


REVIEW ARTICLE

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# A systematic review and meta-analysis comparing conservative and surgical treatments for acute patellar dislocation in children and adolescents

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## Abstract

**Purpose** To clarify treatment evidence to treat patellar dislocation by evaluating which treatment could yield better improvement of clinical outcomes for acute patellar dislocation in children and adolescents less than eighteen years of age.

**Materials and methods** MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials electronic databases were searched for relevant articles comparing clinical outcomes of conservative and surgical treatments for acute patellar dislocation in children and adolescents published from March 2008 to August 2022. Data searching, extraction, analysis, and quality assessment were performed based on the Cochrane Collaboration guidelines. The quality assessment of each study was investigated using the Physiotherapy Evidence Database (PEDro) critical appraisal scoring system and Newcastle–Ottawa Quality Assessment Scale scores. To calculate the overall combined effect size for each outcome, Review Manager Version 5.3 (The Cochrane Collaboration, Software Update, Oxford) was employed.

**Results** Three randomized controlled trials (RCTs) and one prospective study were investigated. In terms of pain (MD: 6.59, 95% CIs: 1.73 to 11.45,  $I^2=0\%$ ), there were significantly better outcomes in conservative group. Nevertheless, there were no significant differences in any evaluated outcomes such as redislocation (RR: 1.36, 95% CIs: 0.72 to 2.54,  $I^2=65\%$ ), Kujala score (MD: 3.92, 95% CIs: -0.17 to 8.01,  $I^2=0\%$ ), Tegner score (MD: 1.04, 95% CIs: -0.04 to 2.11,  $I^2=71\%$ ), or subjective results (RR: 0.99, 95% CIs: 0.74 to 1.34,  $I^2=33\%$ ) between conservative and surgical treatment groups.

**Conclusion** Despite of better outcome in pain with conservative group, the present study revealed no significant differences in clinical outcomes between conservative treatment and surgical treatment in children and adolescents with acute patellar dislocation. Since there are no significant differences in clinical outcomes between the two groups, routine surgical treatment is not advocated for treating acute patellar dislocation in children and adolescents.

**Keywords** Patellar dislocation, Patellar instability, Medial patellofemoral ligament, Reconstruction, Meta-analysis

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## Introduction

Acute patellar dislocation is a common knee injury in children and adolescents, with an incidence of 0.3 to 1.2 per 1000 in children aged 9 to 15 years [1–3]. Without appropriate treatment, patellar dislocation can lead to subsequent redislocation, painful instability, anterior knee pain, and patellofemoral degeneration [4–6]. Thus, effective treatments are required.

Orthopaedic surgeons face difficulties in treating patellar dislocation due to the complexity of the procedures and the unsatisfactory results, which often lead to frequent recurrence. Previously, conservative treatment was considered the preferred option. However, the recurrence rate was high (30–70%) in those without an operative treatment, with the highest rate observed in younger patients [2, 7, 8]. For these reasons, recently there has been a trend toward surgical treatment by medial patellofemoral ligament (MPFL) stabilization. Several studies have reported that surgery is superior to conservative treatment regarding redislocation rate, quality of life, and sporting function in children and adolescents [7, 9, 10]. However, a high incidence of degenerative changes in patellofemoral joint with influence on subjective knee function in long-term follow-ups of these patients has also been reported [11, 12].

Our group has previously published a study on primary patellar dislocation in adults and reported that conservative and surgical treatments have similar clinical results [13]. Furthermore, various systematic reviews and meta-analyses that examined the general population have found that surgical treatment results in fewer incidents of redislocation and better knee function than conservative treatment in the short term, while long-term outcomes are comparable [14–16]. However, children and adolescents have different anatomic characteristics due to their immature musculoskeletal growth. Hence, it would not be appropriate to adapt results of studies on adults to children and adolescents. In addition, children and adolescents have characteristics that indicate rapid growth. Their growth plate is open, making it difficult to choose surgical option. Therefore, clinical results according to treatment treatments for acute patellar dislocation in adults and children/adolescents should be analyzed separately.

Restoring the function of the medial patellofemoral ligament (MPFL) is crucial in the treatment of patellar dislocation. The MPFL serves as the primary restraint against lateral patellar translation and provides 50–60% of the medial restraining force against such translation [4, 17, 18]. The MPFL is often damaged during an acute patellar dislocation in skeletally immature patients, with

the majority of injuries occurring at the site of the ligament's attachment to the patella [19–21]. Adult patients with patellar dislocation typically exhibit a higher prevalence of femoral-based lesions than children, although the injury is usually multifocal and frequently involves the patellar attachment site [22–24]. For these reasons, skeletally immature children might have a different natural history after patellar dislocation than adult populations [25, 26]. Especially, in terms of treatment of patellar dislocation, conservative treatment of first time pediatric acute patellar dislocation has been associated with up to a 69% failure rate [25]. Thus, attention has shifted toward surgical treatment for addressing patellar instability [7, 10, 27]. While multiple studies have shown that surgical treatment results in fewer redislocations and improved knee function compared to conservative treatment in all patients in the short term, long-term outcomes tend to be similar [14–16]. In addition, how surgical treatment will affect children and adolescents for treating acute patellar dislocation remains a controversy.

Thus, the purpose of this review was to summarize treatment evidence to treat patellar dislocation by evaluating which treatment could yield better improvement in stability and functional recovery for acute patellar dislocation in children and adolescents. We hypothesized that surgical treatment might not provide better outcomes after acute patellar dislocation in children and adolescents.

## Materials and methods

### Study selection

The present study employed Cochrane Review methods and followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement for reporting. Controlled vocabulary and free text words listed in [Appendix](#) were utilized to search the MEDLINE, EMBASE, and Cochrane Central Register of Controlled Trials databases to identify relevant studies. We included all relevant studies, regardless of their publication type (e.g., article, poster, conference article, instructional course lectures), language, publication journal, or year of publication. The search was updated in August 2022, and reference lists of the identified studies and review articles were examined for any additional relevant publications. Moreover, we reviewed the reference lists of the investigated studies to identify any further publications that were not found through manual or electronic searches. We also checked for duplication in cases where the same author had two or more studies. If duplicated, only the latest study was included.

### Inclusion and exclusion criteria

Studies were included in our investigation if they met the following criteria: (1) studies on children and adolescent subjects (less than 18 years of age) who received treatment for acute patellar dislocation, (2) studies that compared clinical outcomes of conservative treatment and surgical treatment for acute patellar dislocation, and (3) those with level I or level II evidence. Exclusion criteria were: (1) studies on revision cases or old dislocation, (2) study subjects who had congenital abnormality or congenital disease, (3) studies that evaluated only adult subjects, (4) studies that only reported non-clinical outcome measures or intra-operative measures, (5) studies with level III, IV, or V evidence (retrospective studies, case report, technical note, or letters to the editor), (6) review articles, (7) biomechanical studies, and (8) in vitro studies.

### Data collection and analysis

Two authors independently reviewed the titles and abstracts of studies identified through the search strategy. Full papers were then evaluated for final inclusion. Any uncertainty regarding study inclusion was resolved through discussion and consensus. The authors independently extracted eligible data onto pre-defined forms and checked for accuracy. We gathered information on various study characteristics, including details about the authors, journal, study design, publication year, patient demographics such as sex, age, number of participants, treatment interventions (conservative methods and surgical techniques), and follow-up duration (Table 1). Treatment interventions used in this study were physical therapy (PT) or brace immobilization in the conservative treatment group. And in the surgical treatment group, MPFL repair, lateral retinacula release (LRR), or these

**Table 1** Characteristics of included studies

Study	Journal	Study design	Year	Sample Size	Age (years)	Sex (M: F)	Intervention	Follow-up (m)
Askenberger et al. [28]	American Journal of Sports Medicine	RCT	2018	Conservative: 37 Surgical: 37	13.0 ± 1.1 13.2 ± 1.1	17:20 19:18	Conservative: PT and knee brace which was a lateral stabilizing soft tissue brace for 4 weeks Surgical: arthroscopic MPFL repair, followed by a soft cast splint for 4 weeks	24
Apostolovic et al. [31]	International Orthopaedics	Prospective study	2011	Conservative: 23 Surgical: 14	14.3 ± 1.0 13.1 ± 1.0	4:19 5:9	Conservative: Immobilization for 3 weeks, quadriceps exercise Surgical: MPFL repair or arthroscopic LRR	73.2
Regalado et al. [10]	Knee Surgery Sports Traumatology Arthroscopy	RCT	2016	Conservative: 15 Surgical: 15	13.5 (8–16) 13.5 (8–16)	9:11 5:11	Conservative: PT and knee brace for 4 weeks Surgical: Fulkerson type I: LRR Fulkerson type II, III, IV: proximal and distal LRR and medial imbrications	72
Palmu et al. [8]	Journal of Bone and Joint Surgery Am	RCT	2008	Conservative: 28 Surgical: 32	13.0 ± 2.0 13.0 ± 2.0	9:19 5:27	Conservative: Immobilization with a removable knee extension orthosis or patella-stabilizing orthosis for 6 weeks Surgical: MPFL repair or MPFL repair + LRR, or only LRR	168

RCT randomized controlled trial, PT physical therapy, MPFL medial patellofemoral ligament, LRR lateral retinacula release

two methods were used in combination. And the *clinical results* of the included studies were evaluated, regarding redislocation, postoperative complications, Kujala score, Tegner score, pain, surgery after initial intervention, and subjective result (Table 2). The “pain” was evaluated based on visual analogue scale (VAS) score [8] or pain score of knee injury and osteoarthritis outcome score (KOOS) [28]. In additions, “subjective results” was evaluated based on medical record [8], or questionnaire in a telephone interviews [10]. The data extracted from the eligible studies were used to calculate the number of participants or the mean and standard deviation (SD) of demographic and clinical outcome measures for each group, which were then reviewed and summarized in the results and tables.

**Assessment of methodological quality**

Two investigators independently assessed methodological qualities of each study using the Physiotherapy Evidence Database (PEDro) critical appraisal scoring system, a reliable tool for assessing RCTs and Newcastle–Ottawa Quality Assessment Scale scores for non-RCTs [29, 30]. Any disagreement between authors was resolved through discussion or through a review by the third investigator. Publication bias was not evaluated due to a low statistical power as the number of included studies was less than 10 in each field of research.

**Statistical analysis**

We used Review Manager Version 5.3 (The Cochrane Collaboration, Software Update, Oxford) to calculate the overall pooled effect size for each outcome. For studies involving only randomized trials and prospective studies, we conducted a meta-analysis using a random-effects model. For continuous outcomes, we used the inverse variance method to determine the mean difference (MD) with a 95% confidence interval (CI). For binary outcomes, we calculated the risk

ratio (RR) between groups using the Mantel–Haenszel method. We evaluated statistical heterogeneity among studies using I-squared (I<sup>2</sup>), with values of 25%, 50%, and 75% considered low, moderate, and high, respectively, and Cochrane’s Q statistic (Chi-square test). A *p*-value < 0.10 was considered statistically significant for heterogeneity.

**Results**

**Identification of studies**

At the start of this study, 196 articles were found to be potentially relevant. After eliminating 19 duplicates and screening the remaining 177 articles using titles and abstracts, 19 articles were deemed potentially relevant for full-text review. However, upon full-text review, 15 of these articles were excluded due to a lack of essential data. Ultimately, four clinical studies were included for data extraction and meta-analysis (Fig. 1) [8, 10, 28, 31].

**Quality of included studies**

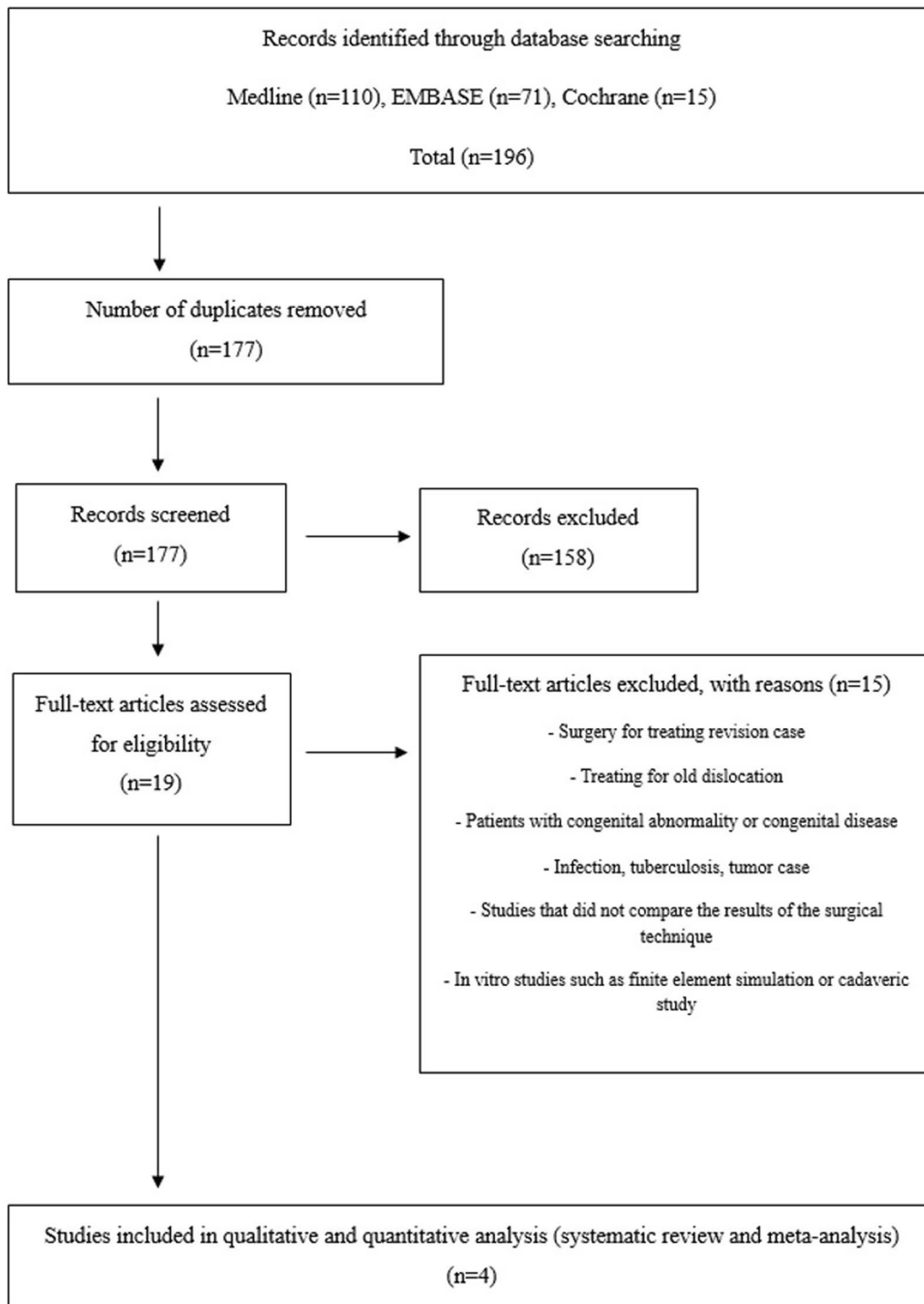
To evaluate the methodologic quality, we used the PEDro critical appraisal scoring system for RCTs and Newcastle–Ottawa Quality Assessment Scale (maximum 9 points) scores for non-RCTs. The average PEDro score for the RCTs was 8.7 points, with a range of 8–9, indicating that most studies were of good or fair quality. All studies met the eligibility criteria and included randomization, adequate follow-up, intention-to-treat analysis, between-group analysis, and point estimates and variability. However, some studies were found to have used an inadequate blinding method, which could potentially have led to a detection bias. Despite this weakness, the majority of the study designs scored over 8, indicating a low risk of bias. In addition, the non-RCT study had Newcastle–Ottawa Quality Assessment Scale scores ≥ 8 points, indicating a low risk of bias of included non-RCT studies.

**Table 2** Clinical outcomes of conservative and surgical treatments in included studies

Study	Group (n)	Redislocation	Postoperative complications	Kujala score	Tegner score	Pain	Surgery after initial intervention	*Subjective results
Askenberger et al. [28]	Conservative: 37 Surgical: 37	16 8	2	95.9 ± 7.2 90.9 ± 13.0	5.0 ± 1.4 4.5 ± 2.0	89.3 ± 11.7 83.1 ± 16.8	Conservative: 6 Surgical: 0	NP
Apostolovic et al. [31]	Conservative: 23 Surgical: 14	1 2	NP	NP	NP	NP	Conservative: 4 Surgical: 4	NP
Regalado et al. [10]	Conservative: 15 Surgical: 15	11 5	3	NP	NP	NP	Conservative: 4 Surgical: 0	Conservative: 11 Surgical: 13
Palmu et al. [8]	Conservative: 28 Surgical: 32	20 24	2	84.0 ± 13.0 83.0 ± 18.0	6.0 ± 1.9 4.4 ± 1.4	91.0 ± 10.0 84.0 ± 18.0	Conservative: 11 Surgical: 16	Conservative: 21 Surgical: 21

VAS visual analog scale, KOOS the Knee injury and Osteoarthritis Outcome Score, QOL quality of life, NP not provided

\*Subjective result: the scoring or the number of patients with excellent or good subjective result were evaluated



**Fig. 1** Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) flow diagram

**Clinical results of included studies**

**Redislocation**

Four studies reported redislocation in conservative and surgical groups (conservative group/surgical group;

103/98). There were no significant differences in redislocation between conservative and surgical groups (RR: 1.36, 95% CIs: 0.72 to 2.54,  $I^2 = 65%$ ) (Fig. 2a).

### **Kujala score**

Two studies reported Kujala scores for conservative and surgical groups (conservative group/surgical group: 65/69). Remaining studies were excluded due to insufficient data. There were no significant differences in Kujala score between conservative and surgical groups (MD: 3.92, 95% CIs: -0.17 to 8.01,  $I^2=0\%$ ) (Fig. 2b).

### **Tegner score**

Two studies reported Tegner scores for conservative and surgical groups, consisting of a total of 134 subjects (65 subjects in the conservative group and 69 subjects in the surgical group). There was no significant difference in Tegner score between conservative and surgical groups (MD: 1.04, 95% CIs: -0.04 to 2.11,  $I^2=71\%$ ) (Fig. 2c).

### **Pain**

Two studies reported pain in conservative and surgical groups, consisting of a total of 132 subjects (59 subjects in the conservative group and 73 subjects in the surgical group). There were significant differences in pain between conservative and surgical groups (MD: 6.59, 95% CIs: 1.73 to 11.45,  $I^2=0\%$ ) (Fig. 2d).

### **Subjective results**

Two studies reported subjective results for conservative and surgical groups, consisting of a total of 90 subjects (43 subjects in the conservative group and 47 subjects in the surgical group). There were no significant differences in subjective results between conservative and surgical groups (RR: 0.99, 95% CIs: 0.74 to 1.34,  $I^2=33\%$ ) (Fig. 2e).

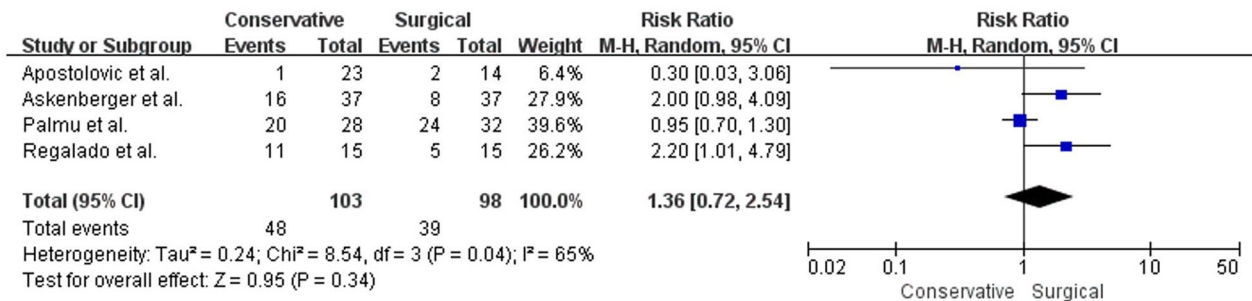
## **Discussion**

The most important finding of the present study was that surgical treatment for acute patellar dislocation in children and adolescents was not superior to conservative treatment in terms of clinical outcomes including redislocation, Kujala score, Tegner score, and subjective results. The results indicate that conservative treatment may be a preferable option for primary acute patellar dislocation, especially in terms of pain. This treatment approach is less invasive than surgical treatment and has been found to be equally effective. Therefore, our hypothesis is supported by these findings. Furthermore, these results are the same as those of conservative and surgical treatment in primary patellar dislocation of adults [13]. Until the end of the twentieth century, conservative treatment was frequently used to treat acute patellar dislocation. However, studies have reported a considerable occurrence (up to 44%) of residual patellar instability, anterior knee pain, and redislocation associated with this approach [32]. Due to advances in proper understanding of functional anatomy and biomechanics of the medial patellar

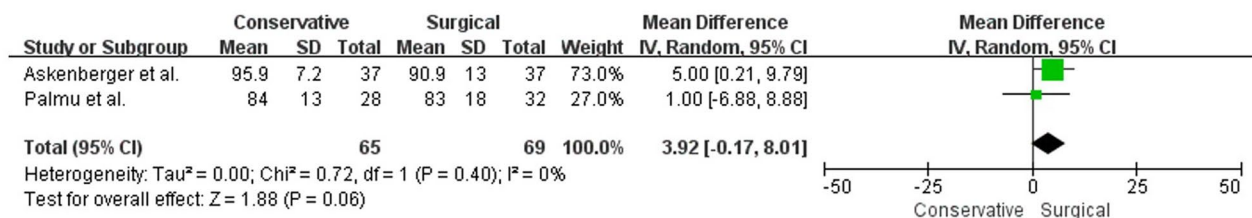
stabilizer, primary surgical treatment has been expanded for acute patellar dislocation [33, 34]. Therefore, surgical treatment may be prioritized as the primary treatment option to not only minimize the chance of reoccurrence but also to optimize functional recovery and facilitate a prompt return to sports activities. Despite the advocacy of these surgical issues, in our study, the clinical results of the two groups did not show significant differences, and the conservative treatment group showed favorable results regarding to pain. In addition, since the original study included in the analysis of pain did not show a statistically significant difference between the two groups, additional large-scale studies are needed for more strengthening evidences.

Recent studies on acute patellar dislocation have involved mainly adult patients and demonstrated that both conservative and surgical treatment could be feasible options for treating acute patellar dislocation [35–38]. However, studies on acute patellar dislocation in children and adolescents comparing clinical outcomes after conservative and surgical treatment are rare. According to McManus et al. [39], the incidence of recurrence after an acute patellar dislocation is estimated to be six children out of every 10. Additionally, several other studies have reported a particularly high risk of recurrence in pediatric patients, with some reporting redislocation rates as high as 60% [40, 41]. Despite these high redislocation rates, many authors stated that there was no significant difference in clinical results between the two groups. For instance, Regalado et al. [10] have reported that a significantly higher redislocation rate in conservative group compared to operative group. However, they suggest that both treatments are feasible options for treating acute patellar dislocation in adolescents. In the same vein, Askenberger et al. [28] have reported that surgical repair of a MPFL injury in skeletally immature children with a primary traumatic patellar dislocation can significantly reduce the redislocation rate without improving subjective or objective knee function compared with a knee brace without repair. Also, Palmu et al. [8] have reported that initial surgical repair of medial structures could not improve long-term outcomes with a very high rate of recurrent instability. As such, in many studies, redislocation rates in conservative and surgical groups have been reported differently for each study, but there was no significant difference in the clinical results of the two groups. Furthermore, in order to establish stronger evidence, it was also possible to confirm a systematic review and meta-analysis study that studied topics similar to the present study. However, compared to our study, one study only analyzed redislocation and lacked analysis of other clinical results [42]. In addition, there were studies that did not include statistical analysis, so there were

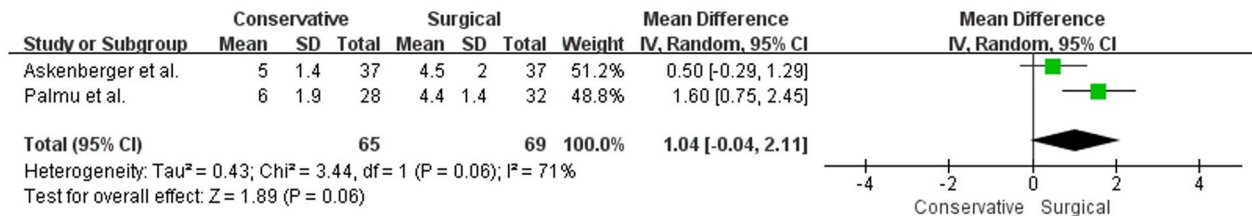
**(a) Redislocation**



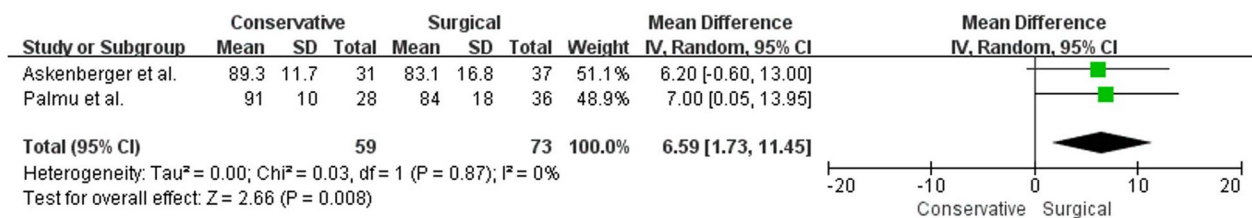
**(b) Kujala score**



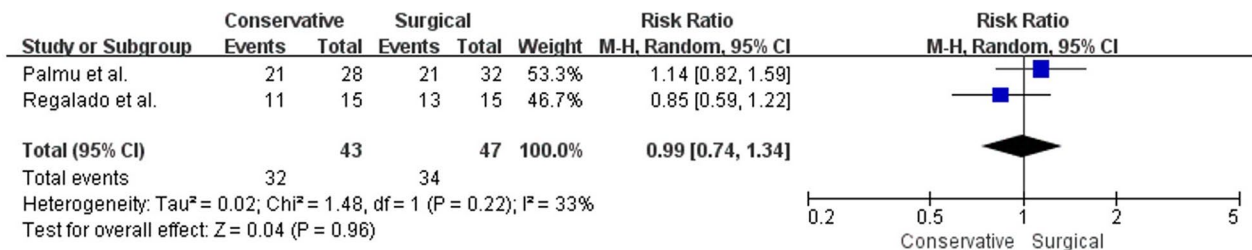
**(c) Tegner score**



**(d) Pain**



**(e) Subjective results**



**Fig. 2** Forest plot showing mean difference or risk ratio in clinical results of conservative versus surgical treatment for patellar dislocation. There were no significant differences in any evaluated outcomes between the two groups (**a** = Redislocation, **b** = Kujala score, **c** = Tegner score, **d** = Pain, **e** = Subjective results). *RR* risk ratio, *SD* standard deviation, *IV* inverse variance, *CI* confidence interval, and *df* degrees of freedom

limitations in obtaining reliable results, and the level of evidence was low because level I and II studies (high quality studies) were omitted from the analysis or retrospective studies were included [9, 43]. Unlike those studies, our study involved only RCTs and prospective study (level I and II). These included trials showed a low risk of bias, indicating that most studies were of good quality. Thus, this meta-analysis has strong evidence for treating acute patellar dislocation in children and adolescents.

Although our study has several strengths, it also has some limitations. One major limitation is the relatively small number of studies included in the meta-analysis for each topic. Additionally, there were few prospective studies available, which is a significant limitation. Nevertheless, we considered each study result to be of clinical value and therefore included them in our analysis. The strength of this study was its study design: a systematic review and meta-analysis including randomized controlled trials and prospective study on skeletally immature children and adolescents. Second, although not analyzed in our study, several risk factors for recurrent patellar dislocation that might affect clinical outcomes should be considered. Jaquith et al. [44] have demonstrated that trochlear dysplasia, skeletal immaturity, patellar alta, and a history of contralateral patellar dislocation are all significantly risk factors for recurrence in patients with first-time patellar dislocation. Thus, various risk factors that might affect recurrent patellar instability following treatment of acute patellar dislocation need to be controlled, including trochlear dysplasia, vastus medialis oblique dysplasia, hyperlaxity, increased patellar tilt, patellar alta, and increased tibial tuberosity-trochlear groove distance [41, 45]. Third, technical factors of surgery that may affect result following surgical treatment need to control. One study performed MPFL repair, and another study performed LRR. There were also studies using two methods combined. In addition, although MPFL reconstruction is widely performed as a treatment for dislocation of the patella, it has not been sufficiently discussed due to the lack of research data related to MPFL reconstruction in children and adolescents. In order to solve this heterogeneity, a larger, well-controlled prospective study is needed. Controlling for confounding factors in a study is crucial to obtain accurate results. In an ideal study, all confounding factors would be removed to evaluate the independent factor. Randomization is performed to minimize confounding factors and distribute them equally among study groups [46]. However, in practice, controlling for all confounding factors affecting clinical outcomes is limited. While a meta-analysis can provide powerful conclusions by analyzing studies on the same topic, it is not possible to exclusively include studies with the same methodology. To minimize bias, inclusion

criteria recommended by the Cochrane collaboration guideline were strictly adopted when selecting papers for the study. Only randomized and prospective studies (level I and II studies) were included using a random effects model statistically, which helped to minimize the risk of bias. However, it should be noted that the limited number of studies available on each topic is a potential limitation of this study.

## Conclusion

Despite of better outcome in pain with conservative group, the present study revealed that there were no significant differences in clinical outcomes between conservative treatment and surgical treatment in children and adolescents with acute patellar dislocation. Since there were no clear differences in clinical outcomes between the two groups, routine surgical treatment is not advocated for treating acute patellar dislocation in children and adolescents.

## Appendix

Electronic search strategy for each database.

### MEDLINE

1. "Medial patellofemoral ligament"[tiab] OR "MPFL"[tiab],  $n = 1233$
2. "Recurrent patellar dislocation" [tiab] OR "recurrent patellar instability"[tiab],  $n = 525$
3. "Patellar dislocation"[Mesh],  $n = 1425$
4. 1 OR 2 OR 3,  $n = 2212$
5. Medial reefing[tiab] OR Medial augmentation[tiab] OR Medial plication[tiab] OR Medial imbrication [tiab] OR Quadricepsplasty[tiab] OR Proximal realignment[tiab],  $n = 271$
6. Single-Bundle[tiab] OR Double-Bundle[tiab] OR ((Single[tiab] OR Double[tiab]) AND Bundle[tiab]),  $n = 6822$
7. 5 OR 6,  $n = 7093$
8. 4 AND 7,  $n = 120$
9. 8 NOT ("review"[Publication Type] OR "review literature as topic"[MeSH Terms]),  $n = 110$

### EMBASE

1. 'knee ligament'/de OR 'knee cruciate ligament'/exp,  $n = 27,734$
2. "Medial patellofemoral ligament":ab,ti,  $n = 1296$
3. "Patellar dislocation":ab,ti,  $n = 1392$
4. 1 OR 2 OR 3,  $n = 29,388$
5. Medial reefing:ab,ti OR Medial augmentation:ab,ti OR Medial plication:ab,ti OR Medial imbrication:ab,



ti OR Quadricepsplasty:ab,ti OR Proximal realignment:ab,ti,  $n = 477$

6. 4 AND 5,  $n = 83$

7. 6 NOT ('conference review'/it OR 'review'/it),  $n = 71$

## COCHRANE

1. "Medial patellofemoral ligament" OR "MPFL":ti, ab,kw,  $n = 86$

2. MeSH descriptor: [Patellar dislocation] explode all trees,  $n = 49$

3. 1 OR 2,  $n = 111$

4. Medial reefing OR Medial augmentation OR Medial plication OR Medial imbrication OR Quadricepsplasty OR Proximal realignment:ti,ab,kw,  $n = 152$

5. Single-Bundle OR Double-Bundle OR ((Single OR Double) AND Bundle):ti,ab,kw,  $n = 806$

6. 4 OR 5,  $n = 950$

7. 3 AND 6,  $n = 16$

8. 7/trials,  $n = 15$

## Abbreviations

RCT	Randomized controlled trial
MPFL	Medial patellofemoral ligament
PT	Physical therapy
LRR	Lateral retinacula release
VAS	Visual analogue scale
KOOS	Knee injury and osteoarthritis outcome score
SD	Standard deviation
MD	Mean difference
CI	Confidence interval
RR	Risk ratio

## Acknowledgements

Not applicable

## Author contributions

DYL, DGK, SCH: substantial contribution to conception and study design. HSJ, SJH, JHB: data collection, data analysis, revising the draft critically, and final approval of the version. All authors read and approved the final manuscript.

## Funding

There was no funding source.

## Availability of data and materials

All data generated or analyzed during this study are included in this published article.

## Declarations

### Ethics approval and consent to participate

Because this study was a literature review, ethical approval and consent to participate were not obtained.

### Consent for publication

The authors read and approved the final manuscript.

## Competing interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Received: 12 October 2022 Accepted: 2 May 2023

Published online: 22 June 2023

## References

- Askenberger M, Ekstrom W, Finnbogason T, Janarv PM (2014) Occult Intra-articular Knee Injuries in Children With Hemarthrosis. *Am J Sports Med* 42:1600–1606
- Fithian DC, Paxton EW, Stone ML, Silva P, Davis DK, Elias DA, White LM (2004) Epidemiology and natural history of acute patellar dislocation. *Am J Sports Med* 32:1114–1121
- Nietosvaara Y, Aalto K, Kallio PE (1994) Acute patellar dislocation in children: incidence and associated osteochondral fractures. *J Pediatr Orthop* 14:513–515
- Matic GT, Magnussen RA, Kolovich GP, Flanigan DC (2014) Return to activity after medial patellofemoral ligament repair or reconstruction. *Arthroscopy* 30:1018–1025
- Nomura E, Inoue M (2005) Second-look arthroscopy of cartilage changes of the patellofemoral joint, especially the patella, following acute and recurrent patellar dislocation. *Osteoarthritis Cartilage* 13:1029–1036
- Sanders TL, Pareek A, Hewett TE, Stuart MJ, Dahm DL, Krych AJ (2018) High rate of recurrent patellar dislocation in skeletally immature patients: a long-term population-based study. *Knee Surg Sports Traumatol Arthrosc* 26:1037–1043
- Camanho GL, Viegas Ade C, Bitar AC, Demange MK, Hernandez AJ (2009) Conservative versus surgical treatment for repair of the medial patellofemoral ligament in acute dislocations of the patella. *Arthroscopy* 25:620–625
- Palmu S, Kallio PE, Donell ST, Helenius I, Nietosvaara Y (2008) Acute patellar dislocation in children and adolescents: a randomized clinical trial. *J Bone Joint Surg Am* 90:463–470
- Nwachukwu BU, So C, Schairer WW, Green DW, Dodwell ER (2016) Surgical versus conservative management of acute patellar dislocation in children and adolescents: a systematic review. *Knee Surg Sports Traumatol Arthrosc* 24:760–767
- Regalado G, Lintula H, Kokki H, Kroger H, Vaatainen U, Eskelinen M (2016) Six-year outcome after non-surgical versus surgical treatment of acute primary patellar dislocation in adolescents: a prospective randomized trial. *Knee Surg Sports Traumatol Arthrosc* 24:6–11
- Sillanpaa PJ, Mattila VM, Visuri T, Maenpaa H, Pihlajamaki H (2011) Patellofemoral osteoarthritis in patients with operative treatment for patellar dislocation: a magnetic resonance-based analysis. *Knee Surg Sports Traumatol Arthrosc* 19:230–235
- Mostrom EB, Mikkelsen C, Weidenhielm L, Janarv PM (2014) Long-term follow-up of nonoperatively and operatively treated acute primary patellar dislocation in skeletally immature patients. *ScientificWorldJournal* 2014:473281
- Lee DY, Park YJ, Song SY, Hwang SC, Park JS, Kang DG (2018) Which technique is better for treating patellar dislocation? A systematic review and meta-analysis. *Arthroscopy* 34(3082–3093):e3081
- Yao LW, Zhang C, Liu Y, Cao DG, Li DJ, Xu DD, Feng SQ (2015) Comparison operative and conservative management for primary patellar dislocation: an up-to-date meta-analysis. *Eur J Orthop Surg Traumatol* 25:783–788
- Saccomanno MF, Sircana G, Fodale M, Donati F, Milano G (2016) Surgical versus conservative treatment of primary patellar dislocation. A systematic review and meta-analysis. *Int Orthop* 40:2277–2287

16. Smith TO, Donell S, Song F, Hing CB (2015) Surgical versus non-surgical interventions for treating patellar dislocation. *Cochrane Database Syst Rev* CD008106.
17. Lenschow S, Schliemann B, Gestring J, Herbolt M, Schulze M, Kusters C (2013) Medial patellofemoral ligament reconstruction: fixation strength of 5 different techniques for graft fixation at the patella. *Arthroscopy* 29:766–773
18. Ji G, Wang S, Wang X, Liu J, Niu J, Wang F (2017) Surgical versus nonsurgical treatments of acute primary patellar dislocation with special emphasis on the MPFL injury patterns. *J Knee Surg* 30:378–384
19. Zaidi A, Babyn P, Astori I, White L, Doria A, Cole W (2006) MRI of traumatic patellar dislocation in children. *Pediatr Radiol* 36:1163–1170
20. Kepler CK, Bogner EA, Hammoud S, Malcolmson G, Potter HG, Green DW (2011) Zone of injury of the medial patellofemoral ligament after acute patellar dislocation in children and adolescents. *Am J Sports Med* 39:1444–1449
21. Askenberger M, Arendt EA, Ekstrom W, Voss U, Finnbogason T, Janarv PM (2016) Medial patellofemoral ligament injuries in children with first-time lateral patellar dislocations: a magnetic resonance imaging and arthroscopic study. *Am J Sports Med* 44:152–158
22. Zhang GY, Zheng L, Feng Y, Shi H, Liu W, Ji BJ, Sun BS, Ding HY (2015) Injury patterns of medial patellofemoral ligament and correlation analysis with articular cartilage lesions of the lateral femoral condyle after acute lateral patellar dislocation in adults: An MRI evaluation. *Injury* 46:2413–2421
23. Tompkins MA, Rohr SR, Agel J, Arendt EA (2018) Anatomic patellar instability risk factors in primary lateral patellar dislocations do not predict injury patterns: an MRI-based study. *Knee Surg Sports Traumatol Arthrosc* 26:677–684
24. Petri M, von Falck C, Broese M, Liodakis E, Balcarek P, Niemeyer P, Hofmeister M, Krettek C, Voigt C, Haasper C, Zeichen J, Frosch KH, Lill H, Jagodzinski M (2013) Influence of rupture patterns of the medial patellofemoral ligament (MPFL) on the outcome after operative treatment of traumatic patellar dislocation. *Knee Surg Sports Traumatol Arthrosc* 21:683–689
25. Lewallen LW, McIntosh AL, Dahm DL (2013) Predictors of recurrent instability after acute patellofemoral dislocation in pediatric and adolescent patients. *Am J Sports Med* 41:575–581
26. Lewallen L, McIntosh A, Dahm D (2015) First-time patellofemoral dislocation: risk factors for recurrent instability. *J Knee Surg* 28:303–309
27. Bitar AC, D'Elia CO, Demange MK, Viegas AC, Camanho GL (2011) Randomized prospective study on traumatic patellar dislocation: conservative treatment versus reconstruction of the medial patellofemoral ligament using the patellar tendon, with a minimum of two years of follow-up. *Rev Bras Ortop* 46:675–683
28. Askenberger M, Bengtsson Mostrom E, Ekstrom W, Arendt EA, Hellsten A, Mikkelsen C, Janarv PM (2018) Operative repair of medial patellofemoral ligament injury versus knee brace in children with an acute first-time traumatic patellar dislocation: a randomized controlled trial. *Am J Sports Med* 46:2328–2340
29. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther* 83:713–721
30. Stang A (2010) Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol* 25:603–605
31. Apostolovic M, Vukomanovic B, Slavkovic N, Vuckovic V, Vukcevic M, Djuricic G, Kocev N (2011) Acute patellar dislocation in adolescents: operative versus nonoperative treatment. *Int Orthop* 35:1483–1487
32. Maenpaa H, Lehto MU (1997) Patellar dislocation. The long-term results of nonoperative management in 100 patients. *Am J Sports Med* 25:213–217
33. Amis AA, Firer P, Mountney J, Senavongse W, Thomas NP (2003) Anatomy and biomechanics of the medial patellofemoral ligament. *Knee* 10:215–220
34. Feller JA, Amis AA, Andrish JT, Arendt EA, Erasmus PJ, Powers CM (2007) Surgical biomechanics of the patellofemoral joint. *Arthroscopy* 23:542–553
35. Christiansen SE, Jakobsen BW, Lund B, Lind M (2008) Isolated repair of the medial patellofemoral ligament in primary dislocation of the patella: a prospective randomized study. *Arthroscopy* 24:881–887
36. Hing CB, Smith TO, Donell S, Song F (2011) Surgical versus non-surgical interventions for treating patellar dislocation. *Cochrane Database Syst Rev* CD008106.
37. Panni AS, Vasso M, Cerciello S (2013) Acute patellar dislocation. What to do? *Knee Surg Sports Traumatol Arthrosc* 21:275–278
38. Smith TO, Song F, Donell ST, Hing CB (2011) Operative versus non-operative management of patellar dislocation. A meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 19:988–998
39. McManus F, Rang M, Heslin DJ (1979) Acute dislocation of the patella in children. The natural history. *Clin Orthop Relat Res* 88–91
40. Beasley LS, Vidal AF (2004) Traumatic patellar dislocation in children and adolescents: treatment update and literature review. *Curr Opin Pediatr* 16:29–36
41. Cash JD, Hughston JC (1988) Treatment of acute patellar dislocation. *Am J Sports Med* 16:244–249
42. Fuller JA, Hammil HL, Pronschinske KJ, Durall CJ (2018) Operative versus nonoperative treatment after acute patellar dislocation: which is more effective at reducing recurrence in adolescents? *J Sport Rehabil* 27:601–604
43. Zhang K, Jiang H, Li J, Fu W (2020) Comparison between surgical and nonsurgical treatment for primary patellar dislocations in adolescents: a systematic review and meta-analysis of comparative studies. *Orthop J Sports Med* 8:2325967120946446
44. Jaquith BP, Parikh SN (2017) Predictors of recurrent patellar instability in children and adolescents after first-time dislocation. *J Pediatr Orthop* 37:484–490
45. Steensen RN, Bentley JC, Trinh TQ, Backes JR, Wiltfong RE (2015) The prevalence and combined prevalences of anatomic factors associated with recurrent patellar dislocation: a magnetic resonance imaging study. *Am J Sports Med* 43:921–927
46. Barcot O, Boric M, Poklepovic Pericic T, Cavar M, Dosenovic S, Vuka I, Puljak L (2019) Risk of bias judgments for random sequence generation in Cochrane systematic reviews were frequently not in line with Cochrane Handbook. *BMC Med Res Methodol* 19:170

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