additional procedures, tibial tubercle osteotomies, lateral retinacular releases, MPFL repair.
[b]Cartilage procedures, microfracture, biocartilage resurfacing, osteochondral fragment fixation.

Primary outcomes of interest were recurrent patellar instability events, defined as patient-reported subluxation or dislocation, and reoperation rates. Additionally, functional outcomes, including time to straight leg raise (SLR) without lag and time to surgeon clearance for return to sport (RTS), were collected from postoperative clinic notes. All surgeons saw patients at 2 weeks, 6 weeks, and 12 weeks after surgery and then again at 4 to 6 months. The corresponding dates which patients achieved an SLR without lag and full clearance to RTS were documented. For patients who underwent bilateral surgeries within 6 months, only the date after the second surgery was used for analysis.

Surgical Technique

All patients who underwent MPFLr were diagnosed preoperatively with recurrent patellar instability, defined as more than one patellar instability event, and had exhausted appropriate nonoperative treatment including rest, activity modification, and physical therapy. A standard diagnostic arthroscopy to evaluate for additional intra-articular

Table 1 Postoperative bracing protocols after medial patellofemoral ligament reconstruction

Bracing protocol (B)	No brace protocol (NB)
- Hinged knee brace locked in extension during ambulation - Full or 0–90 degrees ROM when seated - Weight bearing as tolerated immediately after surgery - ROM during ambulation progressed at 2 weeks postoperation with physical therapist - Brace discontinued at 4–6 wk or when quadriceps strength returned (discontinued by PT)	- Weight bearing as tolerated immediately after surgery - Full range of motion when seated - ROM during ambulation progressed at 2 wk postoperation with physical therapist

Abbreviations: PT, physical therapist; ROM, range-of-motion.

pathology was performed at the time of surgery. The MPFLr technique included an incision over the medial aspect of the patella. Layers 1 and 2 were incised off the medial border of the patella and capsular layer 3 was identified. The medial aspect of the patella was cleared of soft tissue, and two suture anchors spread over the MPFL footprint on the patella were placed for graft fixation. Fluoroscopy was then used to identify Schottle's point on a perfect lateral image of the affected knee. A separate incision over the medial epicondyle was made, and dissection was performed down to the bone. In the majority of cases, Schottle's point was again localized fluoroscopically to place a guide pin, which was then over-reamed to a size matching the diameter of the folded graft. The apex of the folded graft was inserted into the femoral socket and secured with a biocomposite interference screw. Alternatively, in two patients, suture anchors were placed at Schottle's point for femoral fixation to avoid injury to the immature femoral physis. In another small subset of skeletally immature patients, the graft was looped around the adductor tendon at its distal insertion on the femur and secured to the adductor tendon with sutures only (►**Table 2**). In all cases, the free limbs of the graft were then shuttled anteriorly to the prepared medial patella between layers 2 and 3, and the graft was sutured in place using the previously placed patellar anchors. Graft fixation to the patella was performed with the knee in 30 to 45 degrees of flexion to allow patellar reduction in the trochlear groove and prevent overtensioning of the graft. Per surgeon preference, the MPFL remnant was not repaired and distal vastus medialis oblique was not advanced. The wounds were irrigated and closed in layers.

Statistical Analysis

Descriptive statistics were performed. Continuous variables were evaluated for normality with the Shapiro–Wilk test and through the evaluation of histograms. Continuous variables (age, body mass index (BMI), SLR time, and return to sport time) were not normally distributed and were described using median and interquartile range (IQR). Categorical data were described as frequencies and percentages. Differences in demographic variables, procedure variables, and postoperative outcomes were compared between bracing groups using an independent sample median test for continuous variables and a chi-square test for categorical variables. Logistic regression was used to model the relationship between the odds of developing postoperative instability and preoperative patient and operative factors. Factors that were included were age $<$ versus $\geq$18 years, female versus male sex, overweight (BMI $\geq$25 kg/m^2) versus normal weight, use of brace versus no brace, athlete versus nonathlete, revision versus primary surgery, and use of autograft versus allograft. The same methods were applied for the

Table 2 Comparison of procedure data between bracing groups

# of Knees	All ($n=229$)	B ($n=165$)	NB ($n=64$)	p-Value[a]
Primary MPFLr	223 (97.3)	161 (97.6)	62 (95.5)	0.59
Operative side[b]	117 (51.1)	86 (51.5)	32 (50)	0.84
Graft				
Autograft	50 (21.8)	42 (25.5)	8 (12.5)	**0.04**
Allograft	179 (78.4)	123 (74.4)	56 (87.5)	
Femoral fixation				
Int. Screw	211 (92.1)	148 (89.7)	64 (100)	$<$0.001
Suture only	15 (6.6)	15 (9.09)	–	
Suture anchor	2	2		

Abbreviations: B, brace; MPFLr, medial patellofemoral ligament reconstruction; NB, no brace.
Note: Data presented as # (%).
[a]B vs. NB.
[b]Right-sided surgeries.
Bold terms indicate statistical significance with $p<0.05$.

Table 3 Patient demographics

Knees (*n*)	All (*n* = 229)	B (*n* = 165)	NB (*n* = 64)	*p*-Value[a]
Age[a] (years)	16 (14–20)	16 (14–21)	16.5 (15–20)	0.92
Males (*n*, %)	106 (46.3)	80 (48.5)	26 (40.6)	0.28
Body mass index[b] (kg/m^2)	25 (21.5–30.0)	24.5 (21.3–29.5)	26.1 (22.2–31.0)	0.17
Race (*n*, %)				
Caucasian	203 (88.6)	146	57	0.90
African American	13	7	6	
Hispanic	6	6	0	
Other	7	6	1	
Smoker (*n*,%)	11 (4.80)	10 (6.06)	1 (1.56)	0.07
Athlete (*n*,%)	119 (51.9)	85 (51.5)	34 (53.1)	0.83
Jr High School	12	10	2	
High School	98	68	29	
College	4	4	0	
Recreational	5	2	3	

Abbreviations: B, brace; NB, no brace.
[a]B vs. NB.
[b]Data presented as median (interquartile range, IQR).

reoperation outcome, but with Firth penalized likelihood instead of maximum likelihood to account for complete separate in the revision versus primary predictor variable. The significance level was set at $p = 0.05$. Statistical analysis was performed with Excel v.16.43 (Microsoft Inc., Redmond, WA) and SAS statistical software version 9.4 (SAS Institute, Inc., Cary, NC).

Results

Patient Demographics

There were 402 MPFL-related procedures reviewed. In total, 159 knees undergoing concomitant procedures and 14 knees with less than 6 weeks of follow-up were excluded, leaving 229 isolated MPFLr available for analysis (►**Fig. 1**). Overall, 169 patients (82.8%) had ≥6 months postoperative follow-up (B: 121 [83.6%] vs. NB: 48 [82.7%], $p = 0.5515$). The median age at the time of surgery was 16 (IQR, 14–20) and the median BMI was 25 (IQR, 21.5–30.0; ►**Table 3**).

Procedure Data

Graft selection, specifically the use of autograft, significantly differed between bracing groups (autograft, B, 25.5 vs. NB, 12.5%, $p = 0.037$). Patellar fixation was performed with suture anchors in all cases. In 15 cases, the femoral insertion of the graft was looped around the adductor tendon and sutured in place, while in two cases, suture anchors were utilized for femoral fixation. The remaining cases all utilized biocomposite interference screws for femoral graft fixation (►**Table 2**). In the B group, 28 knees (17%) received concomitant procedures that did not meet exclusion criteria, including 15 loose body removals, 11 partial meniscectomies, and 2 heterotopic ossification excisions. In the NB group, 18 knees (28%) received concomitant procedures, including 9 loose body removals, 7 partial meniscectomies, 1 heterotopic ossification excision, and 1 hardware removal.

Time to Straight Leg Raise without Lag and Return to Sport

In total, 89.1% of knees had data indicating when patients were able to perform SLR without lag (204/229 knees: B 88.5% vs. NB 90.6%, $p = 0.64$). Median time to performing an SLR without lag was significantly shorter in patients who did not wear a knee brace postoperatively (NB: 41 [IQR: 20–47] vs. B: 44 [IQR: 35.5–88.3] days, $p = 0.01$).

There were 106 patients (B: 75/146 [51.4%] vs. NB: 31/58 [53.4%], $p = 0.79$) who indicated that they participated in sports prior to surgery. Overall, 84.0% of these patients were cleared to return to their desired sport after surgery. The mean overall time to surgeon clearance to RTS was 158.7 ± 49.6 days (5.3 months). In total, 66 of 75 athletes (88.0%) in the B group were eventually cleared for RTS, compared with 24 of 31 athletes (77.4%) in the NB group ($p = 0.17$). Median time to RTS in the B group was 155 days (IQR: 127.3–193.8 days; 5.2 months) vs. 145 days (IQR: 124–162 days; 4.8 months) in the NB group ($p = 0.31$; ►**Table 4**).

Recurrent Instability and Revisions

In the B group, there were 12 (7.27%) recurrent instability events, compared with 1 event (1.56%) in the NB group, although this difference did not reach statistical significance ($p = 0.09$). Six of these patients in the brace group underwent revision MFPLr for recurrent instability. In total, there were 20 patients in the brace group who underwent either revision MPFLr ($n = 10$) or other reoperations ($n = 10$) (B: 20/165 [12.1%] vs. NB: 0/64, $p = 0.001$; ►**Table 5**).

Results of logistic regression analyses showed the odds of experiencing postoperative instability were greater in

Table 4 Return to sport after MPFLr

Patients	B ($n = 146$)	NB ($n = 58$)	*p*-Value
Athletes, *n* (%)	75 (51.4)	31 (53.4)	0.79
Athletes cleared to RTS, *n* (%)	66 (88.0)	24 (77.4)	0.17
RTS time	155 d [IQR, 127.3–193.8 d] (5.2 mo)	145 d [IQR, 124–162 d] (4.8 mo)	0.31

Abbreviations: B, brace; IQR, interquartile range; MPFLr, medial patellofemoral ligament reconstruction; NB, no brace; RTS, return to sport.

Table 5 Indications for revision and reoperation procedures in the brace group

Revision MPFLr ($n = 10$, 6.06%)	Reoperations ($n = 10$, 6.06%)
- 6 recurrent instability (4 dislocations, 2 subluxations)	- 4 prominent femoral screw removals
- 2 MPFL graft tears (injuries/trauma)	- 2 irrigation and debridement procedures (1 infection, 1 persistent effusion/hematoma)
- 1 persistent knee pain (loose body)	- 3 persistent knee pain (repeat arthroscopy; MPFL grafts intact)
- 1 femoral insertion anchor failure (in skeletally immature patient)	- 1 stiffness (manipulation under anesthesia)

Abbreviation: MPFLr, medial patellofemoral ligament reconstruction.

revision vs primary MPFLr in both univariate (odds ratio [OR]: 9.64, 95%CI 1.59–58.43, $p = 0.014$) and multivariate models (OR: 11.34 95%CI: 1.59–80.97, $p = 0.016$; ►**Table 6**). Similarly, the odds of needing reoperation were significantly increased in revision versus primary MPFLr (15.32, 95%CI: 1.82–129.06, $p = 0.0120$) in the multivariate model. In the same model, the odds of reoperation were also greater in patients who wore versus who didn't wear a brace postoperatively (OR: 19.63, 95%CI: 1.43–269.40, $p = 0.026$) and in female versus male patients (OR: 2.79, 95%CI: 1.01–7.34, $p = 0.0487$; ►**Table 7**).

Discussion

The results of this study show that patients who did not use a postoperative HKB required significantly fewer repeat surgeries and did not experience more recurrent instability events. Patients who did not wear a knee brace were able to perform SLR without lag approximately 2 weeks sooner than those who used a brace. They were also cleared to return to sport at a similar rate and time compared with patients in the brace group. Additionally, all reoperation procedures (revision MPFLr plus other surgeries) were in patients who wore a brace after surgery, and thus, the odds of needing reoperation were significantly increased in these patients. These results partially confirm our hypothesis—patients who were not braced after isolated MPFLr achieved quicker return of SLR without lag and experienced lower reoperation rates, but time to full clearance to RTS was similar to braced patients.

Multiple risk factors for patellar instability exist, and consequently, multiple surgical interventions have been described. Patients with patella alta, trochlear dysplasia, or increased tibial tubercle-trochlear groove (TT-TG) distance may require concomitant procedures like tibial tubercle osteotomy or trochleoplasty. However, in the absence of significant bony malalignment or deformity, isolated MPFLr has demonstrated acceptable outcomes with low failure rates.[14] In the present study, there were 13 total recurrent instability events reported (5.7%), with six patients

Table 6 Binary logistic regression analysis of odds of postoperative instability after isolated MPFLr

Multivariate model				
Effect	OR	95% Confidence limits		*p*-Value
Age < 18 yr	1.212	0.265	5.547	0.80
Female sex	1.100	0.332	3.646	0.88
BMI ≥25 kg/m^2	1.579	0.464	5.370	0.46
Athlete (vs. nonathlete)	1.817	0.448	7.376	0.40
Autograft (vs. allograft)	1.158	0.279	4.818	0.84
Revision MPFLr	11.337	1.587	80.970	0.02
Use of brace (vs. no brace)	2.572	0.520	12.737	0.25

Abbreviations: BMI, body mass index; MPFLr, medial patellofemoral ligament reconstruction; OR, odds ratio.
Note: Postoperative instability defined as subluxation + redislocation.

Table 7 Binary logistic regression analysis of odds of the need for reoperation after isolated MPFLr

Multivariate model				
Effect	OR	95% confidence limits		*p*-Value
Age < 18 yr	0.646	0.209	1.992	0.45
Female sex	2.789	1.006	7.734	0.05
BMI $\geq 25\,kg/m^2$	1.322	0.510	3.424	0.57
Athlete (vs. nonathlete)	1.764	0.559	5.563	0.33
Autograft (vs. allograft)	1.541	0.502	4.736	0.45
Revision MPFLr	15.305	1.815	129.056	0.01
Use of brace (vs. no brace)	19.628	1.430	269.396	0.03

Abbreviations: BMI, body mass index; MPFLr, medial patellofemoral ligament reconstruction; OR, odds ratio.
Note: Odds of needing reoperation after isolated MPFLr (used Firth correction).

ultimately undergoing revision surgery for recurrent instability. The difference in recurrent instability rates between bracing groups did not reach statistical significance; however, more patients in the bracing group more frequently underwent revision surgery. Four additional patients required revision MPRLr in the brace group, including two for MPFL graft tears, one for persistent knee pain, and one for femoral insertion anchor failure in a skeletally immature patient. The total failure rate was 17 out 229 knees (7.4%), which is consistent with reported failure rates after isolated MPFLr in the literature.[3,14]

While MPFLr is being performed at increasing rates for recurrent patellar instability, and even in some cases first-time dislocations, there is still little agreement on appropriate postoperative rehabilitation. There is a paucity of data on the need for postoperative bracing and weight-bearing restrictions following surgery. Indeed, most MPFLr protocols are derived from the ACL reconstruction literature rather than direct studies of the MPFL. Recent reviews of rehabilitation protocols published by academic institutions demonstrate that the majority recommend a period of postoperative bracing following MPFLr, though there is no consensus on the type of brace or duration of immobilization.[7,8] Additionally, major differences in the progression of weight bearing have been identified. In fact, one of the aforementioned studies noted the allowance of full weight bearing in 27 different protocols to vary anywhere between immediately postoperatively to 8 weeks postoperatively.[7] In one of the few available reviews of MPFL rehabilitation, Fithian and colleagues pointed out that MPFLr should not be affected by axial loading of the joint. They therefore recommended early progressive weight bearing in a brace for 4 to 6 weeks following surgery to avoid rotation of the limb while simultaneously allowing the return of quadriceps strength.[13] In the studied cohort, the nonbraced patients demonstrated a faster return of SLR without lag compared with those who were braced. They were also cleared to return to sport at a similar rate and time compared with patients in the brace group. This suggests that avoiding bracing may challenge patients to regain quadriceps control more quickly, as they are unable to rely on a device locked in extension. Despite the lack of statistically different recurrent instability rates, we also speculate that earlier neuromuscular recruitment of the quadriceps resulted in better subjective stability after surgery.

Although most surgeons employ bracing in the immediate postoperative period, there is little evidence to suggest this is necessary. Biomechanically, the graft is at relatively low risk for disruption, barring a strong torsional force applied to the semiflexed knee. Cadaveric studies have found the strength of the native MPFL to be approximately 208 to 209 N.[15,16] Multiple studies have demonstrated the tensile strength of a reconstructed ligament to surpass that of the native ligament.[17,18] Joyner et al examined the force to failure of five different methods of MPFLr with hamstring allograft utilizing suspensory cortical fixation, interference screw fixation, and suture anchor fixation in various combinations on the femur and patella. They found that only constructs employing suspensory button fixation on the femur and suture anchors in the patella had a lower force to failure than the native ligament.[18]

Limitations

There were several limitations to this study. First, patients were not randomized to either bracing group; this was entirely a matter of surgeon preference. Three surgeons routinely utilized postoperative bracing during the study period, while one surgeon did not; this difference needs to be recognized as it could introduce unknown bias in our results. Although the majority of patients received an interference screw, there were variations in the femoral fixation technique, typically due to physeal considerations. However, we do not believe this to have significantly altered our results based on previous studies documenting biomechanical similarities of different MPFLr constructs.[18] Although a standardized postoperative exercise protocol was provided to all patients, ROM was progressed, and braces were discontinued at the discretion of the treating physical therapist. Thus, there was some variation in rehabilitation timing both within and between patient groups. Additionally, return to sport testing for MPFLr is also not well-established and is typically a subjective evaluation by the surgeon and/or physical therapist. Since this was a retrospective study, time to clearance for RTS was used a surrogate measure for the patient ability to perform activities without restriction.

We recognize this measure is different from patients' actual return to sport, which should be investigated in future prospective studies. There was also no power analysis performed, and the finding of no difference in recurrent instability rates may be a matter of an underpowered study. Additionally, follow-up is limited to 6 months and only those with less than 6 weeks of follow-up were excluded so the question of recurrent instability and revision rates must be understood in this context. Finally, we did not control for anatomic considerations of trochlear dysplasia and/or elevated TT-TG distance. However, as this study is limited to isolated MPFLr, we believe patients with significant bony malalignment would have been excluded by the virtue of undergoing more complex combined procedures—our surgeons perform concomitant tibial tubercle osteotomies in all patients with a TT-TG greater than 20 mm, and frequently in those with a value greater than 15 mm.

Conclusion and Clinical Recommendations

Recurrent instability rates and timing of surgeon clearance to return to sport were similar between patients who did or did not use an HKB after isolated MPFLr. Re-operation rates were higher in the braced group. Future prospective studies are needed to identify who may benefit from bracing after MPFLr. Routine brace utilization after MPFLr may be an unnecessary cost and may slow the return of quadriceps function; further prospective comparative study may be warranted.

Note

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Conflict of Interest

None declared.

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