Operative Treatment Has Greater Expected Value Than Nonoperative Treatment for First-Time Patellar Dislocations: A Meta-analysis and Expected Value Decision Analysis

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Purpose: To use expected value decision analysis to determine the optimal treatment for first time patellar dislocations. **Methods:** A meta-analysis according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines and expected-value decision analysis were performed. A decision tree addressing the clinical question (operative vs nonoperative) was created, and a meta-analysis was performed to assess the probability of outcomes after operative compared with nonoperative treatment. In total, 70 patients were assessed regarding potential outcome preferences to a hypothetical injury. An expected-value decision analysis was performed to systematically quantify the clinical decision. Statistical fold back analysis calculated optimal treatment, and a sensitivity analysis was performed to determine the effect of changing redislocation rates on the expected value. **Results:** Forty-five participants (mean age 20 years [range 12-33], 58% male, 71% athletes) met inclusion criteria. Meta-analysis of 10 randomized controlled trials with 624 patients revealed the probability of a "well" outcome was significantly greater for operative treatment (59.3%, 95% confidence interval [CI] 53.7%-64.7%) than nonoperative treatment (44.7%, 95% CI 39.0%-50.5%). Subsequent redislocation rates with operative treatment were significantly lower (29.8%, 95% CI 24.5%-35.17%) compared with nonoperative treatment (44.7%, 95% CI 39.0%-50.5%). Medial patellofemoral ligament reconstruction showed an 88% probability of a "well" outcome, and a 3% redislocation rate. Operative management had a greater chance of a well outcome (risk ratio 1.43; 95% CI 1.12-1.83, $P = .005$). The overall expected value for operative treatment was 6.09 versus 4.96 for nonoperative treatment. Secondary analysis of 27 articles for solely medial patellofemoral ligament reconstruction showed an expected value of 7.80 for operative treatment. **Conclusions:** Meta-analysis showed more frequent favorable outcomes and lower subsequent dislocation rates with operative treatment. Decision analysis on the basis of healthy patient responses to hypothetical scenarios shows that operative treatment has a greater expected value for first time patellar dislocations than nonoperative treatment. **Level of Evidence:** Level IV, economic study.

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Acute patellar dislocations are a common injury in young patients, accounting for 3% of all knee injuries with an incidence of 7 per 100,000 individuals.[1,2] The are several known risk factors for acute dislocations, including increased tibial tubercle trochlear grove distance, osseus malalignment, trochlea dysplasia, chronic laxity of the ligamentous structures, as well as demographic risk factors (e.g., patients who identify as female, younger age).[1,3-5]

There is controversy in the literature regarding the optimal treatment for first-time patella dislocations.[6,7]

Traditionally, patients initially undergo nonoperative treatment unless there are concomitant injuries such as cartilage defects or loose bodies, because a proportion of patients will not sustain a second dislocation.[8-10] Other authors have advocated for early stabilization in order to prevent further cartilage damage, which routinely consists of medial patellofemoral ligament (MPFL) reconstruction with concomitant procedures like lateral retinacular release, tibial tubercle osteotomy, trochleoplasty, and/or cartilage procedures depending on the underlying etiology of the instability.[8,11]

Expected value (EV) decision analysis is a tool that can be used to compare 2 different treatment modalities. A meta-analysis is combined with patient perspectives on hypothetical outcomes to create a theoretical EV. Performing an EV decision analysis can help to quantify the shared-decision making that doctors and patients often face in outpatient clinic on the basis of the best-available objective data and has shown utility in previous sports medicine literature.[12-14] Given the unclarity for the optimal treatment for first-time patellar dislocations, the purpose of this study is to use EV decision analysis to determine the optimal treatment for first-time patellar dislocations. It was hypothesized that immediate surgical intervention would have a greater EV than nonoperative treatment.

Methods

This study was approved by WFU Health Sciences (institutional review board no.: IRB00089493) on November 7, 2022, and consisted of the combination of a meta-analysis on the outcomes of nonoperative and operative treatment of first-time patellar dislocation and an established framework of an EV decision analysis. This involves the following steps: (1) establishing a decision problem, (2) determining the outcome probabilities for various branches, (3) determining patient outcome utilities, (4) performing foldback analysis, and (5) performing a one-way sensitivity analysis.

Step 1: Establish Decision Problem

A decision tree was created to evaluate treatment options for first time patellar dislocations. The first decision point was operative compared with nonoperative management after a first-time acute patellar dislocation. Each decision was then defined to have 1 of 5

Table 1. Potential Outcomes of Operative or Nonoperative Treatment for Patellar Dislocation

Potential Outcome	Description
Well (operative)	Scenario 1: You have surgery to fix your patella dislocation. After surgery and 6 months of physical therapy, you return to playing sports and/or work at the same ability and level of play as before your injury and have no more patella dislocations.
Well (nonoperative)	Scenario 2: After your patella dislocation, you do 2 months of physical therapy. You return to playing sports and/or work at the same ability and level of play as before your injury and have no more patella dislocations.
Mild complication (operative)	Scenario 3: You have surgery to fix your patella dislocation. After surgery and 6 months of physical therapy, you return to playing sports and/or work but at a lower or worse ability and level of play as before your injury but have no more patella dislocations.
Mild complication (nonoperative)	Scenario 4: After your patella dislocation, you do 2 months of physical therapy. You return to playing sports and/or work but at a lower or worse ability and level of play as before your injury but have no more patella dislocations.
Moderate complication (operative)	Scenario 5: You have surgery to fix your patella dislocation. After surgery and 6 months of physical therapy, you cannot return to playing sports and/or work but have no more patella dislocations.
Moderate complication (nonoperative)	Scenario 6: After your patella dislocation, you do 2 months of physical therapy. You return to playing sports but have another patella dislocation that requires 2 more months of physical therapy and time away from sports. You do not have surgery and continue to suffer more patella dislocations and experience pain and instability while playing sports or at work. You cannot return to playing sports and/or work.
Major complication (operative)	Scenario 7: You have surgery to fix your patella dislocation. As a result of treatment, you experience a postoperative serious medical illness such as blood clots in the legs, blood clots in the lungs, pneumonia, or wound infection requiring hospitalization for treatment.
Major complication (nonoperative)	Scenario 8: After your patella dislocation, you do 2 months of physical therapy. You return to playing sports but have another patella dislocation that requires 2 more months of physical therapy and time away from sports. You do not have surgery and continue to suffer more patella dislocations and experience pain and instability while playing sports or at work. Each dislocation causes damage to your knee, which may need surgery to fix.
Reinjury (operative)	Scenario 9: You have surgery to fix your patella dislocation. After surgery and 6 months of physical therapy, you return to playing sports and/or work but have another patella dislocation that requires repeat surgery and more time away from sports and work.
Reinjury (operative)	Scenario 10: After your patella dislocation, you do 2 months of physical therapy. You return to playing sports but have another patella dislocation that requires 2 more months of physical therapy and time away from sports. You do not have surgery and continue to suffer more patella dislocations and experience pain and instability while playing sports or at work.

NOTE. Definitions and criteria for the 5 potential outcomes are shown.

Table 2. Study Characteristics and Demographics

Study	Level of Evidence	Number of Operative Patients	Number of Nonoperative Patients	Average Age, yr	Percentage Female
Askenberger et al., 2018[20]	RCT, I	37	37	13.9	51%
Bitar et al., 2012[21]	RCT, I	21	20	23.9	42%
Camanho et al., 2009[22]	RCT, II	17	16	24.6	65%
Christiansen et al., 2008[30]	RCT, I	28	35	20.0	43%
Ji et al., 2017[23]	RCT, I	30	26	N/A	63%
Nikku et al., 2005[24]	RCT, I	70	57	20.0	74%
Palmu et al., 2008[25]	RCT, II	36	28	13.0	75%
Petri et al., 2012[26]	RCT, II	11	8	27.2	36%
Regalado et al., 2016[27]	RCT, II	20	20	N/A	55%
Sillanpää et al., 2009[28]	RCT, I	22	22	20.0	9%
Zheng et al., 2019[29]	Prospective trial, II	39	39	17.9	62%

N/A, not available; RCT, randomized control trial.

different outcomes: well, mild complication, moderate complication, major complication, or reinjury (Table 1).

Step 2: Systematic Review and Meta-analysis of Outcome Probabilities

Using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines, a systematic review was performed.[15] A query in PubMed, Embase, and CINAHL was performed, assessing articles from inception until February 6, 2024. The studies were tracked in Rayyan (Doha, Qatar). Search terms included patella dislocation, medial patellofemoral ligament reconstruction, medial patellofemoral ligament repair using a Boolean operator. The inclusion criteria used in this review included (1) full-text studies written in the English language, (2) studies in which patients received surgical treatment for an isolated first time patellar dislocation, (3) studies of patients who underwent nonoperative treatment for an isolated acute patella dislocation, (4) studies in which the authors provided quantifiable patient outcomes, (5) studies published in peer-reviewed journal, and (6) studies that were performed as prospective, randomized control trials with Level I or II evidence. Studies were excluded if they included (1) total joint arthroplasty, (2) retrospective studies, (3) literature reviews, (4) meta-analyses, (5) cadaveric or animal studies, (6) biomechanical studies, and (7) editorials.

Two reviewers (A.J.R., T.W.M.) independently reviewed all identified articles on the basis of title and abstract. If there was disagreement between the reviewers, a discussion was had until there was agreement about the article. A second review was performed of full-text articles to assess for strength of inclusion. A secondary author (T.W.M.) evaluated for risk of bias. The risk of bias tools included the Cochrane Risk of Bias Tool, version 2 for randomized controlled trials and the Cochrane Risk of Bias in Non-randomized Studies of Interventions tool for nonrandomized intervention trials.[16,17]

Data were extracted in Microsoft Excel (Redmond, WA) and the following aspects were assessed: visual analog scale for pain (VAS), Kujala Score, complications, and reoperations. Patient information including age, gender, and participation in sports was also collected.

Statistical Analyses

Clopper-Pearson exact tests were performed on the 5 outcomes after both operative and nonoperative management of a first-time patellar dislocation. An inverse variance random effects risk ratio (RR) meta-analysis was performed to assess the clinical outcomes comparing operative and nonoperative treatment after patellar dislocation, necessitating the need for solely randomized control trials (RCTs) in the meta-analyses. Ten of the 11 studies included in the systematic review were RCTs. Because of this very high proportion, only RCTs were chosen for the meta-analyses to give us the ability to perform a risk meta-analyses due to the nature of flipping the analyses to obtain a "well outcome." Because of the low prevalence of complications, the meta-analysis analyzed only a well outcome and redislocation rates. Results were reported as a RR with 95% confidence intervals (95% CIs), with an RR greater than detailing favoring nonoperative treatment. Heterogeneity was assessed through I^2. All analyses were performed in R Core Team.[18] The *meta* package was used for meta-analyses. Differences in gender were not assessed because of the absence of individual outcomes reported in the included studies, disabling separate gender analysis.

Step 3: Outcome Utilities

A prospective survey was administered to determine outcome utilities after institutional review board

approval was obtained. To increase external validity, the survey was administered to a patient population at high risk for acute patellar dislocations. Seventy surveys were administered to patients between the age of 12 and 33 years from December 2022 to August 2023. This sample size is consistent with previous EV decisions analyses. Inclusion criteria for survey administration included (1) age 12-33 years; (2) no history of acute or chronic patellar dislocations; and (3) an orthopaedic complaint resulting in presentation to a sports medicine orthopaedic clinic. Patients included in this study presented for, but not limited to, anterior cruciate ligament tear, labral instability, and ulnar collateral ligament tear, among others. Patients were included if they had any sports medicine pathology, excluding current or a past history of patella instability or dislocation. All histories were self-reported and checked in the electronic medical record. The age of 33 years was chosen given the patent demographics presenting to the home institution, and the mean age presented in the meta-analyses studies. A statistically insufficient age difference between the sample population and the meta-analyses population was desired and given a priori statistics and input for the senior author, an age of 33 years was determined. This is on the greater end of high-risk patients, but they believe that they still fit within this category depending on the etiology of the risk for dislocation. All patients were evaluated by an author (T.W.M.) for inclusion criteria, then their inclusion was confirmed by a second author (A.J.R.).

Questionnaire

All patients were administered a questionnaire while in clinic. Demographic data including age, participation in sports, and previous orthopaedic history were obtained. To calculate outcome utilities, the patients were asked to rate 10 scenarios on the VAS scale of 0 to 10, with 0 being the worst outcome and 10 being the best outcome. The 10 scenarios were operative and nonoperative treatment with well, mild complication, moderate complication, major complication, and reinjury. Incomplete surveys were not included in the analysis.

Step 4: Foldback Analysis

Statistical fold-back analysis was performed to determine the optimal treatment for patients with acute patellar dislocations as described by Kocher et al.[19] Expected value is calculated by multiplying the outcome utilities for each scenario (VAS 0-10) by the outcome probability for that scenario based on the literature (probability 0-1). The sum of this product for the 5 scenarios (well, mild complication, moderate complication, major complication, redislocation) is the calculated EV for that treatment option.

Step 5: One-Way Sensitivity Analysis

One-way sensitivity analysis was performed to determine the effect of varying probabilities and to reduce sampling bias. The analysis was performed in Microsoft Excel (Redmond, WA) by varying the chance of a "redislocation" and its reciprocal change in "well outcome." Multiple calculations were made to assess the hypothetical EVs. This was only performed on the MPFL reconstruction group. The series of values were then compared with the EV of nonoperative management of a first-time patellar dislocation.

Results

Systematic Review Results

A total of 2,526 studies were screened and ultimately 11 studies were included in the systematic review (Fig 1, Table 2).[20-30] Ten studies were RCTs, and as such only the 10 RCTs were included in the meta-analysis to use the *meta* package, with a total of 624 patients, mean age of 19.8 ± 4.5 years and 54.9% female (Fig 2). Six RCTs were classified as Level I evidence, and 4 of the studies were classified as Level II evidence. One study was a Level II prospective trial. The operative interventions included lateral release (21), Roux-Goldthwait procedure (13), MPFL repair (141), medial structural repair/tightening (74), undescribed (22), and MPFL reconstruction (60). Using risk of bias, 30% of studies had a low risk of bias and 70% had some concerns (Appendix Fig 1, available at www.arthroscopyjournal.org). The prospective controlled study was evaluated as having a high risk of bias.

Outcome Probabilities

For each included study, each patient outcome was scored and standardized. Well outcome was defined as a patient with no complications or redislocation. Reinjury was defined as a patient who had a recurrent patellar dislocation. Mild complication included persistent pain or stiffness not requiring reoperation. Moderate complication was defined as patella fracture, stiffness requiring reoperation or manipulation under anesthesia, or prolonged hospital stay. Major complication was defined as a serious medical event including pulmonary embolism, pneumonia, or wound infection requiring hospitalization (Table 1).

From the systematic review and meta-analysis, patients who underwent surgical fixation after a first acute dislocation had: well outcomes 59.3% (95% CI 53.7%-64.7%), mild complications 9.9% (95% CI 6.9%-13.7%), moderate complication 0.6% (95% CI 0%-2.2%), major complication 0.3% (95% CI 0%-1.7%), and reinjury 29.8% (95% CI 24.5%-35.17%). For patients undergoing non-operative management: well outcomes 40.7% (95% CI 35.1%-46.5%), mild complications 14.2% (95% CI 10.4%- 18.7%),

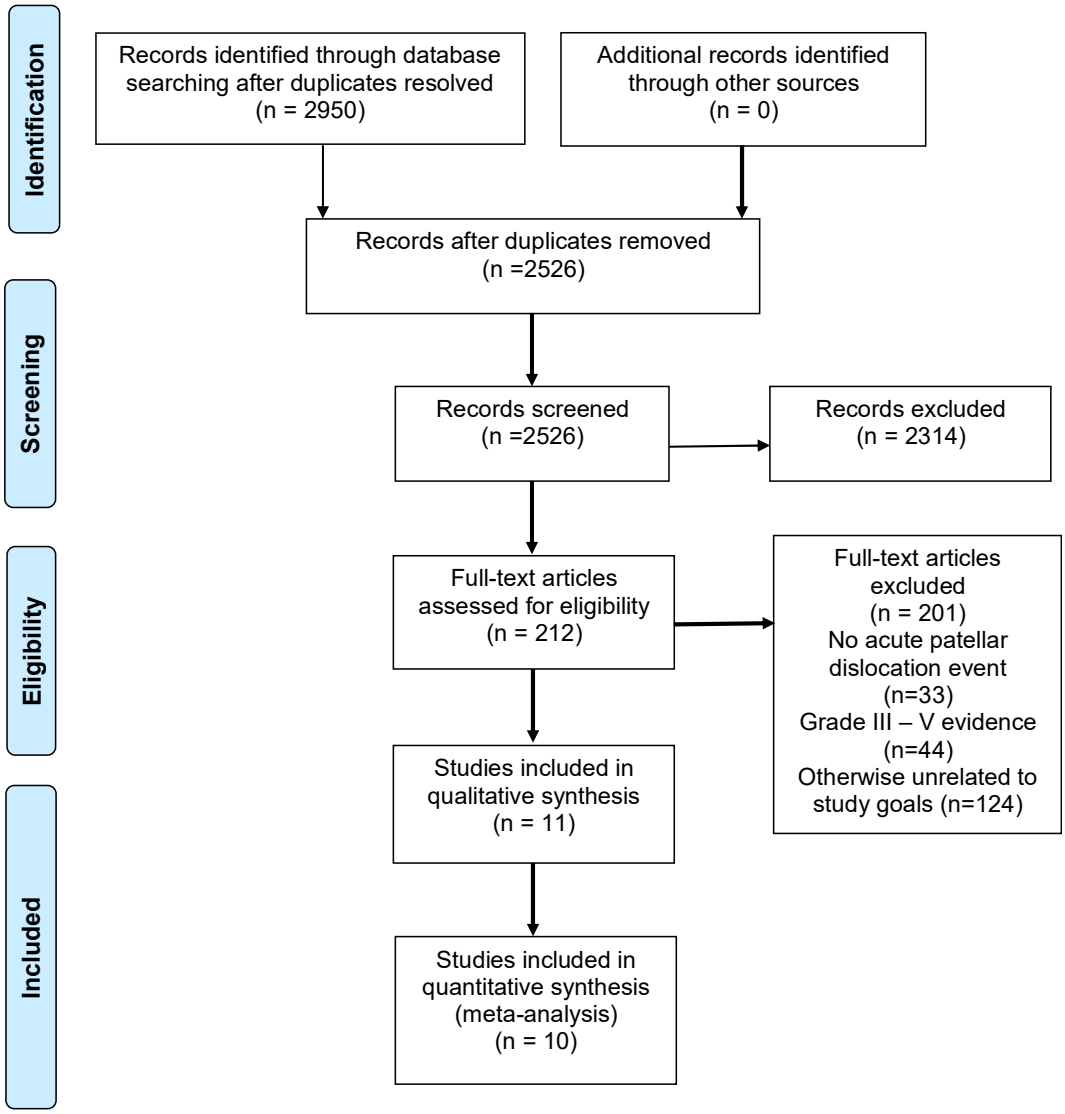

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.

moderate complication 0% (95% CI 0%-1.2%), major complication 0.3% (95% CI 0%-1.8%), and reinjury 44.7% (95% CI 39.0%-50.5%).

Operative treatment showed improved well outcomes (RR 1.43; 95% CI 1.12-1.83; $P = .005$; Fig 2). Redislocation rates with operative treatment were significantly reduced compared with nonoperative treatment (RR 0.683; 95% CI 0.50-0.92; $P = .014$) (Fig 3).

Given that only 2 of the 10 included RCTs included patients treated with MPFL reconstruction, a second analysis was performed on the basis of the meta-analysis of medial patellofemoral ligament reconstruction outcomes by Castagno et al.[31] They included 27 studies (level of evidence III-IV) and 1,200 patients in the analysis. The outcomes and complications for each study was extracted from the meta-analysis and scored with the same 5 possible outcomes (well, reinjury, mild complication, moderate complication, major complication) as our meta-analysis. The outcomes were as follows: well outcomes 88.0% (95% CI 79.0%-94.0%), mild complications 7.0% (95% CI 5.8%-8.2%), moderate complication 2.0% (95% CI 0.1%-3.7%), major complication 0.0% (95% CI 0%-0%), and redislocation 3% (95% CI 1.8%-4.2%), Figure 4.

Outcome Utilities

A total of 45 subjects were included after 19 did not complete the survey, and 6 were excluded for age. The average age of the survey subjects was 20.4 ± 5.8 years with 19 (42%) identifying as female and 32 (71%) participating in sports. Patient utilities for each of the potential outcomes are found in Figure 5 and Figure 6.

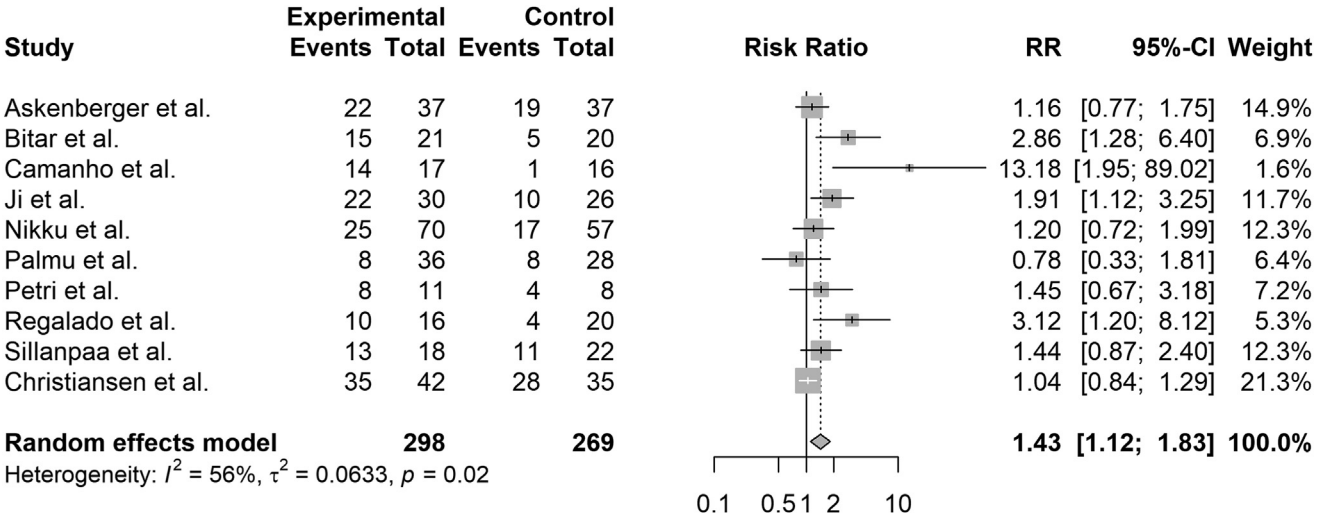

Fig 2. Forest plot with random-effects model of outcome probabilities for "well" outcome. Operative treatment is 1.43 times more likely to have a well outcome (CI, confidence interval; RR risk ratio.)

Decision Analysis

Fold-back analysis showed an EV of 6.09 for operative management and 4.96 for nonoperative management of first-time patellar dislocations (Fig 5). In the secondary analysis with only MPFL reconstruction, fold-back analysis showed an EV of 7.80 for operative treatment of first-time patellar dislocations (Fig 6).

One-Way Sensitivity Analysis

One-way sensitivity analysis of well outcome after MPFL reconstruction is shown in Figure 7. MPFL reconstruction has a greater EV than nonoperative management when the rate of redislocation was less than 36%.

Discussion

This study found that operative fixation after a first-time patellar dislocation (EV = 6.09) has a greater EV than nonoperative management (EV = 4.96). This confirmed our hypothesis that operative fixation after a first-time patellar dislocation has a greater EV than nonoperative management. The secondary analysis showed MPFL reconstruction has a greatest EV. In addition, meta-analysis revealed significantly lower redislocation rates for operative intervention after a first-time patellar dislocation compared with conservative treatment. Redislocation rates were the lowest for MPFL reconstruction. The decision analysis calculated that patients who undergo operative treatment are 1.43 times more likely to have a "well" outcome than those who are treated with nonoperative management. Surgeons can use this information to tailor discussion with patients and plan for surgery on the basis of risk of reinjury rates, specifically for young athletes.

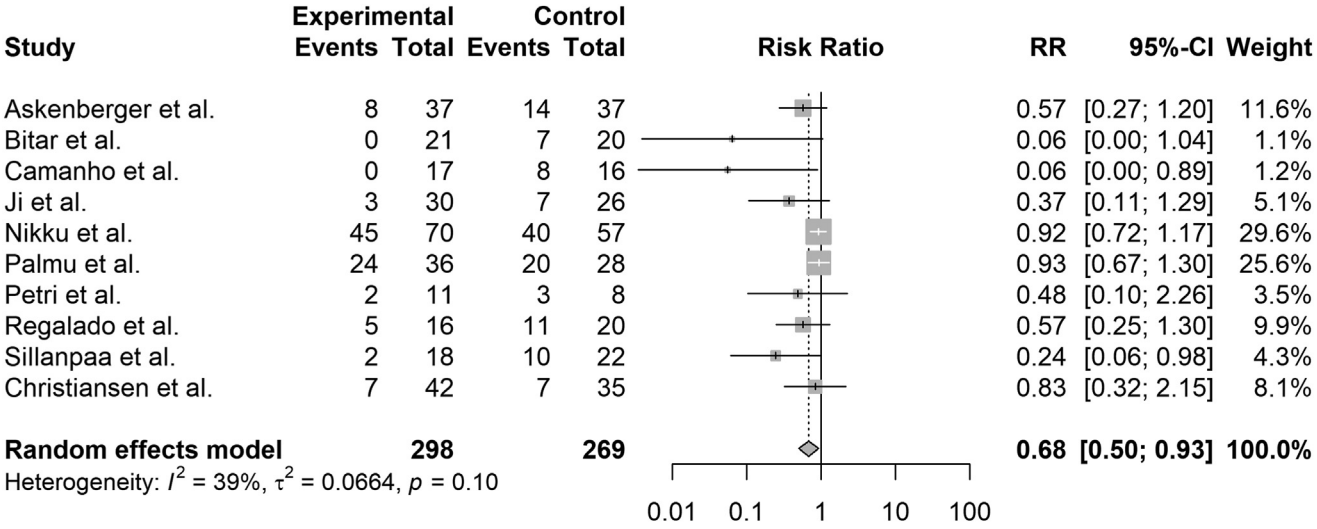

Fig 3. Forest plot with random-effects model of outcome probabilities for redislocation. Non-operative treatment is 1.47 times more likely to experience a redislocation (CI, confidence interval; RR risk ratio.)

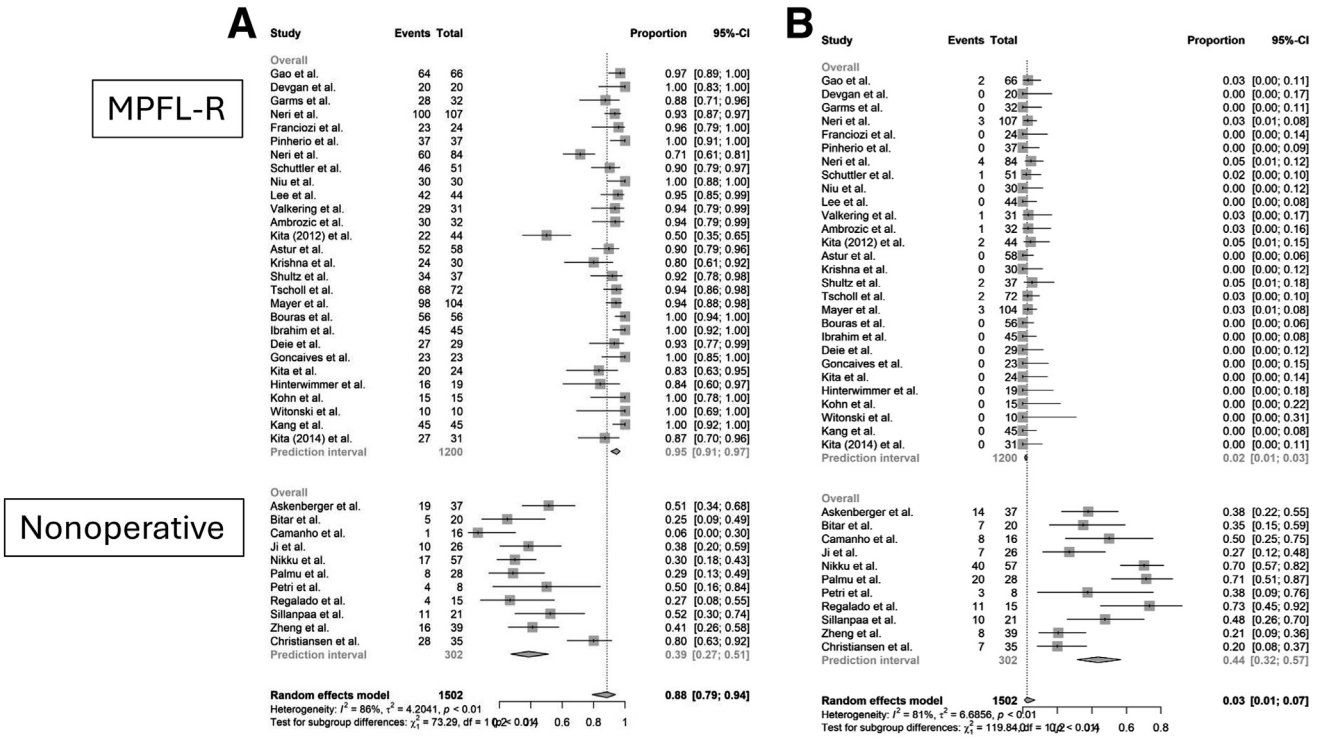

Fig 4. Forest plots illustrating 88% probability of "well" outcome (A) and 3% redislocation rate (B) with medial patellofemoral ligament reconstruction (MPFL-R).

The most important finding of this study was that operative fixation after a first-time patellar dislocation (EV = 6.09) has a greater EV than nonoperative management (EV = 4.96). The EV is even greater for patients treated with MPFL reconstruction (EV = 7.80). This result is multifactorial, as the expected outcome found in the meta-analysis illustrated a significantly greater chance of a well outcome after operative management and significantly lower redislocation rates. Although there is no standardized unit to the EV calculation, these differences in EV are consistent with other decision analysis studies published in literature.[12,14,19,32] More studies are needed to determine the exact impact a point increase in EV brings, but the relative change, and similarity in values to previous studies show the benefit of operative fixation after a first time dislocation. These findings are somewhat surprising, as the literature from the perspective of orthopaedic surgeons is somewhat different.[33,34] Generally, consensus meeting and review articles have recommended to treat first-time patella dislocations nonoperatively, except in the setting of osteochondral fractures or concomitant injuries that require surgical intervention.[7,35,36] These expected-value studies are therefore of high value for this scenario. With this study design, it focuses on an informed, evidence-based, shared decision-making with a special emphasis on the priorities from patients. This is important as it is possible that patients will make different choice when they are presented with objective data and can make their own decision. These EV studies form a valuable perspective in addition to the data from orthopaedic surgeon consensus meetings or meta-analyses on objective data only and can be seen as patient-centered shared-decision making studies.

This meta-analysis also showed that operative treatment has a significantly lower redislocation rate than nonoperative treatment (relative risk = 0.683), on the basis of the data from 10 RCTs. More specifically, of the 10 included RCTs, 9 found lower redislocation rates for operative treatment.[20-24,26-28,30] In their meta-analysis, Castagno et al.[31] showed a redislocation rate of 3% after MPFL reconstruction. As supported by the meta-analysis, operative treatment has significantly lower dislocation rates. In addition, the meta-analysis revealed that patients who undergo operative treatment are 1.43 times more likely to experience a well outcome.[31] This finding is increased for those who undergo MPFL reconstruction, as there is an 88% probability of a well outcome.

The results of our study are consistent with those in the literature. Pagliazzi et al.[37] conducted a meta-analysis of RCTs and determined that operative treatment had a lower redislocation rate than nonoperative treatment (40% vs 58%). Their analysis also determined that patients who underwent operative

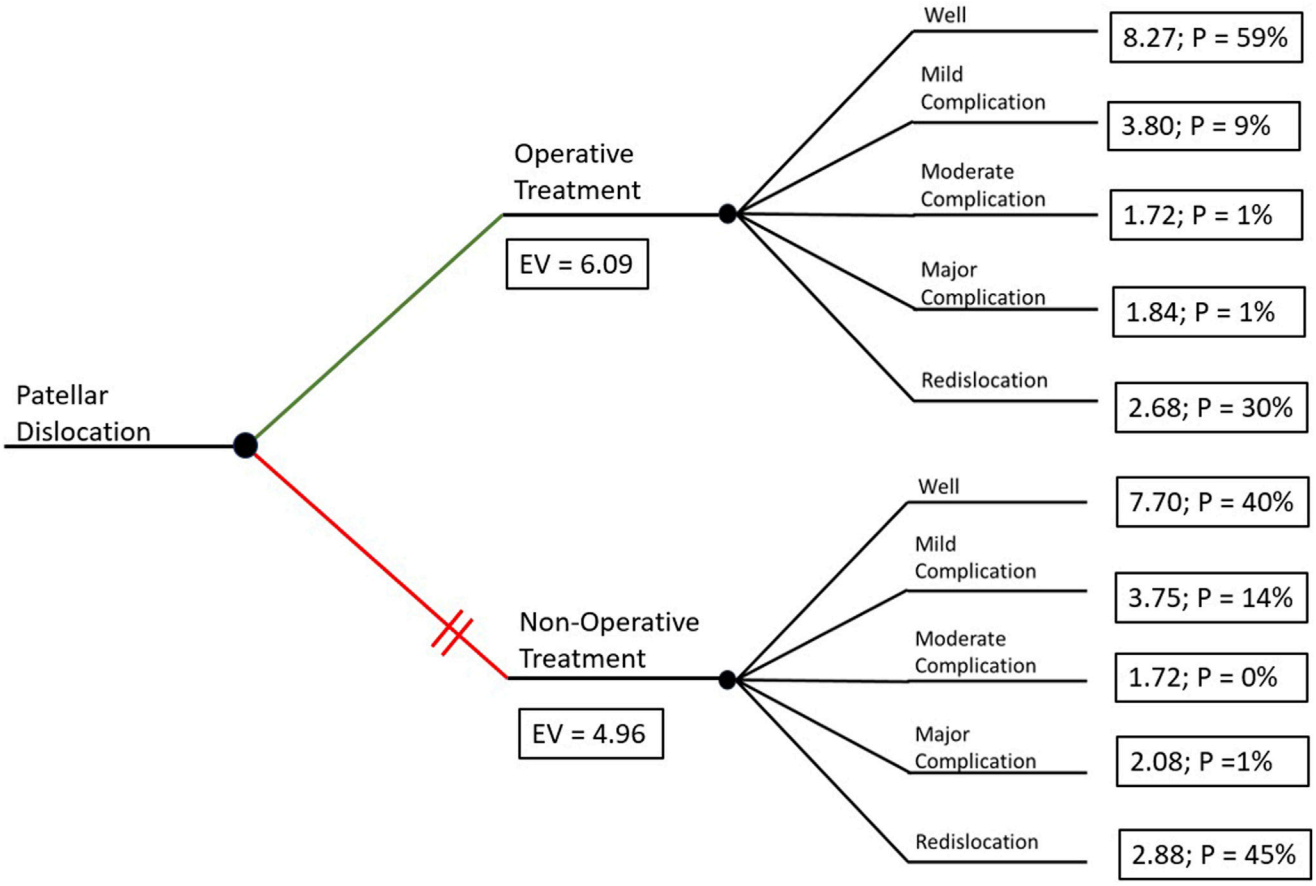

Fig 5. Decision tree of operative versus nonoperative treatment for a patellar dislocation with fold-back analysis showing that operative treatment is the superior treatment choice (EV, expected value.)

treatment had a 10.2-point improvement in Kujala score at short-term follow-up compared with nonoperative treatment. In addition, subgroup analysis of the pediatric population suggested a lower risk of recurrence in the surgery group, although this was not statistically significant.[37] Liu et al [38] performed a meta-analysis comparing MPFL reconstruction, MPFL repair, and nonoperative treatment after a first-time patellar dislocation. They determined that MPFL reconstruction significantly reduced the risk of future dislocation events compared with MPFL repair or operative treatment.[38] This study formed the rationale for only including studies with MPFL reconstruction, as MPFL repair is correlated with greater redislocation rates.[38] Similarly, in another meta-analysis, Smith et al.[9] determined that operative treatment reduced the risk of redislocation by 157 per 1,000 persons. They also determined patients in the operative group had, on average, a 5.73-point improvement on the Kujala score.[9] However, most of these studies do not assess failure rates after first-time patellar dislocations but also include patients with recurrent patellar instability.

Ultimately, deciding how to treat a first-time patellar dislocation comes down to shared decision making with the patient and their surgeon. Each patient is unique in their own risk factors, including patella alta, tibial tubercle trochlear grove distance, trochlear dysplasia, participation in sports, and various social factors. Understanding the patient's individual risk factors can help surgeons convey perceived risk of redislocation and help guide treatment, whether that be an initial trial of nonoperative management or early surgical intervention. To date, neither conservative nor early operative intervention have been proven to be superior, so it is up to the treating surgeon to have an informed discussion with each patient regarding the risks and benefits of early surgery or trialing nonoperative treatment. This expected-value decision-making should not be seen as a surrogate for patient-centered shared decision making but rather a catalyst for conversation between the patient and the treating surgeon.

Limitations

There are several limitations to this study. We chose to perform our initial meta-analysis with the 10 RCTs to limit the bias found within the studies. These studies were of high level of evidence, had low heterogeneity, and likely indicated reliable results. However, the RCTs

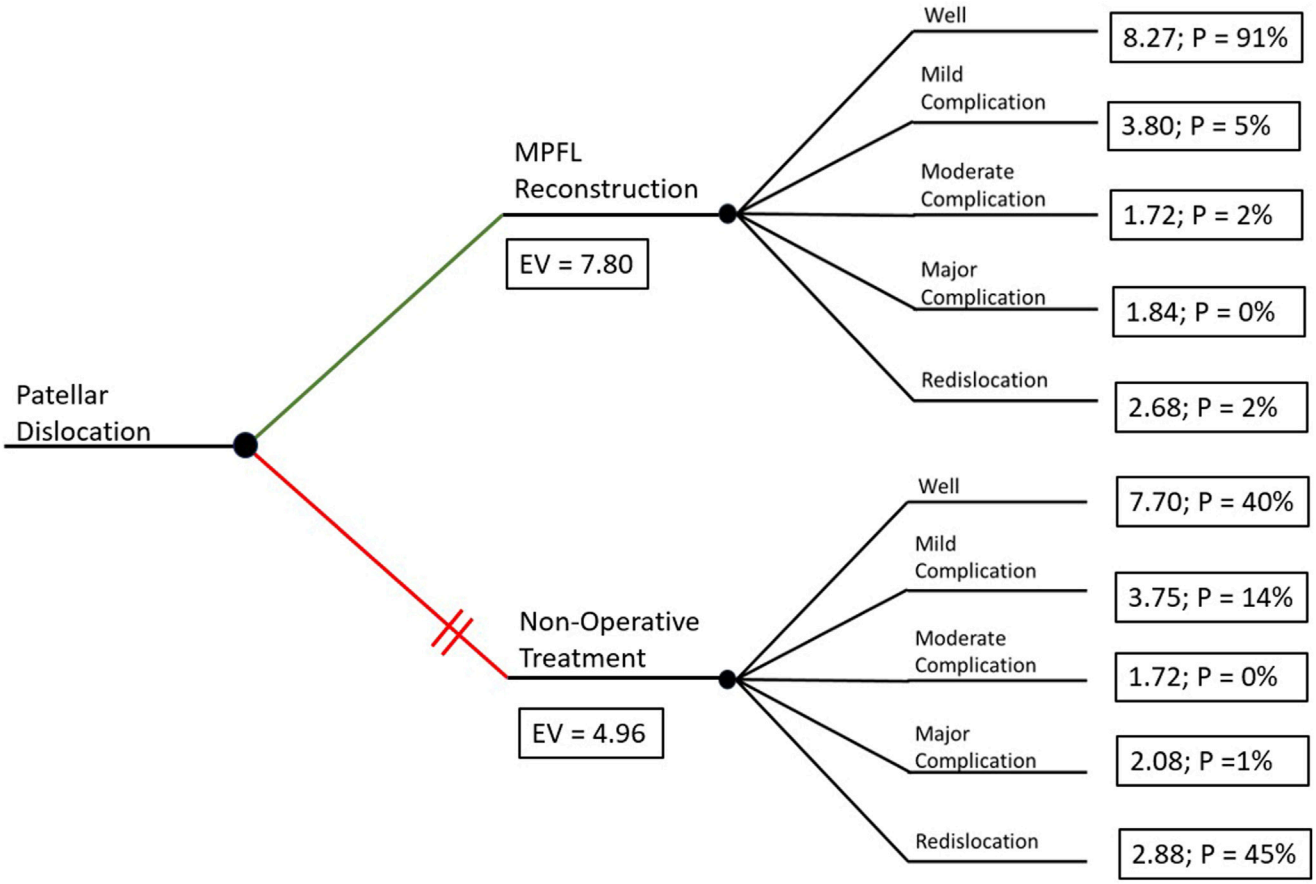

Fig 6. Decision tree of MPFL reconstruction versus nonoperative treatment for a patellar dislocation with fold-back analysis showing that MPFL reconstruction is the superior treatment choice (EV, expected value; MPFL, medial patellofemoral ligament.)

included in the meta-analysis have a heterogeneous treatment group. The operative treatment group was composed of several different surgical techniques, including lateral release, Roux-Goldthwait procedure, MPFL repair, and MPFL reconstruction. This can lead to bias, as not all operative patients were treated with the same surgery. This is why we included the subgroup analysis for MPFL reconstruction, as this treatment methodology provided the best outcomes. Unfortunately the MPFL studies were of lower level of

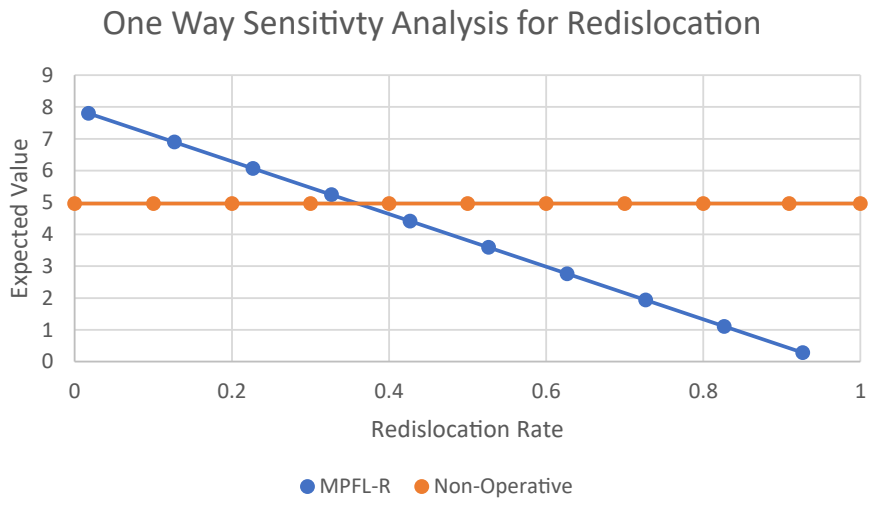

Fig 7. One-way sensitivity analysis of redislocation rates and its effect on the expected value compared with nonoperative management. (MPRL-R, medial patellofemoral ligament reconstruction.)

evidence, higher heterogeneity, and greater risk of bias. In addition, since the etiology of a patellar dislocation is multifactorial, the correct surgical procedure to address the underlying pathology is patient-specific. Thus, the included RCTs are predicated on the assumption that the operative surgeon chose the correct procedure for the patient. Another important limitation is that healthy patients were interviewed and it is possible they would have answered questionnaires in a different way if they truly had a first-time patellar-dislocation.

Conclusions

Meta-analysis revealed more frequent favorable outcomes and lower subsequent dislocation rates with operative treatment. Decision analysis on the basis of healthy patient responses to hypothetical scenarios shows that operative treatment has a greater EV for first time patellar dislocations than nonoperative treatment.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: J.P.L. reports board membership with *Arthroscopy*. N.A.T. reports speaking and lecture fees from DJ Orthopaedics. B.R.W. reports equity or stocks from the Vericel Corporation, Kaliber AI, and Vivorte; board membership with the American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, Arthroscopy Association of North America, *Arthroscopy*, and *Video Journal of Sports Medicine*; speaking and lecture fees from Arthrex; and consulting or advisory with Elsevier, FH ORTHO Group, Musculoskeletal Transplant Association, and Smith & Nephew. All other authors (A.J.R., T.W.M., G.B.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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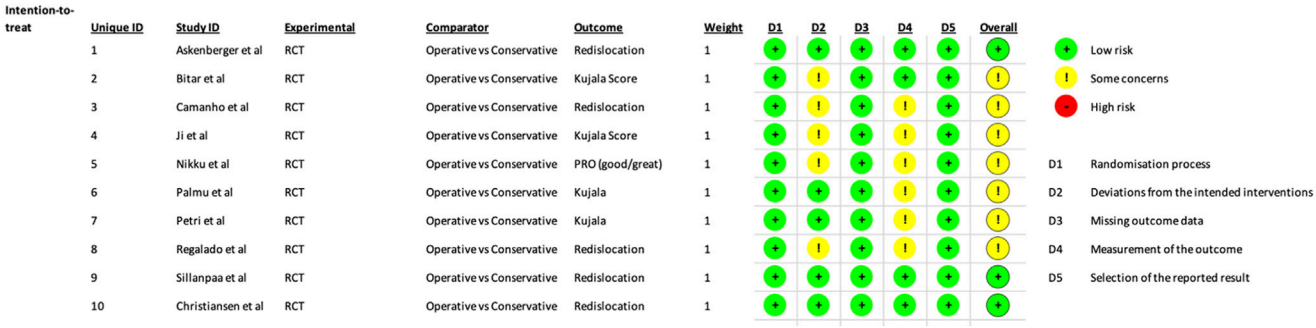

Appendix Fig 1. Risk of bias (RoB2) of meta-analysis studies included.[20-28,30] (RCT, randomized controlled trial.)