



# Reconstruction of the Medial Patellofemoral Ligament for Treatment of Patellofemoral Instability

## A Systematic Review

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**Background:** Growing awareness of the biomechanical contribution of the medial patellofemoral ligament has led to an upsurge in the publication of techniques and trials dealing with reconstructive techniques, warranting a review that includes the most recent evidence.

**Study Design:** Systematic review.

**Methods:** The authors undertook a systematic electronic search and rigorous screening process to find and identify published evidence describing the outcomes of medial patellofemoral ligament reconstruction.

**Results:** Fourteen trials were included for analysis. Although they showed generally excellent outcomes for medial patellofemoral ligament reconstruction modalities, there were several recurring weaknesses. Most were small case series, many had limited follow-up, and a majority employed other adjunctive techniques besides medial patellofemoral ligament reconstruction, making it difficult to distinguish the determining factors in their outcomes.

**Conclusion:** There is limited but growing evidence that a medial patellofemoral ligament-based surgical approach to patellofemoral instability leads to excellent functional outcomes.

**Keywords:** medial patellofemoral ligament (MPFL); reconstruction; patellofemoral instability; patellar dislocation

There is considerable interest in the medial patellofemoral ligament (MPFL) because of its role in patellofemoral instability. This specific disorder constitutes a curable subset of patellofemoral pathology. The incidence of patellar dislocation is 5.8 to 77.8 in 100 000.<sup>19,36</sup> Virtually all acute dislocations cause some degree of macroscopic MPFL damage<sup>23</sup> and anatomic studies suggest that lateral patellar dislocation is frankly impossible without damage to the MPFL.<sup>22</sup> Up to 44% of nonoperatively treated patients go on to suffer redislocation,<sup>44</sup> along with the painful symptoms of chronic instability. This is hardly surprising, as the MPFL provides between 50% and 60% of the innate medial passive resistance to lateral dislocation of the patella.<sup>6,31</sup> These relatively recent insights into the function of the MPFL have led to an upsurge in surgical efforts to address MPFL insufficiency but there is no consensus on

which modality is best. The MPFL, which originates at the posterior aspect of the medial epicondyle and inserts along the superomedial patella and into the deep aspect of the vastus medialis obliquus,<sup>11</sup> is primarily responsible for medializing the patella and keeping it in the trochlear groove, working in conjunction with the lateral retinacula to tether the patella.

The MPFL usually ruptures at its femoral origin upon lateral dislocation of the patella, typically under rotational force with the knee extended. In fact, up to 94% of patients suffer from MPFL rupture after acute patellar dislocation.<sup>33</sup> An MPFL rupture is typically seen in patients with a history of trauma, a recurrent or persisting sensation of instability, anterior knee pain, and/or recurring patellar displacement. Often there is tenderness over the MPFL, a positive J sign and tilt test, and effusion with anterior knee discomfort upon exertion.<sup>15</sup> Indications for surgical reconstruction are persisting or recurring instability, dislocation, and anterior knee pain/discomfort.<sup>13</sup> Surgical management of primary dislocation does not seem to offer any benefit,<sup>4,38,41</sup> even in the case of isolated MPFL repair.<sup>5</sup>

Over 130 distinct techniques for alleviating patellofemoral instability and pain of all origins have been

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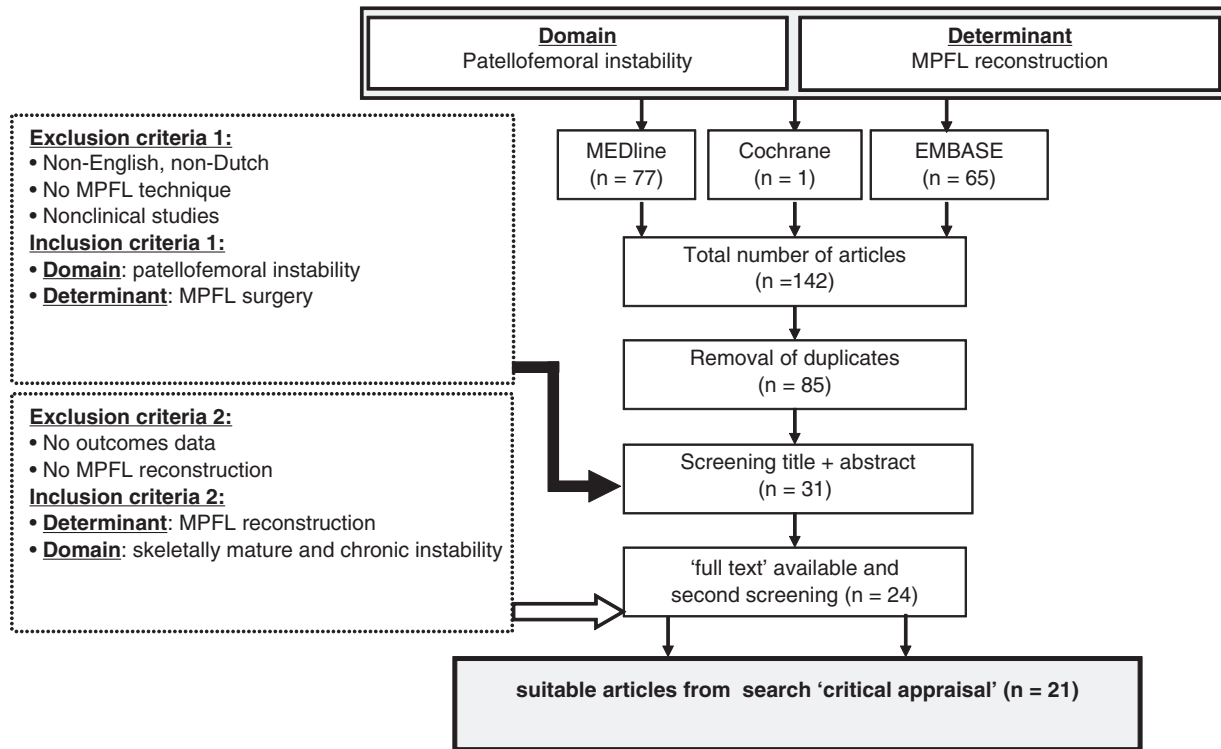


Figure 1. Flowchart illustrating the literature search and selection procedure.

described<sup>26</sup> since 1915.<sup>2</sup> These range from osteotomies (to correct the Q-angle), trochleoplasty (to correct the shape and orientation of the trochlear groove), and numerous soft tissue reconstructions. Among the techniques described that address MPFL insufficiency are realignment, lateral release, repair/reconstruction, and plication techniques.<sup>16</sup> The MPFL reconstruction techniques have been singled out here as the most promising and most logical approach to restore MPFL function, as non-MPFL techniques disturb the native patellofemoral biomechanics and MPFL repair (as opposed to MPFL reconstruction) always involves use of damaged and/or compromised tendon tissue. Various reconstruction procedures using adductor magnus,<sup>8</sup> quadriceps tendon,<sup>40</sup> semitendinosus,<sup>25</sup> gracilis,<sup>34</sup> and synthetic tissue<sup>26</sup> are being applied.

However, there has been no conclusive evidence that 1 surgical modality is superior to others. In the past, surgical results were satisfactory at best. The recognition of the contribution of the MPFL has caused more emphasis to be placed on MPFL modalities, but the case series conducted so far have not yet conclusively demonstrated improved outcomes for any 1 technique.<sup>18,39</sup> In addition, there have been few long-term follow-up trials, but initial results suggest a low incidence of osteoarthritis and redislocation<sup>28</sup> compared with previous techniques. This review is warranted at this time as several recently published trials have been added to the body of evidence, warranting a reinterpretation.

These considerations form the rationale for our review. We opted to focus on functional outcome parameters (postoperative dislocation/subluxation and postoperative

functional outcome scales) because we thought that these outcomes most pertinently describe the symptoms of patellofemoral instability. We also report on the postoperative recovery time, as estimated by time to unassisted full weightbearing, as a rough proxy for operative morbidity.

## METHODS

A systematized electronic search was undertaken using the MEDLINE, EMBASE, and Cochrane databases (summarized in Figure 1). Synonym lists were created for our domain (skeletally mature patellofemoral instability), determinant (MPFL reconstruction), and outcomes and used to generate the search syntax used in the search (Table 1). We searched on domain and determinant only, leaving out outcomes, to ensure maximal content coverage, as is customary in therapy systematic reviews. The search was conducted in October 2008. The results from the 3 databases were compiled and duplicates were removed. The title and abstracts of these were then screened for relevance to the clinical query (inclusion/exclusion criteria 1, Figure 1). We then sought to obtain these articles in full text. Those articles available in full text were then thoroughly screened using the second set of inclusion/exclusion criteria (inclusion/exclusion criteria 2, Figure 1). The resultant articles were then evaluated using the rigorous “critical appraisal” criteria based on the Oxford levels of evidence<sup>30</sup> and adapted for this review (Table 2), to finally yield the articles included in the review.

TABLE 1  
Query Syntax for MEDLINE, EMBASE,  
and the Cochrane Library

Database	Search Strategy
MEDLINE	((Patella[tiab] OR patellar[tiab] OR patellofemoral[tiab]) AND (dislocation[tiab] OR subluxation[tiab] OR instability[tiab] OR maltracking[tiab] OR hyperlaxity[tiab] OR luxation[tiab])) AND ((MPFL[tiab] OR "medial patellofemoral ligament"[tiab]) AND (reconstruction[tiab] OR surgery[tiab] OR surgical[tiab] OR procedure[tiab] OR technique[tiab] OR approach[tiab] OR modality[tiab]))
EMBASE	((Patella:ti,ab OR patellar:ti,ab OR patellofemoral:ti,ab) AND (dislocation:ti,ab OR subluxation:ti,ab OR instability:ti,ab OR maltracking:ti,ab OR hyperlaxity:ti,ab OR luxation:ti,ab)) AND ((MPFL:ti,ab OR "medial patellofemoral ligament":ti,ab) AND (reconstruction:ti,ab OR surgery:ti,ab OR surgical:ti,ab OR procedure:ti,ab OR technique:ti,ab OR approach:ti,ab OR modality:ti,ab))
Cochrane Library	((Patella OR patellar OR patellofemoral) AND (dislocation OR subluxation OR instability OR maltracking OR hyperlaxity OR luxation)) AND ((MPFL OR "medial patellofemoral ligament") AND (reconstruction OR surgery OR surgical OR procedure OR technique OR approach OR modality))

MPFL, medial patellofemoral ligament; tiab (MEDLINE) and ti,ab (EMBASE) signify searches in title and abstract fields.

## RESULTS

We identified 22 articles suitable for critical appraisal (Table 2) from both our initial and revised search. Of these, we included 14 (Table 3) in our final analysis. These papers represent the best available evidence and consist entirely of case series (level IV evidence) and therapeutic series (level III) and were generally performed with a limited number of participants. This may be indicative of the inherent difficulty in performing classical double-blind randomized trials in a surgical context. Table 3 summarizes the main outcomes of the included articles. We now discuss each article in brief.

The trial by Nomura et al<sup>24</sup> demonstrated the midterm (mean follow-up, 71 months) efficacy of synthetic graft MPFL reconstruction. Twenty-four patients (27 knees) with recurrent patellofemoral instability underwent synthetic graft MPFL reconstruction and medial reticulum slip coverage; 10 knees also underwent lateral release. Patellar shaving/drilling was also performed in some patients. They found 15 excellent, 11 good, and 1 fair/poor knee on the Crosby Insall grading system and only 1 postoperative dislocation/subluxation. The apprehension test was positive in 2 knees postoperatively.

Ellera Gomes et al<sup>10</sup> used a semitendinosus autograft reconstruction with lateral release in 15 patients (16 knees) with chronic patellar instability followed for an average of 5 years. They found 11 excellent, 4 good, and 1 poor knee by Crosby Insall, with negative apprehension test in 15 of 16 knees. They do not report the number of postoperative dislocations/subluxations.

Schöttle et al<sup>35</sup> investigated 12 patients (15 knees) with patellofemoral instability who underwent MPFL reconstruction with semitendinosus autograft fixed distally by suture anchors. Additionally, 8 knees also underwent a tibial tubercle transfer (TTT) for large Q-angles. They found 13 of 15 excellent or good by "subjective questionnaire" and a mean Kujala score of 85.7 (from 55.0) at follow-up (mean, 47 months). One patient reported postoperative dislocation and 3 knees had a persistent apprehension sign. Interestingly, they found no differences between patients with trochlear dysplasia and those without.

Cossey and Paterson<sup>7</sup> performed a combined lateral reticulum release, distal TTT, and reconstruction of the MPFL using medial reticulum tissue in 19 patients (21 knees) with lateral instability who had failed conservative treatment, followed for an average of 23 months. There were no recurrent dislocation/subluxations. The average Lysholm score was 95.6 and all had good/excellent postoperative Turba scores. The authors found that the addition of the MPFL reconstruction yielded superior results, but this combined approach makes it difficult to pinpoint the exact contribution of the different component procedures performed. Nonetheless, the results are suggestive.

Nomura and Inoue<sup>25</sup> included 12 patients with recurrent patellar dislocation for a "hybrid" semitendinosus autograft MPFL reconstruction (incorporating the proximal MPFL remnant into the tendon graft insertion) followed for a minimum of 2 years (mean, 4.2 years). Three knees also underwent a lateral release. They found 8 excellent, 2 good, and 2 fair on the Insall criteria and an average Kujala score of 96.0 (from 56.3); there were no dislocations or subluxations and no apprehension sign at follow-up.

Steiner et al<sup>42</sup> retrospectively selected 34 patients with chronic patellofemoral instability and trochlear dysplasia for treatment by MPFL reconstruction with 3 relatively similar autograft procedures. They employed an adductor autograft except in cases of more severe dysplasia, where they used a bone-quadriceps tendon or bone-patellar tendon for added strength. The patients, who were followed for an average of 66.5 months, had an average Kujala score of 90.7 (from 53.3), an average Lysholm score of 92.1 (from 52.4), and a Tegner activity score of 5.1 (from 3.1), with no dislocations and no significant differences between the 3 technique groups. This study suggests that patients with patellofemoral instability and trochlear dysplasia can be adequately treated with a properly selected and treated MPFL reconstruction alone. The different techniques used here limit the scope for comparison between the subgroups, however.

Thaunat and Erasmus<sup>43</sup> retrospectively looked at 20 patients (23 knees) with patellofemoral instability who were followed for 2 years, on average. They underwent a gracilis autograft nonisometric MPFL reconstruction

TABLE 2  
Critical Appraisal

Author(s) (Year of Publication)		Ahmad et al (2009) <sup>1</sup>	Camanho et al (2009) <sup>3</sup>	Ronga et al (2009) <sup>32</sup>	Lim et al (2008) <sup>17</sup>	Gomes (2008) <sup>14</sup>	Christiansen et al (2008) <sup>5</sup>	Watanabe et al (2008) <sup>15</sup>	Panagiotopoulos et al (2006) <sup>31</sup>	Sillanpää et al (2008) <sup>37</sup>	Thaumat and Erasmus (2007) <sup>43</sup>	Nomura et al (2007) <sup>27</sup>	Steiner et al (2006) <sup>42</sup>	Mikashima et al (2006) <sup>21</sup>	Nomura and Inoue (2006) <sup>25</sup>	Fernandez et al (2005) <sup>2</sup>	Cossey and Paterson (2005) <sup>7</sup>	Dele et al (2005) <sup>8</sup>	Schöttle et al (2005) <sup>15</sup>	Mikashima et al (2004) <sup>20</sup>	Ellera Gomes et al (2004) <sup>10</sup>	Drez et al (2001) <sup>9</sup>	Nomura et al (2000) <sup>24</sup>
Relevance	Domain <sup>a</sup>	+	+/-	+	+/-	+/-	+	+	+/-	+	+	+	+	+	+	+	+	+/-	+	+	+	+	+
	Determinant <sup>b</sup>	+	-	+	+/-	+	+	+	+	+	+	+/-	+	+	+	+	+/-	+/-	+	+/-	+	+/-	+
	Outcome <sup>c</sup>	+	+	+/-	+	+/-	+	+	+	+	+	+	+	+	+	+/-	+	+	+	+	+/-	+	+
Validity	Research question <sup>d</sup>	+	+	+	+/-	+	+/-	+	+/-	+	+/-	+	+	+/-	+	+	-	+	+	+/-	+	+/-	+/-
	Sample size <sup>e</sup>	-	+	-	-	-	+	+	+	+	-	+	-	+	-	+	-	-	-	+	+	-	+
	Defined baseline <sup>f</sup>	+	-	+/-	+/-	-	+/-	+	-	-	-	-	+/-	+/-	-	+/-	-	+	-	+/-	+/-	-	+/-
	Observer blinding <sup>g</sup>	?	?	?	?	?	?	?	?	?	?	?	+/-	?	?	?	?	?	?	?	?	?	?
	Adequate follow-up <sup>h</sup>	+/-	+/-	+/-	-	+/-	+/-	+	-	+	+/-	+	+/-	+/-	+/-	+/-	+/-	+	+	+/-	+	+/-	+
	Amount of missing data <sup>i</sup>	?	-	?	?	+/-	?	?	?	?	?	?	+	?	?	?	+	-	+	-	-	+/-	?
	No selection bias <sup>j</sup>	?	-	?	?	-	?	?	?	?	?	?	-	?	-	?	?	-	?	?	?	?	+/-
	Standardization <sup>k</sup>	+/-	+/-	+/-	?	+	?	+/-	+/-	?	?	?	?	-	?	?	+/-	?	?	?	?	?	?
	Study design (level of evidence) <sup>l</sup>	Case series (IV)	Therapeutic study (III)	Case series (IV)	Therapeutic study (III)	Therapeutic study (III)	Case series (IV)	Therapeutic study (III)	Case series (IV)	Therapeutic study (III)	Case series (IV)	Case series (IV)	Case series (IV)	Therapeutic study (III)	Case series (IV)	Case series (IV)	Case series (IV)	Case series (IV)	Case series (IV)	Case series (IV)	Case series (IV)	Case series (IV)	Therapeutic study (III)
Applicability <sup>m</sup>	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	

Scoring items based on different validity evaluation forms.<sup>20-22</sup> MPFL, medial patellofemoral ligament.

<sup>a</sup>(+) Only patients with recurrent/persistent patellofemoral instability; (+/-) patellofemoral instability, possibly with heterogeneity.

<sup>b</sup>(+) MPFL reconstruction technique; (+/-) MPFL reconstruction with other stabilizing procedures; (-) no formal MPFL reconstruction.

<sup>c</sup>(+) Numerical functional outcomes and displacement and subluxation separately recorded; (+/-) functional outcomes and dislocation/subluxation mentioned.

<sup>d</sup>(+) Well defined, in introduction; (+/-) well defined, after reading article; (-) not well defined.

<sup>e</sup>(+) 1:10 rule for number of variables; (-) not enough patients for variables.

<sup>f</sup>(+) Complete; (+/-) incomplete; (-) none.

<sup>g</sup>(+/-) described, not performed; (?) not described.

<sup>h</sup>(+) >5 years; (+/-) 2-5 years; (-) <2 years.

<sup>i</sup>(+) <10%; (+/-) 10%-20%; (-) >20%; (?) not described.

<sup>j</sup>(-) Not adequately or consistently addressed; (?) not described.

<sup>k</sup>(+) Inclusion, baseline, follow-up, and measurement described; (+/-) partially described; (?) not described.

<sup>l</sup>Based on Oxford Centre for Evidence-based Medicine – Levels of evidence (May 2001).<sup>27</sup>

<sup>m</sup>Yes: at least a (+) in domain, determinant and/or outcome; No: (-) in determinant or low methodological quality or no comparable outcomes (more (-) or (?) than (+) or (+/-) in validity section).

designed to offer maximal passive restraint when the knee is in extension. They found no redislocations and no positive apprehension signs. The mean Kujala score was 93.0. Additionally, they found no significant differences between different subgroups separated by preoperative patella height (patella alta) or trochlear dysplasia (Dejour classification). The positive outcomes seen in this small sample suggest that the isometry of the graft is not necessary for good outcome and that anisometry can contribute to the functional stability of the patellofemoral joint.

Nomura et al<sup>27</sup> reviewed 22 former patients (24 knees), at a mean follow-up of 11.9 years, who had undergone MPFL reconstruction with a synthetic graft. Lateral release was also performed in 14 knees. They observed Crosby Insall results at final follow-up of 11 excellent, 10

good, and 3 fair/poor. There were 2 cases of redislocation/subluxation. The mean Kujala score was 94.2 (from 63.2). The Crosby Insall osteoarthritis classification was none to mild in 21 knees and moderate in 3 (from 23 and 1, respectively). This study suggests the long-term superiority of MPFL reconstruction over older stabilizing procedures.

Sillanpää et al<sup>37</sup> retrospectively selected patients with recurrent patellar dislocation for comparison of adductor tendon tenodesis (18 knees) MPFL reconstruction with distal patellar realignment by the Roux-Goldthwait procedure (29 knees) and followed them for an average of 10.1 years after their initial surgery. They observed 1 redislocation in the adductor tenodesis group and 3 in the Roux-Goldthwait group and 2 painful subluxations in each group.

Mean Kujala scores were 88.0 and 86.0, respectively. There was significantly more osteoarthritis in the Roux-Goldthwait group (5 vs. 0), assayed radiologically by the International Cartilage and Repair Society criteria. This article directly compares an (early) MPFL reconstruction technique with a traditional stabilization procedure and demonstrates a slight advantage of MPFL reconstruction in long-term results.

Christiansen et al<sup>5</sup> applied either a MPFL reconstruction with gracilis autograft (fixed distally with 2 drill holes) alone (N = 32) or in combination with TTT (N = 12) to patients with chronic patellofemoral instability and trochlear dysplasia, respectively. They were followed for 12 to 32 months (mean, 22 months). One dislocation and 3 subluxations were observed and 1 patellar fracture. Kujala scores improved from 46 to 84 points on average. It has been suggested that the dislocation/subluxation rate is relatively high in this group because of the method of distal fixation, which places undue stress on the medial patellar edge, with the drill holes acting as stress risers. The patellar fracture was caused by surgical error in placing the patellar drill holes.

Watanabe et al<sup>45</sup> also compared MPFL reconstruction using a hamstring (semitendinosus or gracilis) tendon with TTT to reconstruction without TTT in 40 patients (42 knees) with recurrent patellar dislocation. At average follow-up of 4.3 years, the Lysholm scores improved from 70 to 92 and 72 to 90 in the MPFL (29 knees) and the MPFL + TTT (13 knees) groups, respectively. A subjective knee function visual analog scale was significantly higher in the MPFL group (91 vs 81). This study also seems to demonstrate that MPFL reconstruction alone yields at least equally good results in patients with recurrent patellar dislocation.

Gomes<sup>14</sup> compared 2 MPFL reconstruction techniques. He selected 2 matched-pair groups of 12 patients each for either adductor magnus rigid or semitendinosus dynamic femoral fixation, with the thought behind the comparison being that because the grafts are more rigid than the native MPFL, a dynamic graft using the native adductor magnus insertion will better approximate the normal MPFL function. Lateral release was also performed as part of the adductor procedure. At a mean follow-up of 53 months, 1 of the patients in the adductor magnus group had suffered a subluxation (none in the semitendinosus group). There were no significant differences on the scale of activities of daily living, a subjective functional score (72.8 vs 72.7, respectively). This small study demonstrates some of the complexities associated with reconstructed MPFL biomechanics and how difficult it is to capture the differences between different treatment groups.

Ahmad et al<sup>1</sup> included 20 patients in a study to evaluate their "docking" MPFL technique. This technique seeks to accurately replicate the physiologic function of the MPFL by using a semitendinosus autograft (or allograft in 4 patients) and fixing it to the medial aspect of the patella using tunnels and to the medial femoral epicondyle using a bone anchor. The graft is then sutured along its length into the inferior margin of the vastus medialis obliquus, to dynamize the graft. The patients were followed for an average of 31 months using the Tegner (3.6 to 5.6 at end

of study), Kujala (from 50 to 89 at end of study), and Lysholm (50 to 89 at end of study) scores, as well as physical and radiologic outcome parameters. Lateral release was also performed in selected patients.

Ronga et al<sup>32</sup> selected 28 patients with recurring instability without anatomic predisposition for treatment with MPFL reconstruction using a hamstring (gracilis or semitendinosus) tendon fixed to the patella using transverse tunnels and to the medial epicondyle using a bone screw. They were followed for an average of 3.1 years and had marked improvement of mean Kujala (45 to 83) and modified Cincinnati (52 to 89) scores. Three patients reported a traumatic redislocation within the follow-up period.

Redislocation rates and the subjective functional outcomes used are reproduced (Table 3). For our purposes, the purely clinical and the radiologic outcomes are not as germane and hence not reproduced. As shown by Table 3, there is an overall tendency toward a low redislocation/subluxation rate and excellent subjective functional outcomes in our included articles. Additionally, there is a spectrum of adjunctive patellofemoral-stabilizing surgical techniques employed alongside MPFL reconstruction in the majority of the trials, either in the whole sample or a subset. These range from osteotomies, to lateral reticulum release, to medial reticulum plication, to combinations. As no 2 trials employed the same adjunctive techniques, it is difficult to compare their outcomes on the basis of the MPFL reconstruction techniques. Furthermore, many trials were conducted retrospectively and/or the patient selection/inclusion criteria were ill-defined, introducing the possibility of selection bias. We also found that there was considerable variance in which patient inclusion criteria and baseline parameters were reported, among those studies in which they were reported at all, a fact that further reduced the scope for comparison between these data sets.

## CONCLUSION

The studies found are too small, too heterogeneous, employ too many adjunctive techniques, and do not have sufficient follow-up times to clearly demonstrate the superiority or inferiority of any particular MPFL technique, but several important trends do emerge from a comparative analysis of this literature. Namely, MPFL reconstruction approaches seem to offer superior or at least equal functional outcomes compared with older realignment and stabilization techniques with less perioperative morbidity and fewer long-term complications. The trials reviewed are not conclusive, however, and more work is needed to confirm this.

## DISCUSSION

The tentative conclusions that we can draw have been distilled from the combined results of our selection of the best evidence available, but through our process of critical appraisal, we found that there are recurring methodological deficiencies in the literature with regard to sample size, follow-up period, and varying confounding adjunctive

TABLE 3  
Outcomes of Included Articles<sup>a</sup>

Trial	Procedure(s)	No. of Patients/ Knees	Mean Follow-up (range) if available	Postoperative Dislocations/ Subluxations <sup>b</sup>	Subjective (Functional) Outcomes	Remarks	Weightbearing
Nomura et al (2000) <sup>24</sup>	Artificial ligament graft with medial reticulum slip coverage; lateral release in some	24/27	71 mo (49-114)	1	Crosby Insall excellent or good: 26/27	Also performed lateral release	10 days
Ellera Gomes et al (2004) <sup>10</sup>	Semitendinosus graft fixed with bone tunnels and lateral release	15/16	5 y	?	Crosby Insall excellent or good: 15/16	Also performed lateral release	12 days
Schöttle et al (2005) <sup>35</sup>	Semitendinosus graft; TTT in some patients	12/15	47 mo	0/0	Kujala 85.7	TTT in some patients	6 weeks
Cossey and Paterson (2005) <sup>7</sup>	MPFL reconstruction using medial retinaculum and TTT with lateral release	19/21	23 mo (11-37)	0/0	Lysholm, 95.6; Turba score: good/excellent in all	3 simultaneous techniques; follow-up	0 days (with splint); 4-6 weeks
Nomura and Inoue (2006) <sup>25</sup>	Semitendinosus graft fixed with bone tunnel	12/12	50 mo (37-67.2)	0/0	Kujala 96		13 days
Steiner et al (2006) <sup>42</sup>	MPFL reconstruction with adductor, quadriceps, or patellar graft	34/34	66.5 mo (24-130)	0/0	Kujala, 90.7; Lysholm, 92.1	Suggests that trochlear dysplasia can be treated with properly selected and tensioned MPFL grafts	0 days; knee immobilizer, 4 weeks
Thaunat and Erasmus (2007) <sup>43</sup>	Gracilis tendon autograft with graft tensioning in extension	20/23	27.6 mo (9-54)	0/0	Kujala 93	Group with preexisting patella alta and/or trochlear dysplasia had similar outcomes	4 weeks
Nomura et al (2007) <sup>27</sup>	Artificial ligament graft with medial reticulum slip coverage	22/24	11.9 y (8.5-17.2)	2	Kujala 94.2 Crosby/Insall good or excellent: 21/24 Crosby Insall OA scale none/mild: 23/24 moderate in 1/24	Same technique as described above (in <sup>20</sup> )	10-17 days
Sillanpää et al (2008) <sup>37</sup>	Adductor magnus tenodesis	15/15	10.1 y (8-13)	1	Kujala 88	MPFL reconstruction compared with Roux-Goldthwait procedure in this trial; results reproduced for MPFL arm only	0 days; knee immobilization, 2-4 weeks
Christiansen et al (2008) <sup>4</sup>	Gracilis tendon autograft with TTT in some patients	44/44	22 mo (12-32)	1	Kujala 88	TTT in some patients; follow-up limited	0 days with a brace; free after 2-6 weeks
Watanabe et al (2008) <sup>45</sup>	MPFL reconstruction with semitendinosus or gracilis with or without TTT	42/44	4.3 y (1.5-8.1)	?	Lysholm 92.4	Compared MPFL reconstruction with or without TTT; no real differences in results	2-4 weeks
Gomes (2008) <sup>14</sup>	Adductor magnus rigid compared with semitendinosus dynamic femoral fixation	24/24	53 mo (30-71)	0/1	"Scale of activities of daily living" 72.7		7 days
Ahmad et al (2009) <sup>1</sup>	Semitendinosus autograft or allograft fixed with patellar tunnel with lateral release in some patients	20/20	31 mo (24-39)	0/0	Kujala, 88; Lysholm, 89	Also performed lateral release	0 days with brace, 6 weeks without
Ronga et al (2009) <sup>32</sup>	Semitendinosus or gracilis autograft fixed with a patellar tunnel	28/28	3.1 y (2.5-4)	?/3	Kujala 83		6 weeks; 2-6 weeks in splint

<sup>a</sup>TTT, tibial tubercle transfer; MPFL, medial patellofemoral ligament.

<sup>b</sup>One number indicates no separate reporting; (?) indicates not reported.

surgical procedures. Therefore, the following points are worth bearing in mind when considering the conclusions presented here. The frequently encountered small sample size may indicate a selection bias, reporting bias, or both. The varying follow-up might indicate a significant amount of “missing” events and complications occurring after the follow-up period, in some trials. Most importantly, however, the addition of adjunctive patellofemoral correction procedures constitutes an incorrigible confounder, undermining any potential insights into the efficacy of MPFL reconstruction that these trials might otherwise have offered. This mitigates any conclusions drawn from these data concerning the efficacy of MPFL reconstruction but does not make them impossible.

The rationale of “normalizing” patellofemoral radiologic ratios has been used as a defense for the addition of these procedures by the authors of these trials in all or some of their patients. We posit here that this rationale may need to be rethought, as patellofemoral instability is fundamentally a clinical entity rather than radiologic one. Correcting otherwise functional individual anatomic ratios in a posttraumatic (rather than developmental) pathologic entity may expose patients to unnecessary procedures that do not address the immediate cause of their pathoanatomic problem. This may be the case in patients with mild to moderate osseous malalignment. The newfound understanding of the role of the MPFL has facilitated this awareness by providing a more patient-friendly and biomechanically rational alternative to serve as a basis for comparison to older approaches. The fact that the data here, despite their limitations, invariably seem to show excellent outcomes for MPFL reconstruction techniques across a spectrum of adjunctive procedures tentatively supports this conclusion. It is further compounded by preliminary anatomic in vitro studies,<sup>28,29</sup> which demonstrate the bio-kinematic viability of MPFL reconstruction, even in models of osseous malalignment.

Osseous realignment surgery still has an important part to play in patients with severe malalignment and it remains obvious that osseous malalignment plays a part in predisposing individuals to clinical patellofemoral instability. However, in instability cases with milder pre-existing malalignment, MPFL reconstruction should be considered as an adjunct at the very least, in light of the clinical evidence of its central pathophysiologic role. Furthermore, we suggest that in selected cases of mild to moderate underlying malalignment and (traumatic) instability, carefully selecting an appropriate MPFL reconstruction technique potentially removes the need for major realignment surgery. The addition of MPFL reconstruction in the therapeutic arsenal justifies a review of the indications for extensive realignment procedures, with MPFL reconstruction offering a less invasive option or adjunct in patients with traumatic patellofemoral instability and mild to moderate osseous malalignment.

In closing, the literature reviewed here tentatively suggests that MPFL reconstruction is a promising approach toward alleviating patellofemoral instability that compares favorably with previous procedures. Further research is

warranted to further explore this and to demonstrate the relative efficacy of the different reconstruction techniques, with particular attention to the methodologic quality of future trials.

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