Medial Patellofemoral Ligament Reconstruction With Concomitant Tibial Tubercle Transfer: A Systematic Review Of Outcomes And Complications

By: Jeremy M. Burnham, M.D., **Jennifer S. Howard, Ph.D., A.T.C.**, Christopher B. Hayes, M.D., and Christian Lattermann, M.D.

Abstract

Purpose: To examine the outcomes and complications of medial patellofemoral ligament (MPFL) reconstruction and concomitant tibial tubercle (TT) transfer. Methods: A systematic review of published literature on MPFL reconstruction and TT transfer was performed using the following databases: PubMed/Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature), SPORTDiscus, and Cochrane. To be included, studies were required to present outcomes and/or complication data for MPFL reconstruction performed in combination with TT transfer. Each study was assessed for quality and level of evidence. Results: Five studies consisting of 92 knees met the inclusion criteria. Between 57% and 77% of the patients were female patients, and the mean age at surgery was 20.6 years (range, 19 to 31 years). The mean follow-up period was 38 months (range, 23 to 53 months). Postoperative outcome measures including the Lysholm score, Kujala score, International Knee Documentation Committee score, Knee Injury and Osteoarthritis Outcome Score, and visual analog scale score were similar to those previously reported for isolated MPFL reconstruction. Reported complication rates were lower than 15% and included wound infection, hardware irritation, and stiffness. Four studies were graded as Level IV evidence, and 1 study was graded as Level II evidence. Only 1 study scored greater than 50% in the quality analysis. Conclusions: Results from the analyzed studies indicate that MPFL reconstruction combined with TT transfer is a safe and effective procedure, with a low to moderate risk of complications but overall favorable results. TT transfer is most often performed in conjunction with MPFL reconstruction in the setting of malalignment such as an increased TTetoetrochlear groove distance, and although the surgical indications may differ, the outcomes and risk profiles are similar to those of isolated MPFL reconstruction. With the recognition that these patients are difficult to standardize, additional well-designed studies are needed to further investigate the ideal surgical candidates for MPFL reconstruction with concomitant TT transfer. Level of Evidence: Level IV, systematic review of Level II and IV studies.

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Purpose: To examine the outcomes and complications of medial patellofemoral ligament (MPFL) reconstruction and concomitant tibial tubercle (TT) transfer. **Methods:** A systematic review of published literature on MPFL reconstruction and TT transfer was performed using the following databases: PubMed/Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature), SPORTDiscus, and Cochrane. To be included, studies were required to present outcomes and/or complication data for MPFL reconstruction performed in combination with TT transfer. Each study was assessed for quality and level of evidence. **Results:** Five studies consisting of 92 knees met the inclusion criteria. Between 57% and 77% of the patients were female patients, and the mean age at surgery was 20.6 years (range, 19 to 31 years). The mean follow-up period was 38 months (range, 23 to 53 months). Postoperative outcome measures including the Lysholm score, Kujala score, International Knee Documentation Committee score, Knee Injury and Osteoarthritis Outcome Score, and visual analog scale score were similar to those previously reported for isolated MPFL reconstruction. Reported complication rates were lower than 15% and included wound infection, hardware irritation, and stiffness. Four studies were graded as Level IV evidence, and 1 study was graded as Level II evidence. Only 1 study scored greater than 50% in the quality analysis. **Conclusions:** Results from the analyzed studies indicate that MPFL reconstruction combined with TT transfer is a safe and effective procedure, with a low to moderate risk of complications but overall favorable results. TT transfer is most often performed in conjunction with MPFL reconstruction in the setting of malalignment such as an increased TT—to—trochlear groove distance, and although the surgical indications may differ, the outcomes and risk profiles are similar to those of isolated MPFL reconstruction. With the recognition that these patients are difficult to standardize, additional well-designed studies are needed to further investigate the ideal surgical candidates for MPFL reconstruction with concomitant TT transfer. **Level of Evidence:** Level IV, systematic review of Level II and IV studies.

Patellofemoral instability with recurrent patellar dislocation can be a crippling and devastating condition. The incidence of patellar dislocation in the general population is nearly 6 per 100,000 persons and is highest in 10- to 17-year-old female patients (33 per 100,000).[1] Many patients with patellofemoral instability do not return to their preinjury activity levels.[2] Long-term sequelae from chronic patellofemoral instability result in significant use of health care resources and cost to the economy as a result of decreased productivity and work days missed.[2-5]

Multiple factors contribute to the stability of the patellofemoral joint, including extensor mechanism alignment and soft-tissue and bony stabilizers.[1,2,4,6,7] An important bony factor affecting stability is the anatomy of the trochlea.[2] Soft-tissue dynamic stabilizers include the rectus femoris muscle, vastus lateralis muscle, and vastus medialis obliquus muscle.[6] Soft-tissue static stabilizers, such as the medial and lateral retinaculum, also make a significant contribution to the stability of the patella. A component of the medial retinaculum, the medial patellofemoral

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ligament (MPFL), is particularly important and contributes most to patellar stability when the knee is in 30° of flexion.[6,8] Although the MPFL contributes less to stability as knee flexion progresses, it remains the primary medial stabilizer of the patella during the all-important initial flexion cycle.[2,6,7,9] Furthermore, MPFL rupture is a common result of lateral patellar dislocation,[7] and cadaveric studies have shown that release of the MPFL results in a 50% increase in lateral patellar displacement events.[9] Therefore individuals sustaining a patellar dislocation are at high risk of repeat dislocation if the integrity of the soft-tissue stabilizers is not restored or supplemented.

In addition to soft-tissue restraints, malalignment in the form of pathologic lateralization of the tibial tubercle (TT)—measured as the increased tibial tubercle–trochlear groove (TT-TG) distance (as measured on computed tomography scan or magnetic resonance imaging)—can contribute to lateral patellar instability.[10-12] Excessive lateral positioning of the TT increases the lateral force vectors on the patella.[11] Multiple studies have reported the normal TT-TG distance to be less than 13 mm, abnormal to be greater than 15 mm, and pathologic to be greater than 20 mm.[10,11,13,14]

Although significant focus has been placed on patellofemoral instability in recent years, it was Goldthwait[15] who first described the etiology of patellofemoral instability in 1903, and he ultimately concluded that nonoperative management was not effective. After lackluster results with attempts at medial retinacular plication, he performed a distal realignment procedure with "perfect" results.[15] Since that time, over 100 surgical treatments for recurrent patellofemoral stability have been described.[2,16-25]

The current standard of care for surgical management of chronic lateral patellofemoral instability is reconstruction of the MPFL with either autograft or allograft tendon.[26,27] This method has been associated with good results, and recent studies have reported ever-improving outcome scores and decreasing complication rates.[23,26-30] However, isolated MPFL reconstruction sometimes results in recurrent instability, and transfer of the TT has been advocated as a means of achieving improved extensor mechanism alignment and more durable results after surgery, especially in cases of pathologic TT-TG distances, patella alta, or trochlear dysplasia.[2,11,24] Despite numerous descriptions of TT transfer and other methods of distal realignment in the literature, no systematic reviews have analyzed the outcomes of MPFL reconstruction combined with TT transfer.

The purpose of this study was to examine the outcomes and complications of MPFL reconstruction and concomitant TT transfer. We hypothesized that the outcomes and complications associated with MPFL reconstruction and concomitant TT transfer would be similar to those seen with isolated MPFL reconstruction.

Table 1. Search Query Constructs Used for Systematic Review

Database Searched	Search Terms
PubMed/ Medline	MPFL AND reconstruction AND (tubercle or tuberosity or Fulkerson) OR medial patellofemoral ligament AND reconstruction AND (tubercle or tuberosity or Fulkerson), English and Human filter; (((“medial patellofemoral ligament”) AND (reconstruction) AND (tubercle OR tuberosity OR fulkerson))) OR ((“mpfl”) AND (reconstruction) AND (tubercle OR tuberosity OR fulkerson))
CINAHL	English filter, (((“medial patellofemoral ligament”) AND (reconstruction) AND (tubercle OR tuberosity OR fulkerson))) OR ((“mpfl”) AND (reconstruction) AND (tubercle OR tuberosity OR fulkerson))
SPORTDiscus	English abstract filter, (((“medial patellofemoral ligament”) AND (reconstruction) AND (tubercle OR tuberosity OR fulkerson))) OR ((“mpfl”) AND (reconstruction) AND (tubercle OR tuberosity OR fulkerson))
Cochrane	MPFL OR medial patellofemoral ligament, English filter, Trials filter

NOTE. Search query constructs varied across databases because of differences in available filters and search tool designs. Search constructs for CINAHL (Cumulative Index to Nursing and Allied Health Literature), SPORTDiscus, and Cochrane were purposefully left more broad because of a relatively lower number of search results compared with Medline.

MPFL, medial patellofemoral ligament.

Methods

A systematic review of the available literature on MPFL reconstruction and distal realignment through TT transfer was performed on March 1, 2015. The following databases were used for the search: PubMed/Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature), SPORTDiscus, and Cochrane. Search queries were constructed as listed in Table 1. The reference sections of included articles returned in our search were analyzed in search of additional studies that might have met the inclusion criteria (Fig 1). To be included, studies were required to present outcomes and/or complication data for MPFL reconstruction performed in combination with TT transfer. Studies that reported on both isolated MPFL reconstruction and MPFL reconstruction combined with TT transfer were included if data on MPFL reconstruction with concomitant TT transfer could be extracted separately from isolated MPFL reconstruction results. Articles that did not clearly meet the inclusion or exclusion criteria were reviewed by 3 authors (J.M.B., J.S.H., and C.B.H.) to achieve consensus regarding final eligibility. Each of

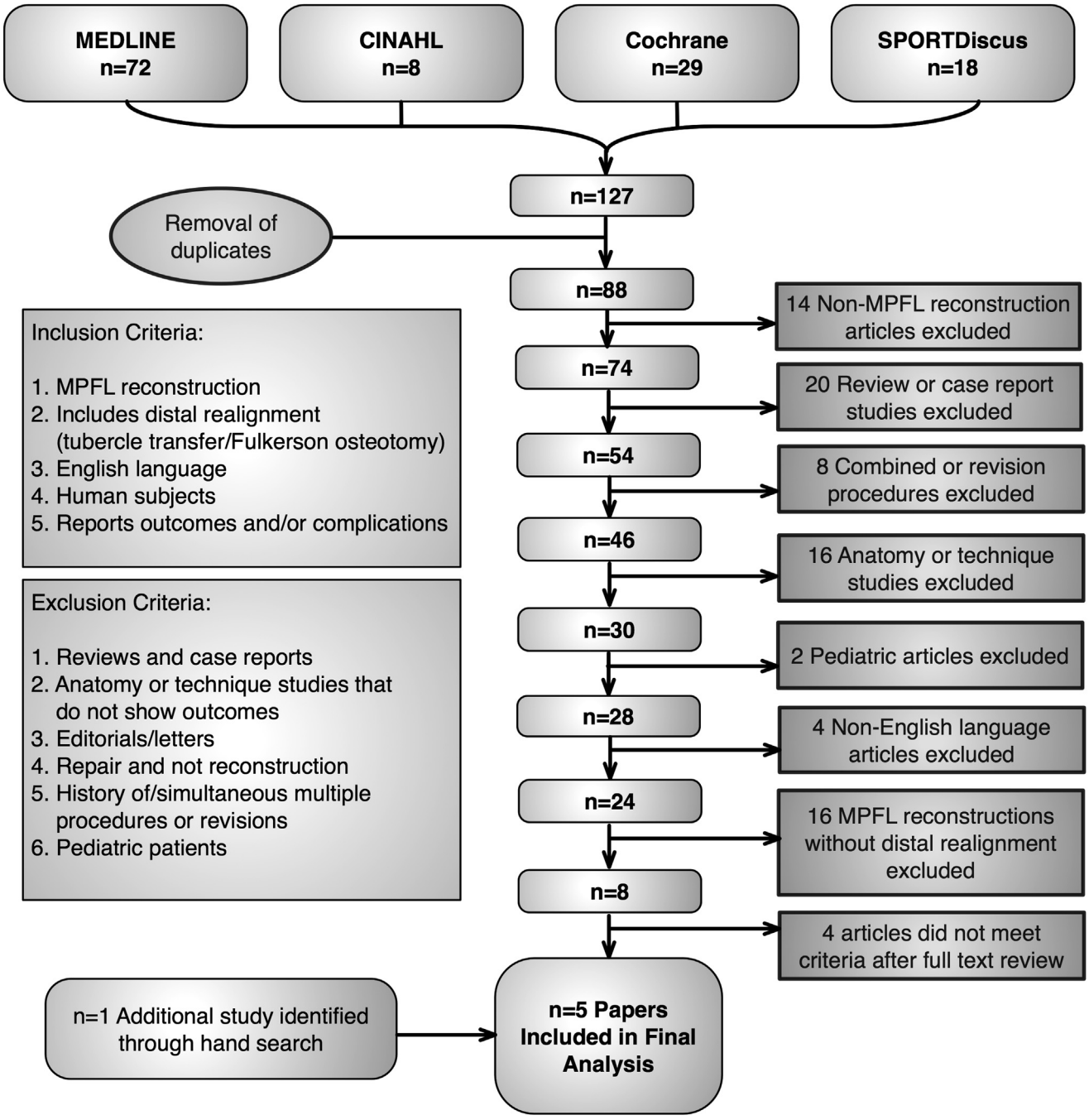

Fig 1. Article selection flowchart as recommended by Preferred Reporting Items for Systematic Reviews and Meta-Analyses.[31] (MPFL, medial patellofemoral ligament.)

the studies meeting the inclusion criteria was then assessed independently by 3 of the authors (J.M.B., J.S.H., and C.B.H.) using the study quality scale (Table 2) described by Zaza et al.[32] The studies were scored using the percentage of quality criteria appropriately met by each study (Table 3). The level of evidence for each study was assessed using the methods described by Marx et al.[33] Subject demographic data, indications for surgery, study methodology, outcome variables, and complications were all compiled in a master database. Reported means for each study were multiplied by the corresponding number of subjects and divided by the total number of subjects to provide a true average across studies.

Results

Study Selection

The study selection diagram is shown in Figure 1. The initial search yielded 88 articles after duplicates were

Table 2. Quality Criteria Used to Assess Studies

1. Descriptions
   a. Was the study population well described?
   b. Was the intervention well described?
2. Sampling
   a. Did the authors specify the sampling frame or universe of selection for the study population?
   b. Did the authors specify the screening criteria for study eligibility?
   c. Was the population that served as the unit of analysis the entire eligible population or a probability sample at the point of observation?
   d. Are there other selection bias issues not identified above?
3. Measurement
   a. Was there an attempt to measure exposure to the intervention?
   b. Were the exposure variables valid measures of the intervention under study?
   c. Were the exposure variables reliable (consistent and reproducible) measures of the intervention under study?
   d. Were the outcome and other independent (or predictor) variables valid measures of the outcome of interest?
   e. Were the outcome and other independent (or predictor) variables reliable (consistent and reproducible) measures of the outcome of interest?
4. Data analysis
   a. Construction of appropriate analysis
      i. Did the authors construct appropriate analysis by conducting statistical testing (when appropriate)?
      ii. Did the authors construct appropriate analysis by reporting which statistical tests were used?
      iii. Did the authors construct appropriate analysis by controlling for design effects in the statistical model?
      iv. Did the authors construct appropriate analysis by controlling for repeated measures in the analysis, for study designs in which the same population was followed with repeated measurements over time?
      v. Did the authors construct appropriate analysis by accounting for different levels of exposure in segments of the study population in the analysis?
      vi. If the authors analyzed group-level and individual-level covariates in the same statistical model, was the model designed to handle multilevel data?
   b. Were there any other problems with data analysis that limit interpretation of the results of the study?
5. Interpretation and results
   a. Did at least 80% of enrolled participants complete the study?
   b. Confounding
      i. Did the authors assess whether the units of analyses were comparable prior to exposure to the intervention?
      ii. Considering the study design, were appropriate methods for controlling confounding variables and limiting potential biases used?
   c. Biases
      i. Did authors identify and discuss potential biases or unmeasured/contextual confounders that may account for or influence the observed results and explicitly state how they assess these potential confounders and biases?

NOTE. Table is modified from Zaza et al.[32]

removed. On review of abstracts, 80 studies were removed for failure to meet the inclusion criteria. The most common reasons for exclusion were that studies were single case reports, were review articles without primary data presentation, or examined MPFL reconstruction in the absence of distal realignment. After full-text review of the 8 remaining studies, 4 of these did not meet the inclusion criteria because they did not report outcomes of MPFL reconstruction with TT transfer. One additional study meeting the inclusion criteria was identified by a hand search. This left 5 scientific articles examining MPFL reconstruction with TT transfer.[17,19,34-36] In 1 of these studies, the results of MPFL reconstruction with concomitant TT transfer were reported together with those of isolated MPFL reconstruction.[19] The results from the study's published data tables were used to examine outcomes for each group. One knee was excluded from the MPFL-TT group analysis because of a history of stabilization surgery on that knee.

Study Descriptions

Table 3 outlines the study design, demographic information, level of evidence, and quality score for each of the included studies. According to the guidelines described by Marx et al.[33] and in accordance with

Table 3. Study Characteristics

Study	Publication Year	Sampling Frame	Location	Design	Level of Evidence*	Quality Rating†
Cossey and Paterson[17]	2005	2001-2003	Australia	Retrospective case series	IV	38%
Mellecker et al.[34]	2013	2002-2007	United States	Prospective case series	IV	43%
Mulliez et al.[36]	2015	2007-2013	Belgium	Prospective cohort	II	65%
Schöttle et al.[19]	2005	1998-2001	Switzerland	Retrospective comparative	IV	40%
Watanabe et al.[35]	2008	1993-2003	Japan	Retrospective comparative	IV	41%

*As described by Marx et al.[33]
†As described by Zaza et al.[32]

previous assessments of 3 of the studies,[37] 4 of the analyzed studies were judged to be Level IV evidence[17,19,34,35] and 1 was judged to be Level II evidence.[36]

In total, 92 knees underwent MPFL reconstruction combined with transfer of the TT (MPFL-TT). Between 57% and 77% of the patients in each study were female patients, and the mean age at the time of surgery was 20.6 years (range, 19 to 31 years). The mean follow-up time across studies was 38 months (range, 23 to 53 months).

Indications

Surgical indications varied among studies. Cossey and Paterson[17] included patients with recurrent patellar instability in whom conservative treatment had failed. Schöttle et al.[19] specified their indications more clearly and included patients with 2 or more patellar dislocations or 1 dislocation and a persistent apprehension sign, as well as lateralization of the patella and medial tenderness. In the study by Schöttle et al., patients with a tibial tuberosity–trochlear groove distance of more than 15 mm by axial computed tomography scan underwent tubercle transfer as well as MPFL reconstruction and were included in the MPFL-TT group. Similarly, Mulliez et al.[36] performed MPFL reconstruction in patients with documented recurrent patellar dislocation or instability, and they added TT anteromedialization in patients with a TT-TG distance greater than 20 mm and tuberosity distalization in patients with patella alta (Caton-Deschamps index[38] >1.2). In contrast, Watanabe et al.[35] transitioned from including TT transfer to performing isolated MPFL reconstruction halfway through the study period, and thus the operative indications for the MPFL-TT group and the isolated MPFL group were the same and were separated only by chronologic time. Mellecker et al.[34] included patients with a history of recurrent dislocations with evidence of maltracking and/or a J-sign. With a similar design to the study by Watanabe et al., the first 16 patients received isolated MPFL repair with TT transfer and the next 21 received allograft MPFL reconstruction and TT transfer.

Surgical Technique

Surgical techniques were similar, and all included MPFL reconstruction and TT transfer. Hamstring autograft was used in most cases for the MPFL reconstruction,[19,34-36] although Cossey and Paterson[17] harvested a longitudinal portion of the medial retinaculum as a graft. Graft fixation to the patella was performed by using bone tunnels or grooves and suture anchors[19,34,36] or by suturing to the prepatellar fascia[35]; the graft was secured on the femoral side using a bone tunnel and suture anchor,[36] EndoButton (Smith & Nephew, Andover, MA),[34,35] or interference screw.[19] The tubercle, including the patellar tendon insertion, that had undergone osteotomy was fixed in the appropriate location using 1,[17] 2,[35,36] or 3[34] cortical screws[34-36] or cancellous screws.[17,36] Graft tensioning was performed throughout the entire range of motion (ROM),[19] in 70° of flexion,[35] or using a femoral nerve stimulator in the terminal 30° of extension.[34] Watanabe et al.,[35] Mulliez et al.,[36] and Schöttle et al.[19] also performed isolated MPFL reconstruction in a separate subset of patients. Cossey and Paterson and Watanabe et al. included lateral retinacular release in at least some of their procedures, and Watanabe et al. included some patients who received their MPFL reconstruction and TT transfer in a staged manner. Cossey and Paterson and Watanabe et al. specified that they performed concomitant arthroscopic procedures (e.g., chondroplasty) when indicated but did not indicate how often this occurred or what specific procedures were performed. Postoperatively, most patients were placed in extension for ambulation and allowed to discontinue the splint at around 4 to 6 weeks, with full activity at around 4 to 6 months.[17,19,34-36]

There was significant heterogeneity among the variables studied (Table 4). Outcome variables recorded included the following: postoperative ROM,[35] Lysholm score,[17,35] subjective functional assessment with a visual analog scale (VAS),[35] knee extension and flexion strength,[35] preoperative[35] and postoperative[19,34,35] apprehension sign, Kujala score,[19,36] a simple subjective assessment of outcome,[19] Knee Injury and Osteoarthritis Outcome Score (KOOS),[34,36] International Knee Documentation Committee (IKDC) functional evaluation form,[34] Tegner activity scale,[17] and Turba score.[17] Complications reported included recurrent instability,[17,19,34-36] knee stiffness,[35,36] wound infection,[17,36] and hardware irritation or malfunction.[17,36] The Lysholm score, Kujala score, KOOS, postoperative apprehension sign, and recurrent instability were included in 2 or more studies. The postoperative apprehension sign and recurrent instability rates were evaluated by 3 or more studies.

Outcome Variables Examined in Multiple Studies

On average, 14% of patients had a positive apprehension sign after surgery (range, 0% to 31%) based on reported data from the studies by Mellecker et al.,[34] Schöttle et al.,[19] and Watanabe et al.[35] Watanabe et al. also reported on the apprehension sign preoperatively and observed that 92% of patients had a positive apprehension sign preoperatively whereas only 31% had a positive apprehension sign postoperatively ($P = .005$). Two studies examined Lysholm scores.[17,35] Watanabe et al. looked at both preoperative and postoperative Lysholm scores, whereas Cossey and Paterson[17] simply looked at postoperative scores. The mean postoperative Lysholm score pooled across the 2 studies

Table 4. Study Results

	Watanabe et al.[35]		Schöttle et al.[19]		Mulliez et al.[36]		Mellecker et al.[34]: MPFL Recon Plus TTT and Femoral Nerve Stimulation	Cossey and Paterson[17]: MPFL Recon Plus TTT and LRR
	MPFL Recon Plus TTT, Occasional LRR	Isolated MPFL, Occasional LRR	MPFL Recon Plus TTT	Isolated MPFL Recon	MPFL Recon Plus TTT	Isolated MPFL Recon		
n	13	29	8	7	38	91	15	19
Mean age, yr (range)	20 (14-32)	19 (11-36)	30.1 (19-36)*		22.8 (11-43)*		24 (14-47)*	21 (18-29)
% female patients	77	69	67*		62.8*		73*	58
Inclusion criteria	Recurrent patellar dislocations		≥2 patellar dislocations or 1 dislocation and persistent apprehension sign; TTT: TT-TG distance >15 mm		Recurrent patellar instability or constant feeling of patellar instability, failure of 6-mo rehabilitation program; TTT: TT-TG distance >20 mm or Caton-Deschamps index >1.2		Recurrent dislocations, patellar subluxation, grossly positive J-sign, TT-TG distance from 12-24 mm	Symptomatic lateral instability with passive lateral shift (≥3 quadrants) and positive apprehension test, failed PT
Mean follow-up, mo (range)	53 (24-96)	51 (18-85)	47 (24-70)*		34 (12-87)*		44 (24-71)*	23 (11-37)
Lysholm score, mean ± SD								
Preoperative	72.4 ± 15.4	70.2 ± 16.7	–		–		–	–
Postoperative	89.6 ± 11.1	92.4 ± 7.6	–		–		–	95.6 ± 3.46
VAS score, mean ± SD	81 ± 28	91 ± 17	–		–		–	–
Apprehension sign, %								
Preoperative	92	97	–	–	–		–	–
Postoperative	31	21	14	43	–		0	–
Kujala score, mean ± SD								
Preoperative	–	–	60.57 ± 8.56	45.86 ± 8.33	53.1 ± 21.5	53.7 ± 23.4	–	–
Postoperative	–	–	91.57 ± 3.55	78.71 ± 17.42	73.7 ± 21.1	75.0 ± 20.4	–	–
KOOS, mean ± SD								
Symptoms	–	–	–	–	74.3 ± 19.9	75.7 ± 20.2	57.14	–
Pain	–	–	–	–	76.9 ± 21.3	78.6 ± 20.4	87.22	–
ADL	–	–	–	–	79.8 ± 24.2	84.6 ± 19.2	92.94	–
Sports	–	–	–	–	46.9 ± 33.5	58.4 ± 30.4	74.66	–
QOL	–	–	–	–	55.2 ± 28.1	59.4 ± 27.5	71.25	–
IKDC score, mean	–	–	–	–	–	–	78.27	–
Tegner score, mean ± SD	–	–	–	–	–	–	–	6.05 ± 1.08
Recurrent instability, %	0	0	0	29	0	1.5	0	0
Wound infection, %	–	–	–	–	1.5*		–	5
Hardware complication, %	–	–	–	–	0.8*		–	5
Other complications	15% (2 patients with knee flexion contractures)	–	–	–	3.9% revision rate (0.8% fractured patella, 1.5% tightness, 1.5% recurrent instability)		–	–

NOTE. Dashes indicate data not available.

ADL, activities of daily living; KOOS, Knee Injury and Osteoarthritis Outcome Score; IKDC, International Knee Documentation Committee; LRR, lateral retinacular release; MPFL, medial patellofemoral ligament; PT, physical therapy; QOL, quality of life; Recon, reconstruction; TT-TG, tibial tubercle–trochlear groove; TTT, tibial tubercle transfer.

*Not reported separately for MPFL–tibial tubercle group.

was 93.2 points. In the study by Watanabe et al., the mean Lysholm score improved significantly by 17.2 points from the preoperative to postoperative evaluations. Mulliez et al.[36] and Schöttle et al. reported preoperative and postoperative Kujala scores. The average postoperative Kujala score across both studies was 76.48 points, an improvement of 22.22 points from the preoperative score. All subdomains of the KOOS improved postoperatively as reported by Mulliez et al., with mean improvements of 10.5 (symptoms), 13.9 (pain), 13.1 (activities of daily living), 21.0 (sports), and 24.3 (quality of life). Similarly, Mellecker et al. observed improved KOOS values postoperatively, although this only included 13 of 31 knees because of incomplete preoperative data collection and the scores included some knees that were treated with MPFL repair and not reconstruction. The pooled postoperative KOOS values for all of the MPFL-TT patients were 69.44 (symptoms), 79.82 (pain), 83.52 (activities of daily living), 54.76 (sports), and 59.74 (quality of life).[34,36]

Outcome Variables Examined by a Single Study

Watanabe et al.[35] reported patients' subjective assessment of postoperative function using a 100-point VAS. The mean score postoperatively was 81 ± 28. Cossey and Paterson[17] reported postoperative Tegner scores (6.05 ± 1.08) and stated that all patients were at the same level or a better level than their preoperative scores, although the actual preoperative scores were not reported. Similarly, they reported that all patients had good to excellent Turba scores postoperatively, but preoperative scores were not reported. The postoperative IKDC score for MPFL-TT patients was 78.27.[34]

Complications

One study reported a redislocation incidence of 0.8%,[36] whereas the other 4 studies reported no recurrent instability or dislocations.[17,19,34,35] Postoperative wound infections were reported in 5% of patients in 1 study[17] and 1.5% of patients in a separate study,[36] although the latter included isolated MPFL and MPFL-TT patients. In all cases the wound infections were successfully treated with antibiotics and did not require further surgery. Hardware complications were observed in 0.8% of patients[36] and 5% of patients,[17] requiring revision surgery in all cases. Postoperative stiffness was described between 1.5%[36] and 15%[35] of the time in the 2 studies commenting on it.

Comparison of MPFL Reconstruction With Concomitant TT Transfer to Other Similar Procedures

The results of MPFL reconstruction with concomitant TT transfer were compared with those of isolated MPFL reconstruction in 3 studies.[19,35,36] No statistically significant differences between procedures were reported for ROM deficits,[35] postoperative apprehension sign,[19,35] Lysholm score,[35] Kujala score,[19,36] KOOS,[36] or strength.[35] However, a lower score on the "Japanese full sitting" portion of the VAS functional assessment was observed for MPFL-TT patients as compared with isolated MPFL-reconstructed patients.[35] This also helped to drive a lower overall VAS functional score for the combined MPFL-TT patients.[35] Mellecker et al.[34] compared MPFL reconstruction versus MPFL repair and reported 1 patient with isolated MPFL repair having recurrent instability, as compared with no patients who underwent MPFL reconstruction and TT transfer. The statistical significance of this finding was not reported. However, significantly greater improvements in KOOS and IKDC scores were observed in the MPFL-reconstructed patients as compared with the MPFL-repaired patients.[34]

Discussion

Our study found that patients undergoing MPFL reconstruction with TT transfer had good to excellent outcomes and a low redislocation rate. The overall complication rate is low to moderate, similar to complication rates described in previous investigations focusing on isolated MPFL reconstruction.[29,30,39,40] In addition, almost all outcome measures used in the included studies showed positive improvements in patient function and pain after surgery, and scores were similar to those previously reported for isolated MPFL reconstruction. Only the VAS functional assessment in the work by Watanabe et al.[35] showed a significant difference in outcome scores between MPFL reconstruction with TT transfer and isolated MPFL reconstruction. Overall, the results of this review suggest that MPFL reconstruction combined with TT transfer is a safe and effective treatment for patellar instability.

The Kujala score improved by an average of 22.22 points (on a 0- to 100-point scale[41]) across studies.[19,36] This statistically significant improvement is consistent with results from other studies focusing on isolated MPFL reconstruction[30,42] and did not differ significantly from isolated MPFL reconstruction patients in the same studies. Although the Kujala score may not be as sensitive at detecting functional deficits as other similar instruments,[29] the improvement in scores does suggest a significant improvement in patellofemoral pain.[43]

The Lysholm score, though historically used less often in the setting of MPFL reconstruction,[29] was used in 2 of the analyzed studies.[17,35] Watanabe et al.[35] reported a statistically significant improvement of 17.2 points between preoperative and postoperative Lysholm scores, exceeding both the minimal clinically important difference (MCID) and the minimal detectable change.[41] They also compared MPFL-TT patients with

isolated MPFL patients and did not find a significant difference in preoperative or postoperative Lysholm scores between the 2 groups.[35] In line with this finding, the postoperative Lysholm scores for MPFL-TT patients in our analysis ranged from 89.6 ± 11.1 points[35] to 95.6 ± 3.46 points[17] and paralleled the scores previously reported for isolated MPFL reconstruction.[44,45] Although the Lysholm score was originally designed for evaluation of anterior cruciate ligament–deficient knees,[46,47] it has been characterized as more sensitive than the Kujala score when evaluating the functional disability of MPFL-reconstructed patients.[48] However, both the Lysholm and Kujala instruments have been variably described as either physician administered or patient completed, and the methods of completion used in the analyzed studies are unclear.

Watanabe et al.[35] also included a 100-point VAS in their assessment, which has been suggested to be more sensitive than the Lysholm score in assessing knee symptoms.[49] Furthermore, the VAS forms were completed by the patients and may have been less bias prone than physician-administered tests.[48] Watanabe et al. reported a worse overall score on the VAS assessment for the MPFL-TT group as compared with the isolated MPFL reconstruction group. This finding was mostly driven by worse scores for the Japanese full sitting position. The difference between scores for this portion of the VAS was 28 points, which exceeds the MCID reported in similar VAS studies.[50] The authors speculated that the lower score for MPFL-TT patients might be due to ROM deficits or from physical blocking of the aforementioned position by the transferred tubercle and hardware.[35] The Japanese sitting position is similar to a kneeling position, with the legs resting on the ground completely, the knees in maximal flexion, and the thighs resting nearly parallel to the ground and the legs.[51] It may be that the high anterior tibial contact pressures inherent to this sitting position will always pose difficulties for patients with prior tubercle surgery and/or tubercle hardware. It is unclear if removal of painful hardware might resolve this difference.

Other patient-reported outcome instruments used in the analyzed studies included the KOOS and IKDC. Reported IKDC scores[34] were similar to those observed with primary MPFL reconstruction.[23,25,40,52] All of the KOOS subdomain improvements[36] surpassed the reported MCID and minimal detectable change,[53-56] and postoperative scores did not differ from isolated MPFL reconstruction within the same studies.[34,36] Interestingly, the symptom subdomain improved the least, but the quality-of-life subdomain still improved dramatically. This finding would suggest that the quality of the persistent symptoms did not interfere with the global improvement experienced after surgery.

The presence or absence of an apprehension sign was the only outcome variable reported in at least 3 of our studies.[19,34,35] Overall, 86% of patients did not have a positive postoperative apprehension sign. Schöttle et al.[19] and Watanabe et al.[35] both reported the number of positive postoperative apprehension signs separately for the MPFL-TT and isolated MPFL groups. Watanabe et al. found a higher rate of positive postoperative apprehension signs in the MPFL-TT group, whereas Schöttle et al. found the opposite. This discrepancy may have been because of differences in functional demands and cultural activity levels between the 2 groups. For example, regular time spent in the Japanese sitting position may have led to patellofemoral pain that left the patients in the study by Watanabe et al. more susceptible to the presence of a postoperative apprehension sign.

Reported complication rates were moderately low, and none of the studies comparing isolated MPFL reconstruction versus MPFL reconstruction with TT transfer observed a difference in complication rates between the 2 groups.[19,35,36] Furthermore, no recurrent instability was reported in patients undergoing MPFL reconstruction with concomitant TT transfer among the analyzed studies.[17,19,34-36] The highest complication rate reported was 15.4%, and this consisted of 2 of 13 patients having postoperative stiffness. The complication rate in a separate study was 10% and was due to 1 patient having hardware irritation and another patient having a superficial wound infection. The study with the largest MPFL-TT group reported an overall complication rate of 8.6%, and although not reporting separate complication rates for the isolated MPFL and MPFL-TT groups, it observed no difference in complications between the procedures.[36] The remaining 2 studies did not systematically report complications.[19,34] Of note, none of the studies reported more serious complications, such as proximal tibia fracture, which had previously been described (in rare cases) after distal realignment surgery.[49,57,58] Mulliez et al.[36] did report an instance of patellar fracture but did not specify whether it was in the MPFL or MPFL-TT group. The reported complication rates in the analyzed studies were lower than the 26.1% complication rate reported by Shah et al.[37] in a 2012 systematic review on isolated MPFL reconstruction but were within the ranges reported in more recent reviews, which found complication rates as low as 0.46% for major complications and 4.0% for minor complications.[29,30] These results suggest that MPFL reconstruction with combined TT transfer is an effective treatment for patellar instability with no greater risk profile than that of MPFL reconstruction alone.

Study Quality

Although all included studies showed positive and safe outcomes after MPFL reconstruction with combined TT transfer, the strength of recommendation for

this procedure is limited because of the low quality of the available studies. Four of the included studies were Level IV evidence and received a study quality score of less than 50%. A single study was graded as Level II evidence and scored above the 50% mark in the quality assessment.[36] The most common deficiencies in study quality were failure to fully address selection bias,[17,19,34,35] lack of valid and/or reliable outcome variables,[17,19,34,35] failure to control for repeated measures or differences in exposure to treatment,[17,19,34,35] and failure to adequately describe the study population.[17,19,34] Furthermore, only 2 studies were prospective in nature.[34,36] None of the studies comparing MPFL reconstruction with concomitant TT transfer versus isolated MPFL reconstruction included a power analysis to determine if they were adequately powered to identify differences between the procedures,[19,35] and none were randomized controlled trials. However, this may be understandable given the somewhat different indications for these procedures. Although all of the presented studies did contain patient-relevant clinical data, because of the limited quality of the available data, our strength of recommendation[59] for MPFL reconstruction with combined TT transfer for patients with patellar instability attributed to soft-tissue deficiencies and/or bony malalignment is grade B. In addition, the analyzed data do not provide adequate information to make recommendations regarding specific patient populations.

Limitations

There were significant limitations in this study. First, we were only able to identify 5 peer-reviewed articles that reported the outcomes and/or complications of MPFL reconstruction with concomitant TT transfer. The number of subjects in each of these studies was relatively low, and when combined with the small number of studies that we analyzed, this led to a small patient sample in our analysis. Other factors further complicated our analysis, including a high level of heterogeneity among study methodologies, surgical indications, sampling frames, surgical techniques, outcome measures collected, and reporting methods. For instance, only 3 validated outcome measures were reported by 2 or more of the studies (Lysholm score, Kujala score, and KOOS). Similarly, the only outcome scores (Lysholm score, Kujala score, and KOOS) collected preoperatively and postoperatively were found in separate studies.[19,35,36] Finally, the indications for MPFL reconstruction with transfer of the TT are often different than those for isolated MPFL reconstruction. The decision to perform TT transfer is frequently made based on the TT-TG distance. If this distance is elevated, it is thought that the patient will benefit from repositioning of the distal extensor mechanism in a more anatomic position.[2,6,10,12,60] However, the indications for tubercle transfer in the analyzed studies were mixed. Some tubercle transfers were performed routinely with all MPFL reconstructions during a specific period,[17,35] and some were based on the TT-TG distance[19,34,36] or presence of patella alta.[36] This heterogeneity makes a true comparison across studies difficult. In summary, the limitations of our analysis are, in large part, because of the relative paucity and heterogeneity of data examining MPFL reconstruction with concomitant TT transfer.

Although there is a substantial body of evidence supporting the efficacy and safety of isolated MPFL reconstruction, the data analyzed in our study are insufficient to determine which group of patients would benefit from concomitant TT transfer. In addition to anatomic pathology, such as an increased TT-TG distance and trochlear dysplasia, cultural and functional demands may play a role in deciding which procedure to perform. These findings further underscore the need for more robust research in this area.

Conclusions

Reconstruction of the MPFL with concomitant transfer of the TT is a safe and effective procedure, with a relatively low complication rate and favorable results. Although the surgical indications may differ, the outcome and risk profile are similar to those of isolated MPFL reconstruction. Future efforts should be directed at conducting high-quality, well-designed, prospective research to investigate the results of MPFL reconstruction with concomitant TT transfer using responsive, relevant, and reliable outcome measures.

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