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REVIEW ARTICLE

Medial Patellofemoral Ligament Reconstruction is Preferred to Repair or Reefing for First-Time Patellar Dislocation: A Systematic Review and Meta-analysis

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Abstract

Purpose The purpose of this systematic review aimed to investigate the clinical outcome of medial patellofemoral ligament (MPFL) reconstruction, MPFL repair and medial reefing for patients with first-time patellar dislocation.

Methods Databases of PubMed, EMBASE, Cochrane Library and Web of Science were searched up to May 8, 2022. Only articles treating first-time patellar dislocation with MPFL reconstruction, MPFL repair and medial reefing were included in the analysis. Eligible identification, data extraction, quality assessment and statistical analysis were performed by two independent reviewers. The primary outcome measures were the incidences of postoperatively redislocation and reoperation. The second outcomes were the Kujala functional score and complications (including infection, osteoarthritis, and loss of range of motion).

Results Twenty-two studies involving 668 patients met the inclusion criteria. Of which, four studies involving 126 patients were in MPFL reconstruction group, ten studies involving 220 patients in MPFL repair group and 9 studies involving 322 patients in medial reefing group. Our results showed that the MPFL reconstruction (1.8%, 95% CI − 0.5 to 4.0%) had a significantly lower rate of postoperative redislocation and reoperation rate than the MPFL repair (15.4%, 95% CI 5.2–25.7%) and medial reefing (18.0%, 95% CI 9.3–26.7%). Besides, no significant differences were found in the Kujala score and complication rate among the three treatments.

Conclusion The available evidence demonstrated that MPFL reconstruction could achieve significantly lower redislocation rate and reoperation rate than MPFL repair and medial reefing after first-time patella dislocation. Furthermore, there was not enough evidence to reveal that MPFL reconstruction provided better functional outcome compared with MPFL repair and medial reefing. MPFL reconstruction is a preferred surgical treatment for patients with first-time patellar dislocation.

Level of Evidence Level IV, systematic review of Level I–IV.

Keywords Acute patellar dislocation · Medial patellofemoral ligament · MPFL reconstruction · MPFL repair · Medial reefing

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Introduction

Acute first-time lateral patellar dislocation is the most common knee injury among children who present with acute knee hemarthrosis [44]. The prevalence of first-time patellar dislocations is estimated to be 29 cases per 100,000 person-years among adolescents [37]. First-time patellar dislocation can result in knee pain and limited activity level, osteochondral injuries [14]. Potential long-term consequences of first-time lateral patellar dislocation are symptomatic patellofemoral arthritis with a cumulative incidence as high as 39–49% at 25 years [38].

Over the past decade, some literatures [12, 29, 36, 43, 44] have focused on the subject of whether these first-time patellar dislocations should be managed with surgical or conservative treatment. A Cochrane reviews [43] found that although there is some evidence to support surgical over non-surgical management of primary patellar dislocation in the short term, the quality of this evidence is very low because of the high risk of bias and the imprecision in the effect estimates. The available evidence suggests that surgery was superior to non-surgical treatment to reduce the redislocation rate. However, the superiority of either surgical or non-surgical treatment in functional outcomes did not conclude [12, 29, 36, 44].

Currently, various surgical techniques have been used for patients with first-time patellar dislocation, including medial reefing repair [1], medial patellofemoral ligament (MPFL) repair [19] and MPFL reconstruction [5]. These procedures have been acknowledged to reduce recurrent dislocation rates after surgery. A recent meta-analysis by Previtali et al. [33] revealed that MPFL reconstruction and medial patellofemoral soft tissue surgery procedures were both effective in preventing redislocation for patients with recurrent patellar dislocation. Nonetheless, the best surgical treatment for first-time patellar dislocation has yet to be identified.

Hence, we conducted a comprehensive systematic review to evaluate all eligible studies to examine the clinical outcomes of different surgical treatments (MPFL reconstruction, MPFL repair and medial reefing) for patients with first-time patellar dislocation. The hypothesis of our study was that MPFL reconstruction for first-time patellar dislocations would provide superior clinical outcomes than MPFL repair and medial reefing repair.

Materials and Methods

This systematic review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) guidelines [25]. This study was registered in the "International Prospective Register of Systematic Reviews" (PROSPERO).

Search Method

A computerized literature search was conducted through the PubMed, Cochrane Library, EMBASE and Web of Science for relevant articles from inception to May 8, 2022. Search terms included 'first time OR acute OR primary OR traumatic', 'Patellofemoral OR patellar', 'dislocation OR instability', 'medial patellofemoral ligament OR MPFL reconstruction OR repair OR medial reefing'. We conducted literature search using Medical Subject Headings and free text terms. Additionally, reference lists of identified articles and related review were also manually searched to identify any additional relevant papers. Two investigators conducted the literature search independently.

Inclusion and Exclusion Criteria

All the identified studies from original searches were assessed based on the following inclusion criteria: (1) subjects were patients who were diagnosed with first-time patellar dislocation, (2) the MPFL reconstruction was defined as MPFL reconstruction using autograft or allograft; MPFL repair was defined as repair the MPFL using suture or anchors at patellar or femoral insertion site; medial reefing was defined as repair of the medial capsule or medial retinacular with suture, (3) studies evaluated postoperative recurrence rates and functional outcomes, (4) all included studies were only English language studies.

Exclusion criteria included the following: (1) articles reported data in patients with recurrent patellar dislocations, (2) Patients with bony abnormalities or family history as presence of these factors affects the outcome, (3) articles reported the outcomes of redislocations or patient-report outcomes, (3) animals or cadaveric studies, letters, comments, editorials, reviews and protocols.

Data Extraction

Data abstraction was conducted by the two authors independently. Any discrepancies between the two authors were solved by discussion. The following information was collected from the extracted data: the first author's name, publication year, study design, location, study participants, mean age, gender, the methods of surgical techniques, redislocation rate, duration of follow-up and clinical outcomes, such as the Kujala score. The primary outcome measures in the present systematic review were the incidences of postoperatively redislocation and reoperation. The second outcomes were the Kujala functional score and complications (including infection, osteoarthritis, and loss of range of motion).

Methodological Assessment

The methodological quality of randomized control trials was evaluated according to the Cochrane Quality Assessment Tool [20], which consisted of five domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Quality assessment of non-randomized studies was assessed based on MINORS (methodological index for non-randomized studies) [42]. A maximum score of 16 is available for non-comparative studies and 24 for comparative studies.

Statistical Analysis

The statistical analyses were conducted through OpenMeta [Analyst] (Centre for Evidence-Based Medicine). The interval of confidence was set at 95%. The mean difference (MD) with 95% confidence intervals (CIs) was used for continuous variables. For dichotomous results, an odds ratio (OR) effect measure with 95% CIs was used. Homogeneity among included studies was tested using the Q statistic and the I^2 statistic. If there was high homogeneity with I^2 value > 50%, a random effect model was used; otherwise, a fixed-effect model was performed. If the outcome identified more than ten studies, publication bias was evaluated through visual analysis of the funnel plots. The binary results were assessed by Pearson chi-square test, and continuous results with the pooled estimated mean were assessed by one-way analysis of variance and Student 2-tailed t test. A p value less than 0.05 was considered statistically difference.

Results

Search Results

A total of 685 publications were identified through the search strategy, of which 128 publications were included once duplicates were removed. 557 articles were initially screened by title and abstract, which resulted in further exclusion of 510 articles for various reasons. The remaining 47 articles underwent a full-text review. Of which, 25 papers were excluded because 5 papers used the Roux–Goldthwait technique, 8 papers used the lateral retinacular release, 4 paper did not provided available data and 8 papers focused on recurrent patellar dislocation. Ultimately, 22 eligible articles [1–3, 5, 8–11, 13, 16, 17, 21, 24, 26–28, 30–32, 40, 41, 49] were

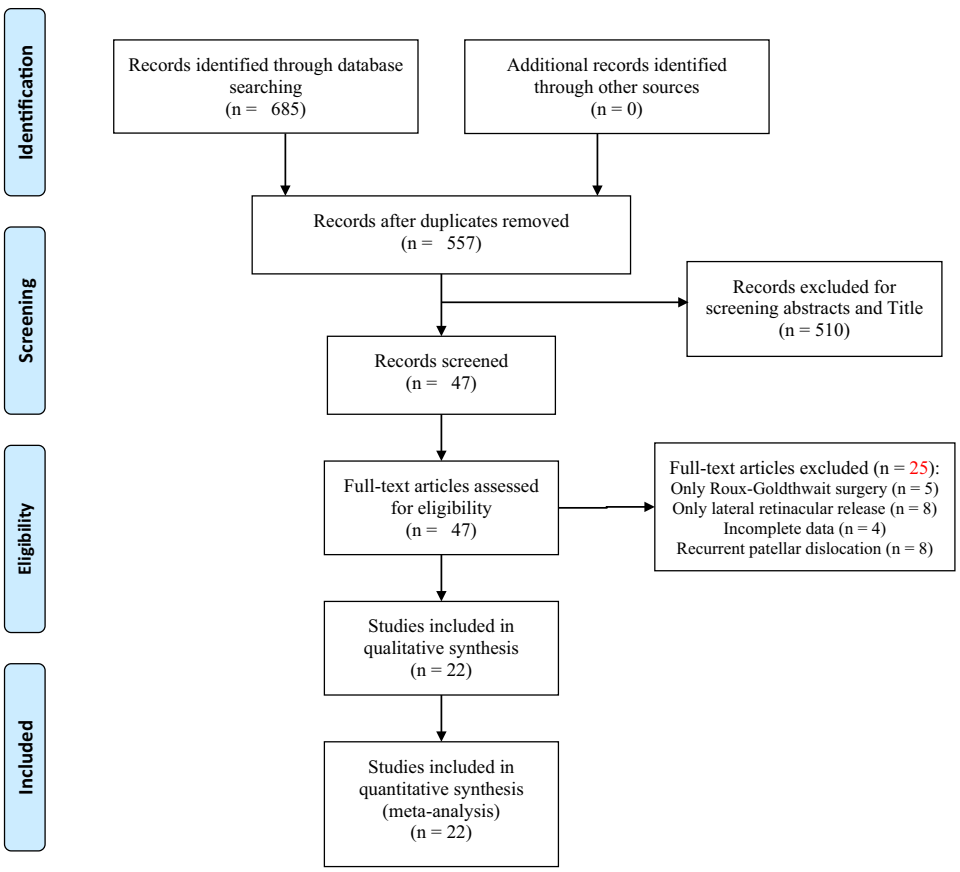

Fig. 1 PRISMA Flow Diagram

included in our review (Fig. 1). Search agreement was sought between reviews on the title (κ = 0.61, moderate), abstract (κ = 0.77, substantial), and full-text (κ = 0.98, substantial).

Study Characteristics

The basic information of included studies was summarized in Table 1 and Table 2. A total of 22 studies involving 668 patients were included for our systematic review. Of which, 4 studies [5, 13, 16, 49] involving 126 patients were in MPFL reconstruction group, 10 studies

Table 1 Characteristics of included studies

First author (year)	Country	Study design	No. of patients	Age (years)	Gender (M/F)	Surgical techniques	Level of evidence	MINORS
Ahrend [1]	Germany	Case series	55	18.6	32/23	Medial reefing repair	IV	13 of 16
Apostolovic [2]	Serbia	Prospective	14	13.1	5/9	Medial reefing repair	II	17 of 24
Askenberger [3]	Sweden	Randomized	37	13.2	19/18	MPFL repair with suture anchors at patellar or femoral site	I	NA
Bitar [5]	Brazil	Randomized	21	23.9	9/12	MPFL reconstruction using patellar tendon	I	NA
Buchner [8]	Germany	Retrospective	37	19.9	21/16	Medial retinaculum repair	III	17 of 24
Camanho [9]	Brazil	Randomized	17	24.6	6/11	MPFL repair with suture at patellar or with anchors at femoral site	I	NA
Cash [10]	USA	Retrospective	16	21.7	NR	Medial reefing repair	III	17of 24
Christiansen [11]	Denmark	Randomized	42	20	24/18	MPFL repair with suture anchors at femoral site	I	NA
Gurusamy [13]	USA	Retrospective	30	14.2	17/13	MPFL reconstruction with allograft	III	18 of 24
Ibrahim [16]	Kuwait	Case series	45	22.8	17/28	MPFL reconstruction with hamstring tendon	IV	12 of 16
Ji [17]	China	Randomized	32	20	11/19	MPFL repair with suture anchors at femoral site	I	NA
Lee [21]	China	Retrospective	11	21	4/7	MPFL repair with suture anchors at patellar or femoral site	III	19 of 24
Mariani [24]	Italy	Case series	17	21	11/6	MPFL repair with PDS suture at patellar site	IV	13 of 16
Nikku [27]	Finland	Randomized	70	19.5	18/52	Medial reefing repair	I	NA
Nikku [26]	Finland	Randomized	70	19.5	18/52	Medial reefing repair	I	NA
Nomura [28]	Japan	Case series	5	19.8	2/3	MPFL repair with spiked washer and cancellous screw at femoral site	IV	11 of 16
Palmu [30]	Finland	Randomized	36	13.0	9/27	MPFL repair with suture anchors at patellar or femoral site, lateral release	I	NA
Petri [31]	Germany	Case series	40	22.4	26/14	MPFL repair with suture at patella or femoral site	IV	11 of 16
Petri [32]	Germany	Randomized	12	27.2	8/4	Repairs including mainly suture and optional tightening of the ruptured medial structures	I	NA
Sillanpää [40]	Finland	Prospective	30	20	29/1	Medial reefing repair	II	19 of 24
Sillanpää [41]	Finland	Randomized	18	20	17/1	Medial retinaculum repair	I	NA
Zheng [48]	China	Prospective	30	18.3	14/16	MPFL reconstruction tibialis anterior allograft	II	19 of 24

MPFL medial patellofemoral ligament, *MINORS* methodological index for non-randomized studies, *NA* not applicable

Table 2 Results of different surgical treatment

Outcomes	MPFL reconstruction	MPFL repair	Medial reefing	Statistical analysis (χ^2 or F, p value)		
				Rec vs. Rep	Rec vs. Ref	Rep vs. Ref
Re-dislocation	1.8%	15.4%	18.0%	$\chi^2=10.111$, $p=0.001^*$	$\chi^2=16.269$, $p=0.000^*$	$\chi^2=1.110$, $p=0.292$
Re-operation	1.7%	3.7%	4.9%	$\chi^2=4.129$, $p=0.031$	$\chi^2=5.853$, $p=0.016^*$	$\chi^2=0.727$, $p=0.394$
Kujala score	88.5	88.7	89.5	$F=0.251$, $p=0.875$	$F=0.251$, $p=0.534$	$F=0.251$, $p=0.572$
Complications	2.0%	1.8%	1.0%	$\chi^2=0.008$, $p=0.928$	$\chi^2=1.452$, $p=0.228$	$\chi^2=1.470$, $p=0.225$

Rec MPFL reconstruction, *Rep* MPFL repair, *Ref* medial reefing

$^*p<0.05$

[3, 9, 11, 17, 21, 24, 28, 30, 31] involving 220 patients in MPFL repair group and 9 studies [1, 2, 8, 10, 26, 27, 31, 40, 41] involving 322 patients in medial reefing group. The mean age was 19.81 years (range 14.2–23.9 years) in the MPFL reconstruction group, 19.44 years (range 13.0–24.6 years) in the MPFL repair group and 19.5 years (range 13.1–27.2 years) in the medial reefing group. The proportion of females was 52.1% among MPFL reconstruction group, 52.2% among MPFL repair group and 53.8% among medial reefing group. Thirteen of the retrieved studies were conducted in Europe (Finland (5), Germany (4), Sweden (1), Denmark (1), Serbia (1), Italy (1)), five in the Americas (USA (3), Brazil (2)) and five studies in Asia (China (3), Japan (1), Kuwait (1)).

In the MPFL reconstruction group, two studies [5, 16] harvested the autograft tendon with the gracilis tendon or patellar tendon for the reconstruction, two [13, 49] used the allograft tendon. In the MPFL repair group, three studies [11, 17, 28] only repaired the femoral insertion site of MPFL, one study [24] only repaired the patellar insertion site, and others repaired both patellar and femoral insertion site. In the medial reefing group, all included studies used medial reefing repair (Table 1).

Quality Assessment

Among the included studies, 10 were RCTs, 8 were comparative studies and 6 were cases series. The quality of the RCTs was presented in Fig. 2 and Fig. 3. Five of 10 RCTs did not report the detailed information of random generation sequence and allocation concealment. Most of the studies did not conduct the blinding for patients and clinicians. These reasons all reduced the quality of this systematic review. The mean MINORS score for comparative studies ranged from 11 to 13 and for the identified non-comparative studies ranged from 17 to 19. The MINORS score agreement between the two reviewers was substantial ($\kappa=0.84$) and eventually reached a perfect rating ($\kappa=1.00$) after discussion with a senior author.

Redislocation Rate

All 22 included studies reported redislocation rates after different surgical treatment. The overall redislocation rate in the MPFL reconstruction group was 1.8% (95% CI − 0.5 to 4.0%), in the MPFL repair group was 15.4% (95% CI 5.2–25.7%) and in the medial reefing group was 18.0% (95% CI 9.3–26.7%) (Fig. 4). There was high heterogeneity in the outcomes among MPFL repair and medial reefing groups ($I^2=88.3\%$, 76.5%, respectively). The redislocation

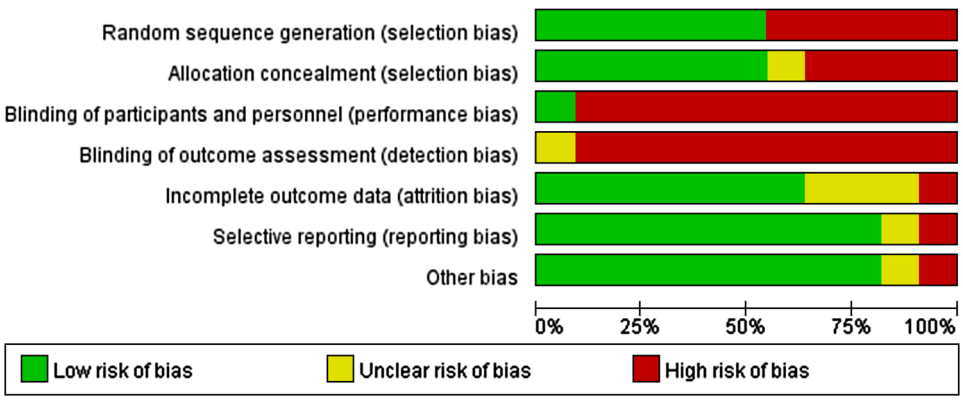

Fig. 2 Risk of bias graph

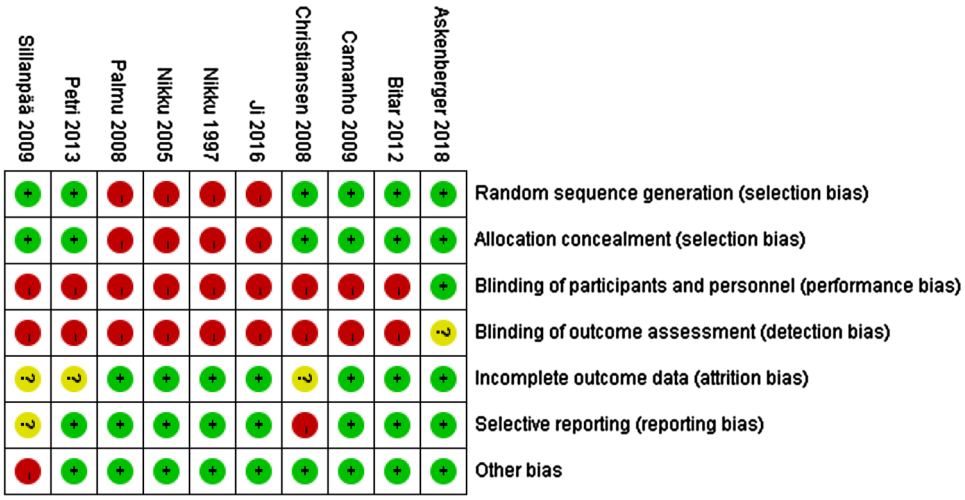

Fig. 3 Risk of bias summary

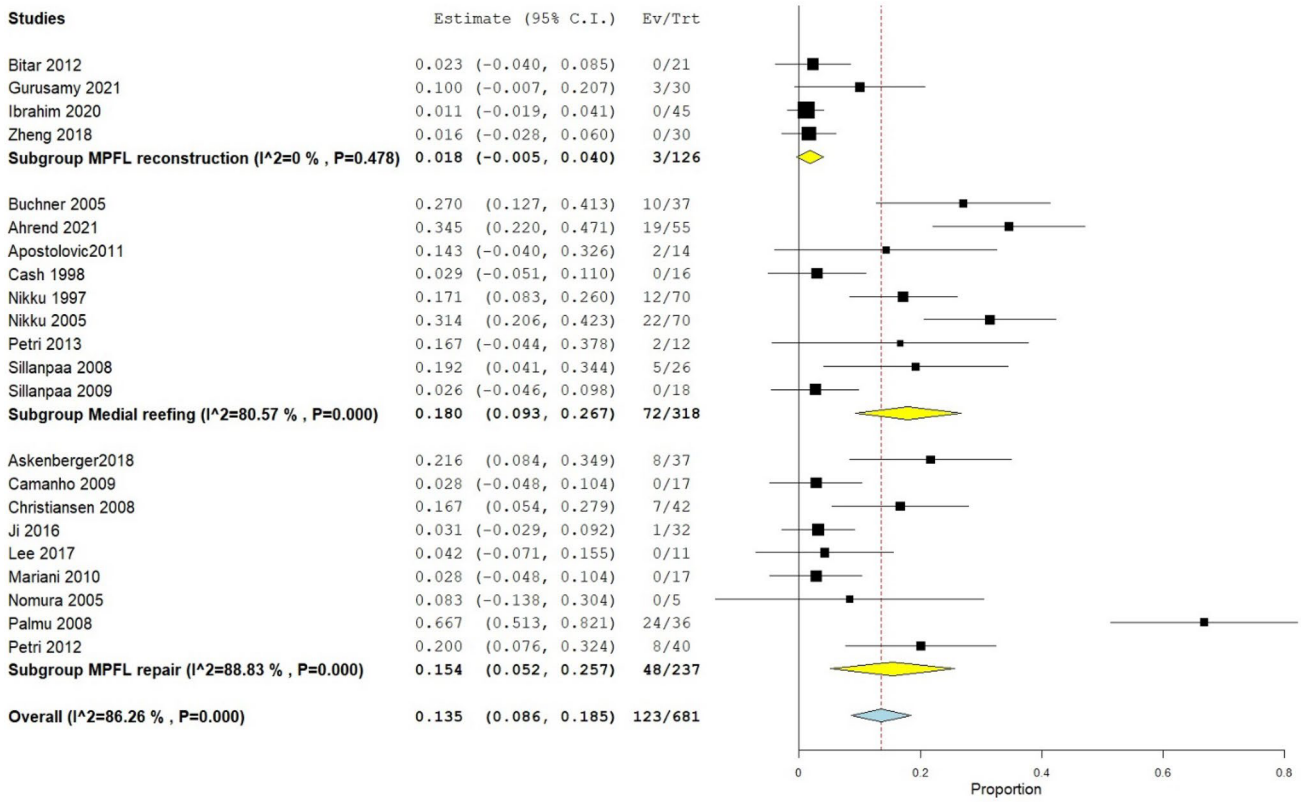

Fig. 4 Forest plots of studies showing the redislocation rate after different surgical treatment

rate in the MPFL reconstruction group was significantly lower than MPFL repair or medial reefing group while there was no statistical difference between MPFL repair and medial reefing group (Table 2).

Re-operation Rate

The overall reoperation rate in the MPFL reconstruction group was 1.7% (95% CI − 0.5 to 4.0%), in the MPFL repair group was 3.7% (95% CI 0.1–7.3%) and in

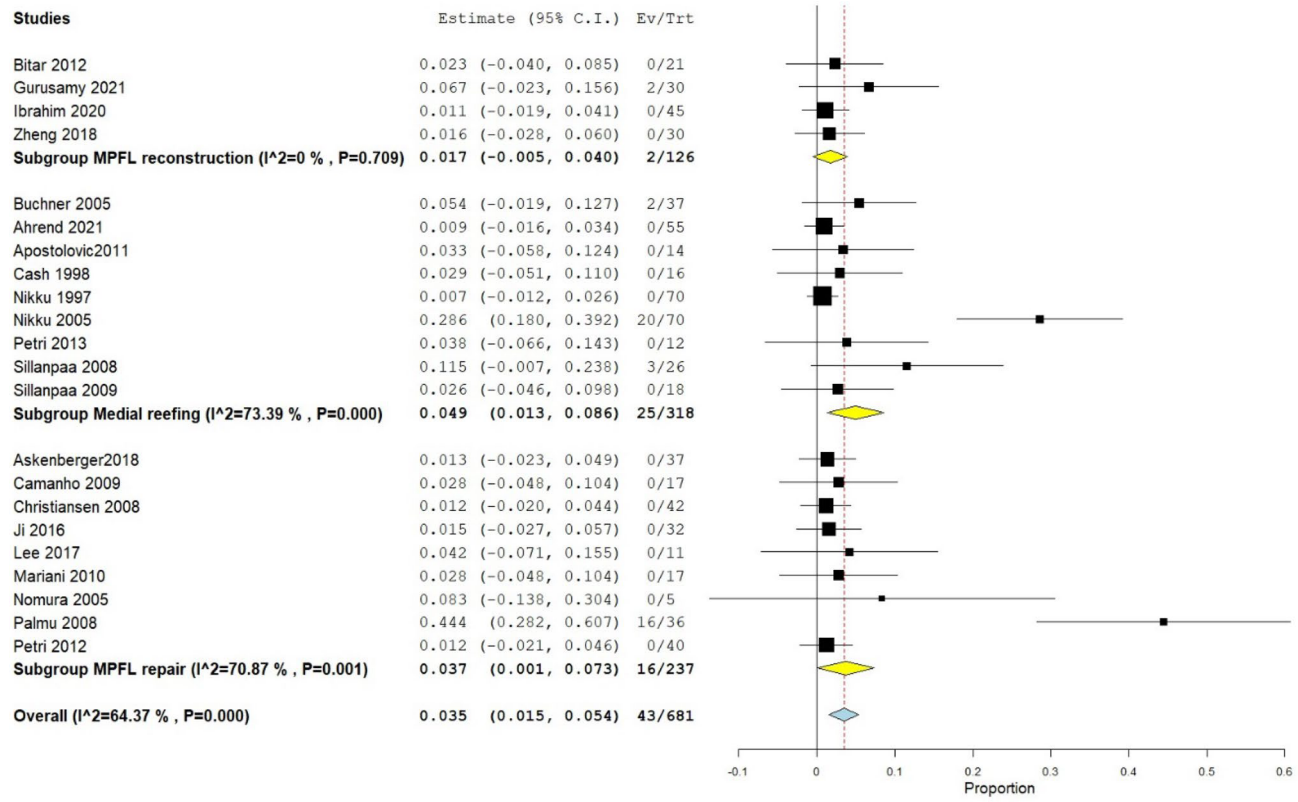

Fig. 5 Forest plots of studies showing the reoperation rate after different surgical treatment

the medial reefing group was 4.9% (95% CI 1.3–8.6%) (Fig. 5). There was some heterogeneity in the outcomes among groups ($I^2 = 0\%$, 70.87%, 67.32%, respectively). The reoperation rate in MPFL reconstruction group was significantly lower than medial reefing group but not MPFL repair group, and there was no statistical difference between MPFL repair and medial reefing groups (Table 2).

Kujala Scores

Regarding postoperative Kujala scores, 18 studies [1, 3, 5, 9, 11, 13, 16, 17, 24, 26, 28, 30–32, 40, 41, 49] provided the data. The mean postoperative Kujala score in the MPFL reconstruction group was 88.479 (95% CI 85.2–91.8), the MPFL repair group was 88.750 (95% CI 85.6–91.9) and the medial reefing group was 89.5 (95% CI 85.8–93.3) (Fig. 6). There was high heterogeneity in the outcomes among groups ($I^2 = 80.25\%$, 64.37%, 85.38%, respectively). There was no statistically significant difference in postoperative Kujala scores among three groups (Table 2).

Complications

Seven studies [3, 13, 21, 35, 40, 41, 49] provided the data of complications. The overall complication rate in MPFL reconstruction group was 2.0% (95% CI − 0.4 to 4.5%), in the MPFL repair group was 1.8% (95% CI 0.1–3.4%) and in the medial reefing group was 1.0% (95% CI − 0.1 to 2.1%) (Fig. 7). There was no statistically significant difference in postoperative complication rates among three groups (Table 2). The complications related to MPFL repair or reconstruction were shown in detail in Table 3.

Discussion

The most important findings of this systematic review and meta-analysis demonstrated that MPFL reconstruction had a significantly lower risk of redislocation rate than MPFL repair group and medial reefing group for patients with first-time patellar dislocation. However, these three surgical treatments achieved similar clinical outcomes in knee Kujala score and complications. In addition, MPFL reconstruction

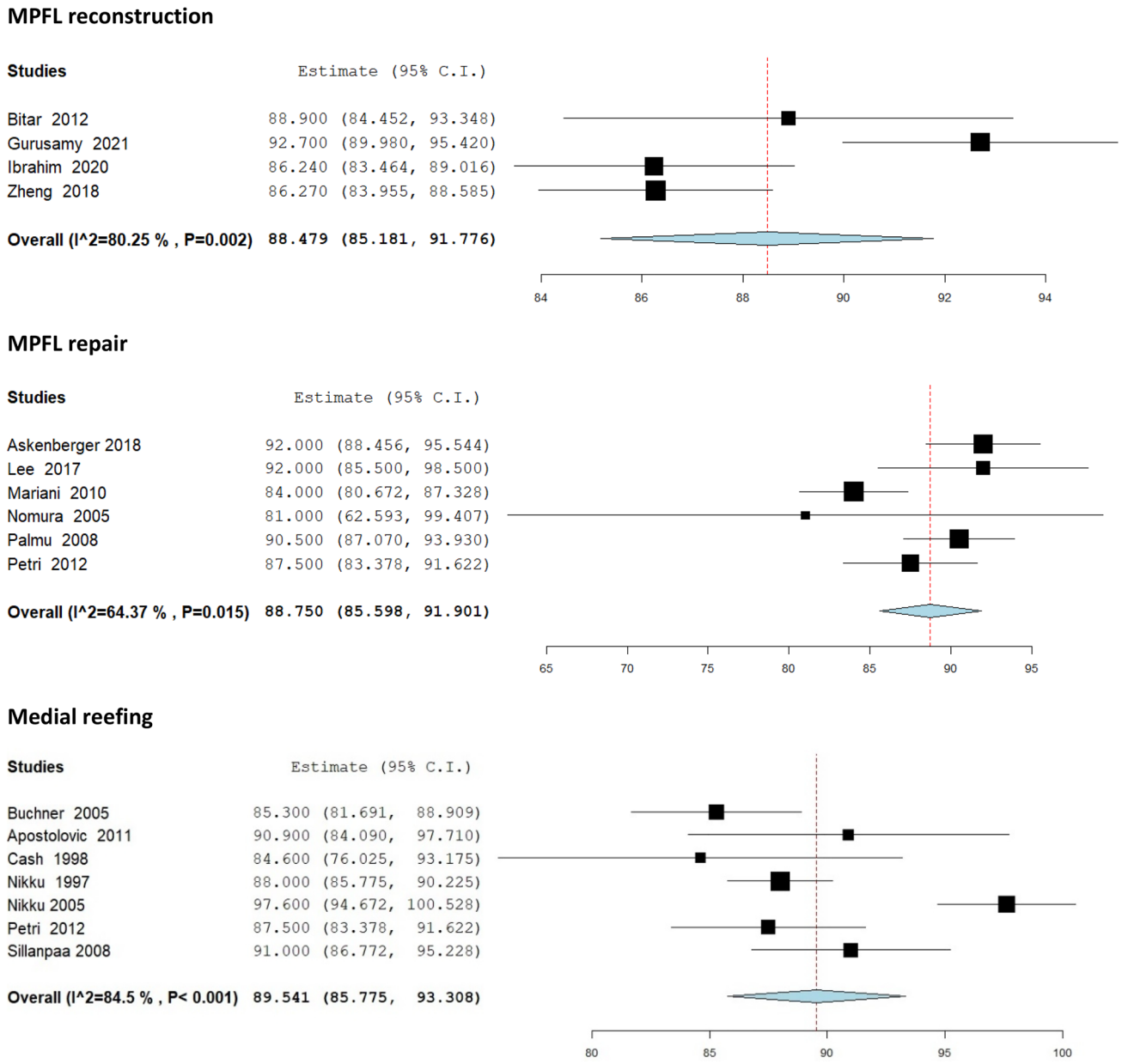

Fig. 6 Forest plots of studies showing the Kujala score after different surgical treatment

Table 3 Complication profiles

	MPFL reconstruction	MPFL repair	Medial reefing
Complication in detail	2 Range of motion deficit [13, 15]	4 Apprehension [3, 22]	2 Osteoarthrosis [42, 43]
	1 Medial plica syndrome [13]	2 Wound infection [3, 37]	
	1 Femoral nerve palsy [13]	1 Painful hardware [3]	

showed lower rates of reoperation than medial reefing, not than MPFL repair group (Fig. 7).

A previous meta-analysis on this subject was recently published in 2020 for patients with recurrent patellar dislocations. Previtali et al. [33] compared MPFL reconstruction with other soft tissue surgical techniques, including medial reefing, retinaculum plication, and retinaculum plasty and repair, and found no significant differences

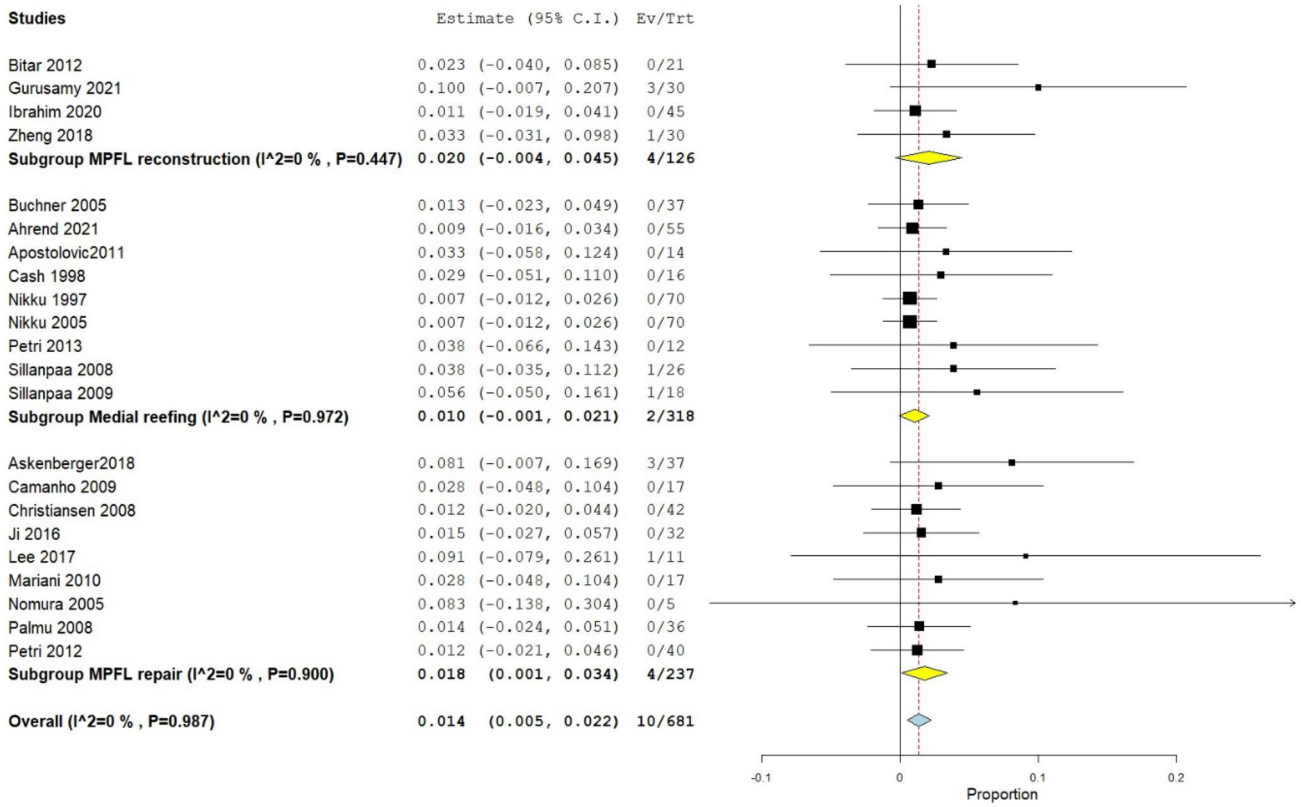

Fig. 7 Forest plots of studies showing the complications rate after different surgical treatment

between the groups in redislocation (0.7% vs. 2.9%) or minor complication (12% vs. 9%) rates. However, there still lacks evidence on the best surgical treatment for patients with first-time patellar dislocation.

In general, a variety of surgical treatment were indicated for first-time patellar dislocation, including medial reefing repair, MPFL repair, MPFL reconstruction, lateral retinacular release, and Roux–Goldthwait procedure. The MPFL is proved to be the most important soft tissue stabilizer of the patella, which contributed 60% of the force restricting lateralization from 0 to 30 degrees of knee flexion [7, 13, 16, 21]. After the first patellar dislocation, nearly 94–100% of patients were associated with medial MPFL injuries [48]. Recent studies have provided satisfactory outcomes with the application of MPFL reconstruction for recurrent patellar dislocations [15, 22]. Medial reefing is frequently employed to achieve proximal realignment for patellar instability in the past. In a case series with a follow-up of 60 months, Boddula et al. [6] reported 70% patients achieved excellent or good results of Lysholm and Tegner scores at long-term follow-up. Although all above surgical treatment achieve excellent results, there remains controversial that which surgical treatment is best for first-time patellar dislocation.

In the present study, the pooled redislocation rate in the MPFL reconstruction group was 1.8%, which was significantly lower than the MPFL repair (15.4%) and medial reefing group (18.0%). In a previously systematic review of investigating the effectiveness of MPFL reconstruction in patients with recurrent patellar dislocation, Mackay et al. [23] identified 22 studies and reported a mean redislocation rate of 2.44% (1.29–4.46%), which was similar with our finding for first-time patellar dislocation. In a previous meta-analysis comparing MPFL repair versus conservative treatment for first-time patellar dislocation, Tian et al. [45] included 5 randomized studies and found that the redislocation rate in MPFL repair group was 28.6%. As for comparing MPFL reconstruction with medial soft tissue surgery, Previtali et al. [33] found that MPFL reconstruction yielded significantly lower rate of redislocation than medial soft tissue surgery for recurrent patellar dislocation. Our meta-analysis also confirmed the advantage of MPFL reconstruction in reducing redislocation rate than MPFL repair and medial reefing.

In fact, the main cause of dissatisfying results for MPFL repair and medial reefing might depend on the different patterns and locations of MPFL injuries. Ruptures of the MPFL could be classified into four types, consisting of the patellar

site, the femoral site, the mid-substance site and combined injury [47, 48]. In a recent systematic review, Kluczynski et al. [19] showed that the most commonly site of MPFL injuries were at the patellar insertion (37.1%) and femoral insertion (36.8%), then were combined sites (25.1%) and the mid-substance sites (15.6%). In general, the patellar insertion of MPFL tear can be surgically repaired with a satisfactory functional outcome [18]. However, the surgical repair for the femoral site of MPFL tear would be more challenging for it was difficult to accurately optimize the femoral insertion site [19]. In a prospective magnetic resonance imaging study, Zhang et al. [47] found that an isolated femoral site injury (OR 6.04) following a first-time patellar dislocation was a significant risk factor for second time patellar dislocation. In addition, the repair for mid-substance MPFL tear also becomes difficult, so that it is not recommended [4]. Furthermore, in a recent meta-analysis comparing MPFL repair versus conservative treatment for first-time patellar dislocation, Tian et al. [45] found that there was no statistical difference in redislocation rate between MPFL repair (28.6%) and conservative treatments (33.3%) ($p = 0.32$). Thus, simple repair for the restoring medial patellar stability was influenced by these negative factors, and the clinical success would be undermined. For these causes, MPFL reconstruction is considered as the preferred surgical treatment for first-time patellar dislocation.

Regarding the subjective scores for knee function, our study found that there was similar Kujala score among these three surgical treatments. The pooled mean Kujala score in MPFL reconstruction, MPFL repair and medial reefing were 88.5 (95% CI 85.2–91.8), 88.7 (95% CI 85.6–91.9), 89.5 (95% CI 85.8–93.3), respectively. This indicates that all the three surgical techniques lead to equivalent improvement of function outcomes. Puzzitiello et al. [34] reported that no significant difference was found in the average Kujala score between the MPFL repair and reconstruction group ($p = 0.72$) for recurrent patellar dislocations. Tompkins et al. [46] also showed that there were no significant differences in IKDC and Kujala scores between MPFL repair and reconstruction group at last follow-up. However, the findings of our systematic review should be interpreted with caution due to the considerable heterogeneity.

Concerning complications, the overall rate of the complications following MPFL reconstruction, MPFL repair and medial reefing were 2.0%, 1.8% and 1.0%, respectively. According to the literature, the most common complications after MPFL reconstruction were decreased knee range of motion, patellofemoral arthrosis, graft impingement and graft failure [39]. In our study, complications in MPFL reconstruction group were range of motion deficit, media plica syndrome and femoral nerve palsy. The most common complications following MPFL repair were wound infections and painful hardware while the only complication in medial reefing group was osteoarthrosis. Medial reefing was associated with less complications compared with other two surgical treatments.

There were some shortcomings and deficiencies in this meta-analysis. First, 11 identified studies were graded poor quality with the level of evidence of Level 3 or Level 4, which might lead to a high risk of selection bias and uncertain results. Besides, the number of each eligible studies and patients included in this systematic review was relatively small. Given these limitations, data from this study should be interpreted with caution. Second, among the included studies, surgical procedures varied across the studies, which may influence the outcomes and results can be biased based on this. For example, different graft source (autograft, allograft) and different fixation methods were used in MPFL reconstruction. However, a subgroup analysis according to surgical procedures was not conducted due to the limited number of identified studies. Further studies on subcategories of surgical procedures will help in understanding the importance and efficiency of various surgical procedures.

Conclusion

The available evidence demonstrated that MPFL reconstruction could achieve significantly lower redislocation rate and reoperation rate than MPFL repair and medial reefing after first-time patella dislocation. Furthermore, there was not enough evidence to reveal that MPFL reconstruction provided better functional outcome compared with MPFL repair and medial reefing. MPFL reconstruction is a preferred surgical treatment for patients with first-time patellar dislocation.

Author Contributions All named authors have substantially contributed to conducting the underlying research and drafting this manuscript.

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Data Availability Not applicable.

Code Availability Not applicable.

Declarations

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval This study was a meta-analysis not involving human subjects and therefore did not require IRB approval.

Informed consent For this type of study, informed consent is not required.

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