



# Online Rehabilitation Protocols for Medial Patellofemoral Ligament Reconstruction With and Without Tibial Tubercle Osteotomy Are Variable Among Institutions

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**Purpose:** To compare and contrast the various rehabilitation protocols for medial patellofemoral ligament (MPFL) reconstruction and MPFL reconstruction plus tibial tubercle osteotomy (TTO) published online by academic orthopaedic surgery residency programs and private practice institutions throughout the United States. **Methods:** We performed a systematic electronic search of MPFL reconstruction rehabilitation protocols in academic orthopaedic surgery residency programs in the United States using Google's search engine ([www.google.com](http://www.google.com)) based on the Fellowship and Residency Electronic Interactive Database Access System (FREIDA). Private practice organizations publishing MPFL reconstruction or MPFL reconstruction–TTO rehabilitation protocols that were found on the first page of search results were also included, but no comprehensive search for private practice protocols was performed. Protocols specifying an MPFL reconstruction with TTO were included for separate review because of altered weight-bearing status postoperatively. A list of comparative criteria was created to assess the protocols for the presence and timing of the various rehabilitation components. **Results:** From the list of 189 U.S. academic residency programs, as well as additional private practice protocols found in the Google search, 38 protocols were included for review (31 protocols for isolated MPFL reconstruction and 7 protocols for MPFL reconstruction plus TTO). A return to full range of motion by week 6 was recommended by 15 (48.4%) of the isolated MPFL reconstruction protocols and 6 (85.7%) of the MPFL reconstruction–TTO protocols. Six weeks of knee brace wear was recommended by 13 isolated MPFL reconstruction protocols (43.3%) and 4 MPFL reconstruction–TTO protocols (57.1%). Moreover, 6 isolated MPFL reconstruction protocols (19.4%) and 3 MPFL reconstruction–TTO protocols (42.9%) recommended use of a patellar stabilizing brace postoperatively. **Conclusions:** There is substantial variability among rehabilitation protocols after MPFL reconstruction, as well as MPFL reconstruction plus TTO, including postoperative range of motion, weight-bearing status, and time until return to sport. Furthermore, many online protocols from academic orthopaedic surgery residency programs and private practices in the United States fail to mention several of these parameters, most notably functional testing to allow patients to return to sport. **Clinical Relevance:** Proper rehabilitation after MPFL reconstruction with or without TTO is an important factor to a patient's postoperative outcome. This study outlines the variability in online rehabilitation protocols after MPFL reconstruction with or without TTO published online by academic residency programs and private practice institutions.

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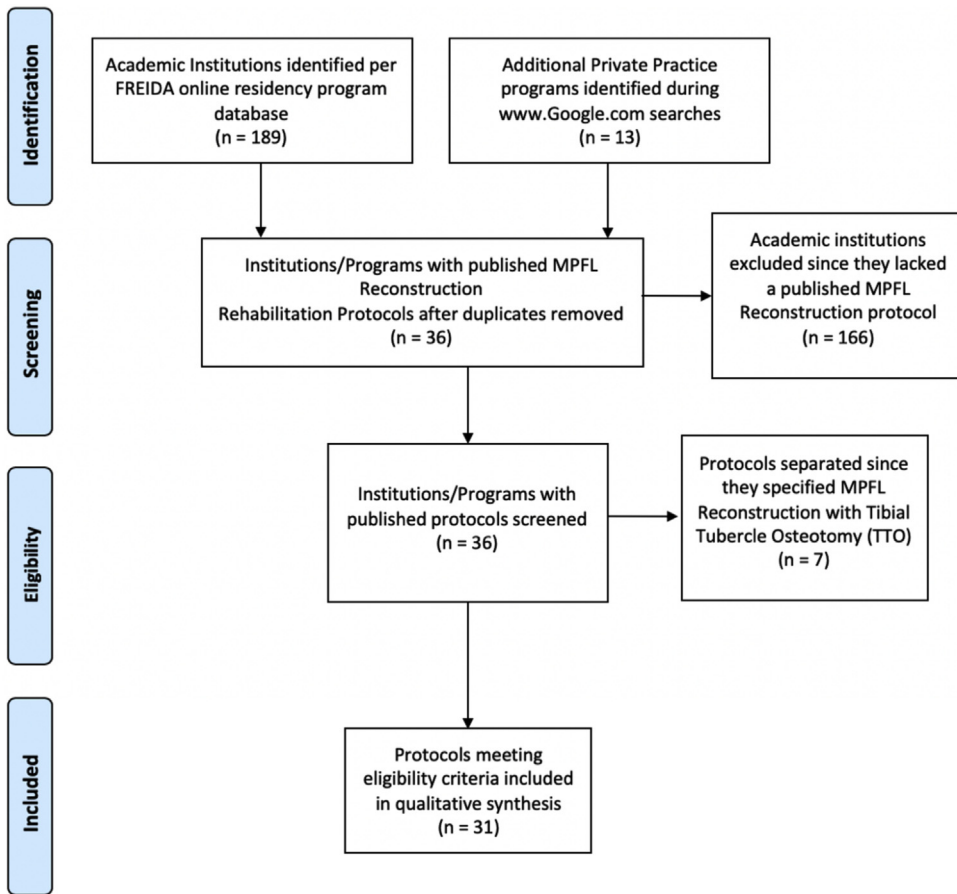
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The medial patellofemoral ligament (MPFL) is considered the main soft-tissue stabilizer against lateral displacement of the patella. Patellar instability with subluxation or dislocation is a painful and commonly recurring condition,<sup>1</sup> with recurrent instability reported to occur after a first-time patellar dislocation in 15% to 44% of patients.<sup>2</sup> Most acute patellar dislocations occur in young active patients (aged < 20 years), most commonly during sports such as football, gymnastics, soccer, and basketball. Patellar dislocation occurs primarily as a result of noncontact injuries, often with a valgus force applied to a flexed knee.<sup>3</sup>



**Fig 1.** Flow diagram used for study. (FREIDA, Fellowship and Residency Electronic Interactive Database Access System [AMA (American Medical Association) Residency and Fellowship Database]; MPFL, medial patellofemoral ligament; TTO, tibial tubercle osteotomy.)

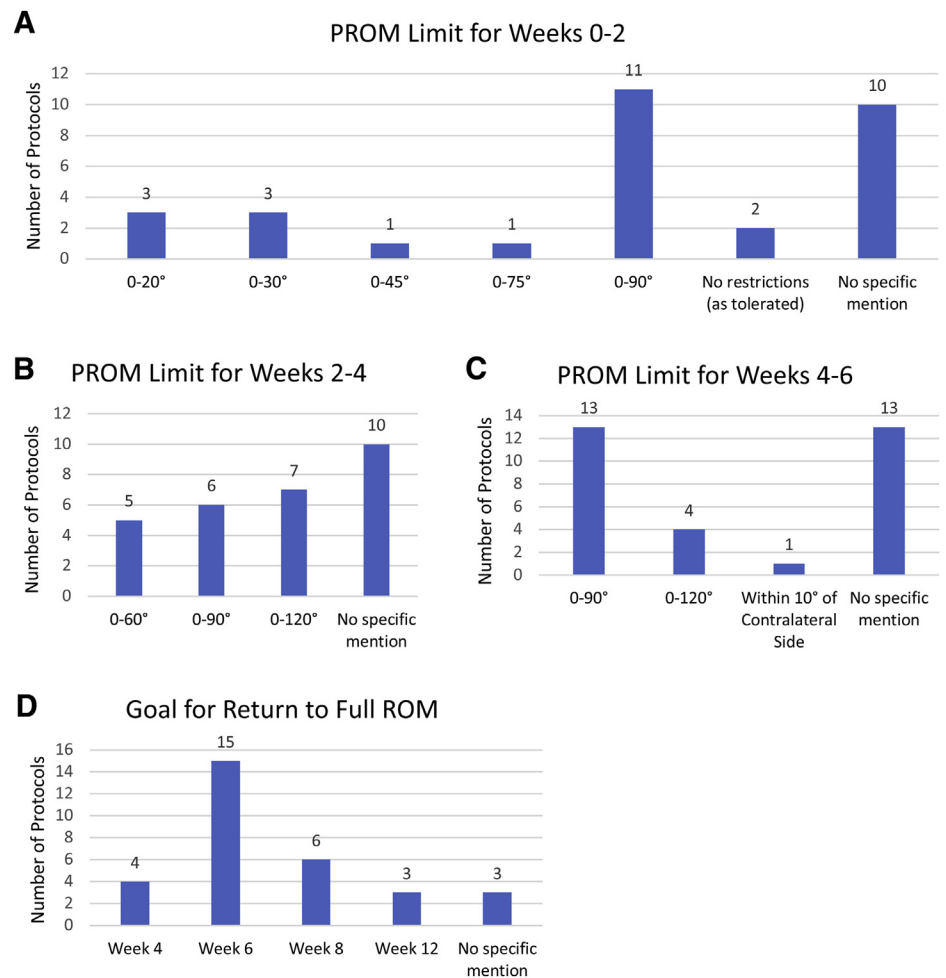
Considerable progress has been made in understanding the MPFL and its role as the primary stabilizer in preventing lateral patellar displacement.<sup>4</sup> Patellar dislocations frequently result in tearing of the medial stabilizing structures (medial patellotibial ligament, medial patellomeniscal ligament, and MPFL), with the primary structure affected being the MPFL. First-time patellar dislocations are often treated nonoperatively with a brief period of immobilization and up to 6 weeks of physical therapy.<sup>5</sup> MPFL reconstruction is not recommended after an initial dislocation event without a concomitant injury because there are no clear long-term benefits over nonoperative management.<sup>5-8</sup> However, surgical intervention is warranted after a subsequent dislocation, given the high risk of persistent instability.<sup>5,7</sup>

Multiple factors are taken into account when determining the appropriate treatment options for a patient with recurrent patellar instability, including ligamentous injury, cartilage damage, patella alta, trochlear dysplasia, and tibial tubercle–trochlear groove distance.<sup>9,10</sup> If a patient has both ligamentous and bony abnormalities, then an MPFL reconstruction with tibial tubercle osteotomy (TTO) may be indicated. The 3 major types of TTO are

Fulkerson, Maquet, and Elmslie-Trillat.<sup>11</sup> Although the specific surgical procedures may vary between patients, both isolated MPFL reconstruction and MPFL reconstruction with TTO have shown low redislocation rates and good clinical and functional outcomes.<sup>12,13</sup>

Physical therapy after MPFL reconstruction or MPFL reconstruction plus TTO is important for restoring normal knee range of motion (ROM) and strength, which—in turn—reduces the risk of recurrence and improves patient outcomes.<sup>14</sup> Rehabilitation typically follows a 4-phase progression with a gradual increase in ROM and quadriceps activation: protective phase (day 1 to week 6), moderate protection phase (weeks 7-12), minimum protection phase (weeks 13-16), and return-to-full activity phase (weeks 17-20 [or beyond]).<sup>4</sup> However, this 4-phase progression is not standardized to every rehabilitation protocol after MPFL reconstruction with and without TTO.

Only a subset of U.S. orthopaedic teaching institutions publish MPFL reconstruction rehabilitation protocols online.<sup>15</sup> Furthermore, there is minimal evidence published regarding rehabilitation protocols for MPFL reconstruction with TTO. The purpose of this study was to compare and contrast the various rehabilitation



**Fig 2.** (A-D) Passive knee range of motion (PROM) status after surgery in the 31 rehabilitation protocols specific to isolated medial patellofemoral ligament reconstruction. (ROM, range of motion.)

protocols for MPFL reconstruction and MPFL reconstruction plus TTO published online by academic orthopaedic surgery residency programs and private practice institutions throughout the United States. Our hypothesis was that there would be wide variation among protocols between the different rehabilitation components for MPFL reconstruction, as well as MPFL reconstruction plus TTO.

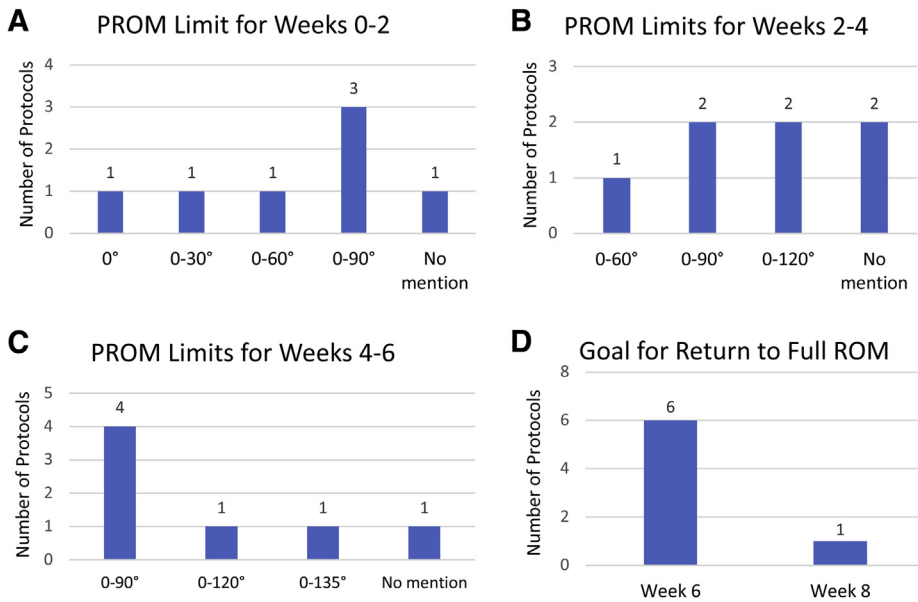
## Methods

To avoid selection bias, a list of publicly available academic orthopaedic surgery residency programs in the United States was obtained from the Fellowship and Residency Electronic Interactive Database Access System (FREIDA). A Web-based search using Google ([www.google.com](http://www.google.com); Alphabet, Mountain View, CA) was performed with the search term “[Program/affiliate hospital/affiliate medical school name] MPFL reconstruction rehabilitation protocol.” Protocols from private practice organizations that were identified during the [www.google.com](http://www.google.com) searches were also examined to determine whether there were additional relevant

protocols. However, no comprehensive search for private practice protocols was performed. Websites listed on the first page of search results were evaluated because further pages did not include rehabilitation protocols or were irrelevant to our study.

Websites were included if they were written in the English language and included rehabilitation protocols after MPFL reconstruction. Rehabilitation protocols specifying MPFL reconstruction with TTO were also included but were compared separately because patients are required to be non-weight bearing for a period after MPFL reconstruction plus TTO. Protocols were excluded if they did not specify the MPFL as the reconstructed ligament, reported reconstruction of the MPFL with concurrent cartilage repair, or included other concurrent bony or ligamentous injuries.

After duplicates were removed, rehabilitation protocols were compared based on the following components: ROM, weight-bearing status, time until return to sport (RTS), time until running, time spent in a knee brace, use of a patellar stabilizing brace, and use of continuous passive motion (CPM) machines. The



**Fig 3.** (A-D) Passive knee range of motion (PROM) status after surgery in the 7 rehabilitation protocols specific to medial patellofemoral ligament reconstruction with tibial tubercle osteotomy. (ROM, range of motion.)

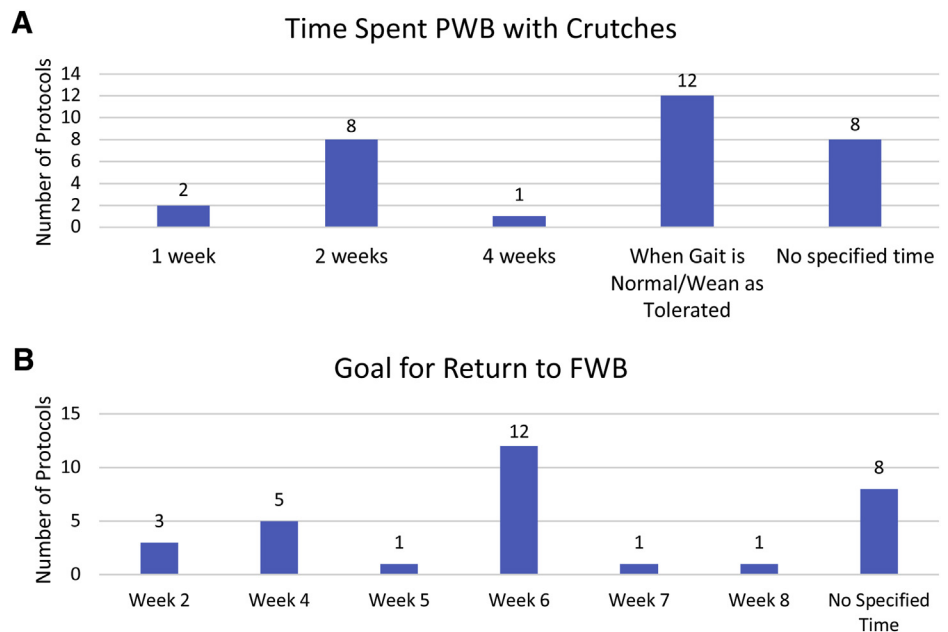
primary outcome of this study was the inclusion or exclusion of each component in the rehabilitation protocol, as well as the timing of initiation of each component.

**Results**

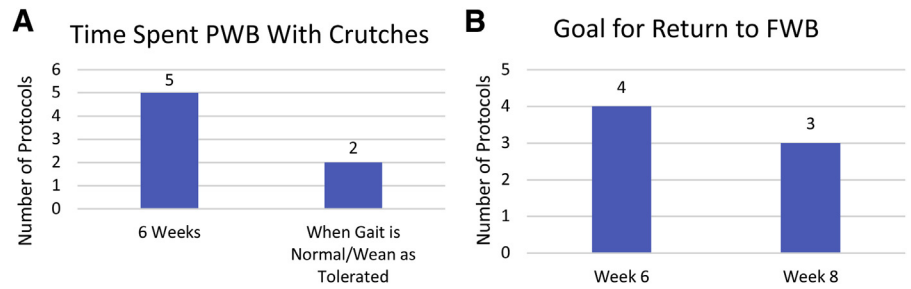
Overall, the websites for 189 academic orthopaedic surgery residency programs identified using the FREIDA online residency program database, as well as any private practice programs identified during the

Google searches, were included for review. A total of 23 academic orthopaedic surgery residency programs (12.2%) and 13 private practice groups had publicly available MPFL reconstruction rehabilitation protocols published online. From these 36 programs, 38 protocols (2 programs had protocols for both MPFL reconstruction and MPFL reconstruction plus TTO) met the inclusion criteria and were included in this study. Seven protocols were separated for independent review because they specified MPFL reconstruction with TTO,

**Fig 4.** (A, B) Intervals for weight-bearing status from the date of surgery in the 31 rehabilitation protocols specific to isolated medial patellofemoral ligament reconstruction. (FWB, full weight bearing; PWB, partial weight bearing.)



**Fig 5.** (A, B) Intervals for weight-bearing status from the date of surgery in the 7 rehabilitation protocols specific to medial patellofemoral ligament reconstruction with tibial tubercle osteotomy. (FWB, full weight bearing; PWB, partial weight bearing.)



leaving 31 protocols specific for rehabilitation after isolated MPFL reconstruction. The flow diagram used for this study is shown in [Figure 1](#).

**Range of Motion**

The 31 included protocols specific for rehabilitation after isolated MPFL reconstruction showed substantial variability in recommendations for initiating and advancing passive knee range of motion (PROM) ([Fig 2](#)). If the protocol specified a range, the initial value of each range was used (e.g., if a protocol specified a return to full ROM in 6-8 weeks, the value of 6 weeks was used). For the time interval of 0 to 2 weeks postoperatively ([Fig 2A](#)), 11 protocols (35.5%) recommended limiting PROM to 0° to 90° whereas 10 (32.2%) did not specify the PROM status. For the period of 2 to 4 weeks postoperatively, 5 protocols (16.1%) recommended limiting PROM to 0° to 60°, 6 (19.4%) recommended limiting PROM to 0° to 90°, and 7 (22.6%) recommended limiting PROM to 0° to 120°. Thirteen protocols (41.9%) did not specify the PROM status for this period ([Fig 2B](#)). For the period of 4 to 6 weeks postoperatively ([Fig 2C](#)), 13 protocols (41.9%) recommended limiting PROM to 0° to 90° whereas 4 (12.9%) recommended limiting PROM to 0° to 120°. Thirteen protocols (41.9%) did not specify the PROM status. Finally, 15 protocols (48.4%) recommended a return to full ROM by 6 weeks postoperatively ([Fig 2D](#)).

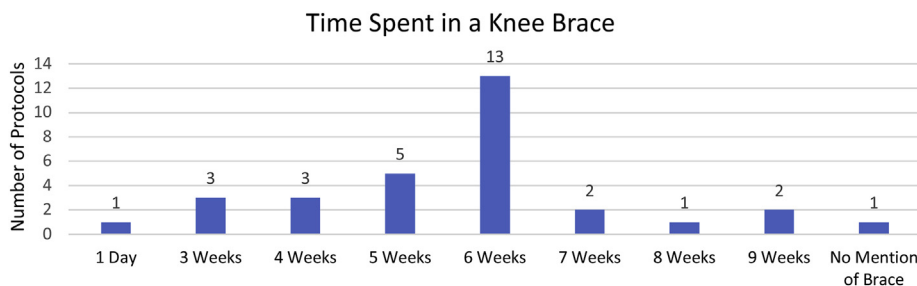
The 7 rehabilitation protocols for MPFL reconstruction with TTO also showed variability in recommendations for advancing PROM ([Fig 3](#)). For the interval of 0 to 2 weeks postoperatively ([Fig 3A](#)), 3 protocols

(42.9%) recommended limiting PROM to 0° to 90° whereas the other 4 protocols (57.1%) each had different recommendations. For the period of 2 to 4 weeks postoperatively ([Fig 3B](#)), 1 protocol (14.3%) recommended limiting PROM to 0° to 60°, 2 (28.6%) recommended limiting PROM to 0° to 90°, and 2 (28.6%) recommended limiting PROM to 0° to 120°. Two protocols (28.6%) did not specify the PROM status for this period. For the period of 4 to 6 weeks postoperatively ([Fig 3C](#)), 4 protocols (57.1%) recommended limiting PROM to 0° to 90°. Finally, 6 protocols (85.7%) recommended a return to full knee ROM by week 6, whereas 1 (14.3%) recommended full ROM by week 8 ([Fig 3D](#)).

**Weight-Bearing Status**

Among the 31 included protocols specified for isolated MPFL reconstruction rehabilitation, various weight-bearing statuses were recommended after surgery ([Fig 4](#)). If the protocol specified a range, the initial value of each range was used. Regarding the duration of partial weight bearing (PWB) postoperatively ([Fig 4A](#)), 12 protocols (38.7%) recommended PWB with crutches until gait returned to normal (or weaning from crutches as tolerated) whereas 8 (25.8%) recommended PWB with crutches for 2 weeks. Aside from these, 8 protocols (25.8%) did not delineate a specific status for time spent PWB with crutches.

In terms of the timing of the return to full weight bearing (FWB) postoperatively ([Fig 4B](#)), 12 protocols (38.7%) recommended a return to FWB starting at 6 weeks, whereas the second largest group, comprising 5



**Fig 6.** Recommendations for total time spent in a knee brace after isolated medial patellofemoral ligament reconstruction.

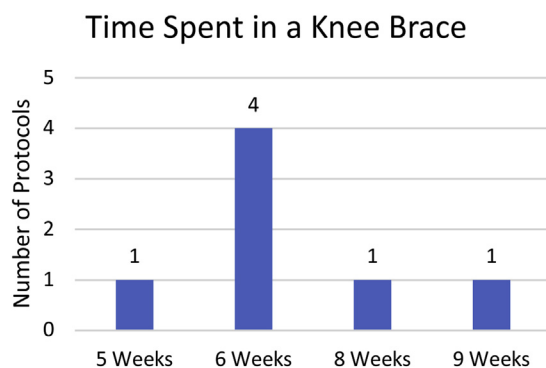
protocols (16.1%), recommended a return to FWB starting at 4 weeks. Of the protocols, 8 (25.8%) did not have specific recommendations on when to return to FWB status.

Among the 7 included protocols specified for rehabilitation after MPFL reconstruction with TTO, various weight-bearing statuses were recommended after surgery (Fig 5). Regarding the duration of PWB postoperatively (Fig 5A), most protocols (71.4%) recommended PWB with crutches for 6 weeks whereas 2 protocols (28.6%) recommended PWB with crutches until gait returned to normal (or weaning from crutches as tolerated). Regarding FWB postoperatively (Fig 5B), 4 protocols (57.1%) recommended a return to FWB starting at 6 weeks whereas 3 (42.9%) recommended a return to FWB starting at 8 weeks.

### Time Spent in Knee Brace

We evaluated the time spent in a knee brace postoperatively in each protocol (Fig 6). If the protocol specified a range, the initial value of each range was used. Of the 31 protocols specific for rehabilitation after isolated MPFL reconstruction, 30 (96.8%) had specific instructions regarding knee brace wear. Of the protocols, 13 (43.3%) recommended wearing a knee brace for a total of 6 weeks, 5 (16.7%) recommended 5 weeks of postoperative brace wear, and 1 (3.2%) recommended only 1 day of postoperative brace wear. The other 13 protocols (41.9%) recommended periods of postoperative brace wear of between 3 and 9 weeks. Time spent in a patellar stabilizing brace (if included in the protocol) was not included in these data.

We also evaluated the total time spent in a knee brace in each protocol designated for MPFL reconstruction with TTO (Fig 7). Of these protocols, 4 (57.1%) recommended 6 weeks of knee brace wear whereas the other 3 recommended anywhere from 5 to 9 weeks of brace wear. Time spent in a patellar stabilizing brace (if included in the protocol) was not included in these data.



**Fig 7.** Recommendations for total time spent in a knee brace after medial patellofemoral ligament reconstruction with tibial tubercle osteotomy.

### Return to Sport

Recommendations for RTS were evaluated for both isolated MPFL reconstruction and MPFL reconstruction with TTO (Fig 8). If the protocol specified a range, the initial value of each range was used. Of 31 protocols specific to isolated MPFL reconstruction, 11 (35.5%) recommended RTS at 16 weeks (4 months) postoperatively whereas 8 (25.8%) recommended RTS at 24 weeks (6 months) postoperatively. There was high variability in the remainder of the isolated MPFL reconstruction protocols, ranging from 12 to 36 weeks. Of the 7 protocols specific to MPFL reconstruction with TTO, 3 (42.9%) recommended RTS at 12 weeks (3 months) whereas 2 (28.6%) recommended RTS at 16 weeks (4 months). Furthermore, only 13 of the 38 protocols (34.2%) included specific strength or functional testing guidelines for criteria to RTS.

### Patellar Stabilizing Brace

Use of a patellar stabilizing brace was compared between the various protocols (Fig 9). Of the 31 protocols for rehabilitation after isolated MPFL reconstruction, 25 (80.6%) did not recommend use of a patellar stabilizing brace postoperatively. However, of the 6 protocols that did recommend using a patellar stabilizing brace, 4 (66.7%) suggested using this beginning at 6 weeks postoperatively. Only 3 of the 7 protocols (42.9%) for rehabilitation after MPFL reconstruction with TTO recommended use of a patellar stabilizing brace postoperatively.

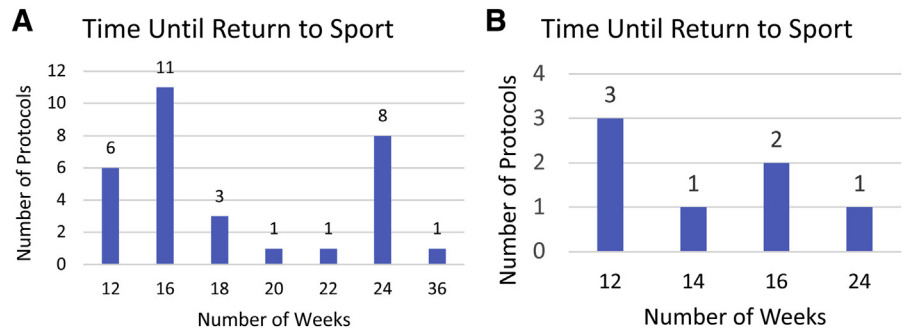
### Continuous Passive Motion

Of the 31 protocols for rehabilitation after isolated MPFL reconstruction, 27 (87.1%) did not recommend use of CPM postoperatively. However, all 4 of the protocols that recommended CPM suggested using the device for a total of 6 weeks postoperatively. The 1 protocol (14.3%) for rehabilitation after MPFL reconstruction with TTO that recommended CPM also suggested 6 weeks of use.

## Discussion

There is substantial variability among MPFL reconstruction rehabilitation protocols published online by academic orthopaedic surgery residency programs and private practice groups in the United States (Fig 10). Although there were trends in certain components between the protocols, such as 48.4% of the isolated MPFL reconstruction protocols recommending a return to full knee ROM by week 6, there was an overall lack of agreement within other components. For each component compared in our study, there was rarely a group of protocols that represented a majority agreement. Although variability was also clearly evident in MPFL reconstruction—TTO protocols, a higher consensus was found more often in these protocols.

**Fig 8.** Recommendations for time until return to sport after medial patellofemoral ligament reconstruction (A) or medial patellofemoral ligament reconstruction with tibial tubercle osteotomy (B).



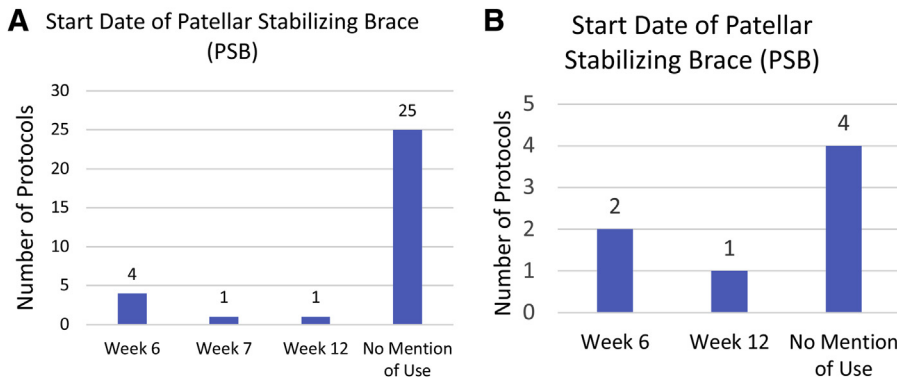
However, this is likely because of the fact that there were only 7 such protocols available for review. Further research regarding the proper timing and duration of the various components of these rehabilitation protocols after MPFL reconstruction and MPFL reconstruction plus TTO is recommended.

One of the greatest challenges postoperatively is the management of knee stiffness, emphasizing the importance of early postoperative rehabilitation and knee ROM.<sup>4,16</sup> Several of the protocols in this study failed to mention specific rehabilitation components or the timing of initiation and advancement. For example, 10 of the 31 protocols specific to isolated MPFL reconstruction (32.2%) did not delineate a specific PROM status for postoperative weeks 0 to 2. Failing to include such an essential factor such as immediate postoperative knee ROM in a rehabilitation protocol can lead to an increase in complications (e.g., stiffness).<sup>4</sup>

Several previous studies have discussed the risk of fracture during rehabilitation after TTO.<sup>17-19</sup> A systematic review by Payne et al.<sup>17</sup> comparing 19 studies with a total of 772 TTO procedures (Elmslie-Trillat technique in 472, Fulkerson technique in 193, and complete tibial tubercle detachment for medialization or distalization in 102) found that an overaggressive rehabilitation protocol after TTO can lead to an increased risk of postoperative fractures. On the basis of the results of their study, they recommended that

patients work on PROM with limited weight bearing for the first 6 to 8 weeks postoperatively and that the return to competitive sports should be delayed until 9 months to 1 year postoperatively. Although other studies have also recommended a more conservative approach to rehabilitation after TTO,<sup>18,20</sup> our study observed that most MPFL reconstruction–TTO rehabilitation protocols (85.7%) recommended RTS by 4 months. Our study found that online rehabilitation protocols for MPFL reconstruction plus TTO may be in contradiction to published evidence and therefore could increase the risk of complications such as fractures after TTO.

A study by Saper et al.<sup>21</sup> looking at RTS after MPFL reconstruction found that adolescent athletes may not consistently recover dynamic functional stability or adequate muscle strength until 7.4 months postoperatively. This finding is concerning considering that only 1 of the 38 protocols in our study (2.6%) recommended waiting more than 7 months to RTS. The study by Saper et al. also concluded that physicians should not rely solely on the time from surgery to declare a patient ready to RTS but should also use the results of strength and functional testing to determine readiness. Only 13 of the 38 protocols in our study (34.2%) had specific strength or functional testing guidelines for criteria to RTS, which included some or all of the following: 90% functional hop test result, greater than



**Fig 9.** Recommendations for start date of patellar stabilizing brace (PSB) after medial patellofemoral ligament reconstruction (A) or medial patellofemoral ligament reconstruction with tibial tubercle osteotomy (B).

**Isolated MPFL Protocols:**

- Brigham and Women's Hospital - Harvard Medical School
- Center for Sports Medicine & Orthopedics– Chattanooga TN
- Children's Hospital of Philadelphia
- Children's Hospital of Orange County (CHOC)
- Keller Orthopedics
- Lahey Hospital & Medical Center
- Missouri Orthopaedic Institute
- Mountain Orthopedics
- New York University (NYU)
- Ohio State University
- Oregon Health & Science University
- OrthoNY
- Orthopedics Specialists of North Carolina
- Rush University
- Rutgers – New Jersey Orthopaedic Institute
- Sanford Orthopedics & Sports Medicine
- St. Louis University (SLU)
- Tallgrass Orthopedics & Sports Medicine
- Tri-Valley Orthopedics
- Tucson Orthopedic Institute
- University of California, Los Angeles (UCLA)
- University of Connecticut (UCONN) Musculoskeletal Institute
- University Hospitals Case Medical Center
- University of Delaware
- University of Minnesota
- University of Virginia Health System
- University of Wisconsin Sports Medicine
- University Orthopedics – Affiliate of Brown Alpert Medical School
- Virginia Commonwealth University (VCU)
- Wake Forest University School of Medicine
- William Beaumont Army Medical Center

**Fig 10.** List of protocols included in study. (MPFL, medial patello-femoral ligament; TTO, tibial tubercle osteotomy.)

**MPFL + TTO Protocols:**

- Baylor College of Medicine
- Brigham and Women's Hospital - Harvard Medical School
- Colorado University
- Henry Ford Health System
- New Mexico School of Medicine
- St. Mary Specialty Clinic – St. Joseph Heritage Healthcare
- Tri-Valley Orthopedics

85% isokinetic test result at 180°/s and 300°/s, full knee ROM, and 90% strength compared with the contralateral lower extremity.

It is also important to consider whether the recommendations made by these protocols are supported by

evidence from the literature. There does not seem to be any standardization of several components of the rehabilitation protocols, including duration of brace wear. One protocol in this study recommended only 1 day of postoperative knee brace wear, whereas other



protocols recommended up to 9 weeks; therefore, there is clearly a need to further investigate this and other components of rehabilitation protocols to better standardize rehabilitation after MPFL reconstruction, as well as MPFL reconstruction plus TTO.

### Limitations

There are several limitations to this study. We acknowledge that rehabilitation may still vary slightly among patients because not every MPFL tear is the same and further variables must be considered that may change rehabilitation among patients. An additional limitation is that only 38 MPFL reconstruction and MPFL reconstruction–TTO rehabilitation protocols published online met the inclusion criteria. The search was based on academic orthopaedic surgery residency programs and did not specifically involve searching for protocols published by orthopaedic surgery private practice groups in the United States. Therefore, it is possible that other rehabilitation protocols published online by private practice groups were not identified in the search. Furthermore, it is likely that many additional academic orthopaedic surgery residency programs and private practice groups have rehabilitation protocols that would meet the inclusion criteria but have not been published online for public access and therefore could not be included in the study. Finally, because this is an online review, we are unable to determine whether providers at each institution actually follow their institution's protocols versus their personal protocols.

### Conclusions

There is substantial variability among rehabilitation protocols after MPFL reconstruction, as well as MPFL reconstruction plus TTO, including postoperative ROM, weight-bearing status, and RTS. Furthermore, many online protocols from academic orthopaedic surgery residency programs and private practices in the United States fail to mention several of these parameters, most notably functional testing to allow patients to RTS.

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