Comparison Between Surgical and Nonsurgical Treatment for Primary Patellar Dislocations in Adolescents

A Systematic Review and Meta-analysis of Comparative Studies

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Background: Whether surgical or nonsurgical management is more appropriate for primary patellar dislocations (PPDs) in adolescents (younger than 18 years) remains controversial.

Purpose: To compare the clinical outcomes of surgical versus nonsurgical treatment for adolescents and children with PPDs.

Study Design: Systematic review; Level of evidence, 3.

Methods: There were 2 reviewers who independently searched the PubMed, Embase, Ovid, and Cochrane databases for English-language studies of randomized controlled trials (RCTs), quasi-RCTs, and observational studies comparing surgical with nonsurgical treatment for PPDs. The primary outcomes were redislocations, the Kujala score, and the Knee injury and Osteoarthritis Outcome Score (KOOS), and the secondary outcome was subsequent surgery.

Results: A total of 6 studies were included in our systematic review and meta-analysis. Among patients younger than 18 years, surgery was associated with a lower redislocation rate compared with nonsurgical treatment within 5 years of treatment (risk ratio [RR], 0.58 [95% CI, 0.37-0.91]; $P = .02$; $I^2 = 47\%$) but not beyond 5 years (RR, 0.80 [95% CI, 0.59-1.07]; $P = .14$; $I^2 = 34\%$). However, surgery resulted in worse Kujala and KOOS scores compared with nonsurgical treatment. Yet, the treatment difference between the 2 groups tended to decrease over time.

Conclusion: The available evidence suggests that for adolescents with PPDs, surgery was superior to nonsurgical treatment in the short term to reduce the redislocation rate but resulted in poorer outcomes of knee function based on the Kujala and KOOS scores. However, the superiority of either surgical or nonsurgical treatment in adolescents did not appear to persist in the long term.

Keywords: primary patellar dislocation; adolescents; surgery; nonsurgical treatment

A primary patellar dislocation (PPD) occurs when an undamaged patella is displaced from the natural trochlear groove outward toward the lateral side.[6] Its incidence ranges from 5.8 to 77.8 per 100,000, and it is particularly prevalent among young people.[8,24] Without effective treatment, PPDs can lead to subsequent redislocations, painful instability, and patellofemoral degeneration.[18,20,28]

Nonsurgical treatment has been regarded as the first-line option for PPDs, except in patients with osteochondral fractures or other severe joint disorders in the knee.[5] However, such treatment is associated with a high redislocation rate and residual symptoms of instability in up to 44% of patients.[5,17] Therefore, attention has shifted toward surgical treatment for addressing patellar instability.[3,4,25] Several systematic reviews and meta-analyses focusing on the overall population have concluded that surgery yields fewer redislocations and better knee function than nonsurgical treatment among all patients at short-term follow-up but that outcomes are similar in the long term.[27,29,34]

However, how surgery compares with nonsurgical treatment in adolescents or children remains a controversy. Only 2 systematic reviews,[7,22] with conflicting conclusions, have investigated this topic in adolescents or children. One concluded that surgery is associated with fewer redislocations and better knee function than nonsurgical treatment,[22] while the other revealed similar findings regarding redislocations and knee function between the 2 treatment methods.[7] Unfortunately, neither review

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included the 2018 high-quality randomized controlled trial (RCT) by Askenberger et al[2] indicating that surgery may not lead to better outcomes than nonsurgical treatment in adolescents.

The current study aimed to compare outcomes after surgical versus nonsurgical treatment for the management of PPDs in adolescents and children through a systematic review and meta-analysis of available comparative studies. The primary outcome measures were redislocation rate and results on the 2 most frequently reported indicators for knee function, the Kujala score and the Knee injury and Osteoarthritis Outcome Score (KOOS), in both the short (within 5 years of treatment) and long term (beyond 5 years). The secondary outcome measure was rate of reoperations. We hypothesized that surgical treatment may not provide better results in preventing redislocations and improving functional outcomes in adolescents and children.

METHODS

Search Strategy

The PubMed, Embase, Ovid, and Cochrane databases were searched using the following terms: ("patella* dislocation") AND (primary OR acute OR first-time OR traumatic) AND (operat* OR surg*) AND (conservative OR non-operat* OR non-surg*) AND (adolescent* OR child* OR juvenile OR skeletally immature). Studies were first excluded on the basis of their titles and abstracts if they seemed clearly irrelevant. Remaining studies were read in full to determine whether they should be included. Reference lists from eligible studies, conference papers, and dissertations were also screened.

Selection Criteria

Studies were included in our review and meta-analysis if they were RCTs, quasi-RCTs, or other studies that compared surgical to nonsurgical treatment in skeletally immature patients with PPDs and that reported at least 1 of the primary outcomes (patellar redislocation, Kujala score, KOOS score) or the secondary outcome (subsequent surgery). The Kujala and KOOS scores are both calculated according to a 100-point system, with a higher score reflecting better knee function.

Studies were excluded if they were case reports, reviews, editorial letters, or expert opinions. Studies were also excluded if they involved patients older than 18 years or with recurrent patellar dislocations, previous severe knee injuries or surgical procedures, PPDs with concomitant injuries in the ligament and/or meniscus needing treatment, PPDs involving only osteochondral fractures treated with fixation, open injuries or surgical procedures, or patellar fractures.

In the included studies, PPDs were diagnosed on the basis of the appearance of an acute locked dislocation; typical clinical manifestations and signs, such as knee pain, hemarthrosis, palpation of the femoral epicondyle or medial peripatellar structures, and positive apprehension sign; imaging findings of effusion in the patellofemoral joint, medial retinacular injury, osteochondral lesions, and/or loose bodies; examination results of an easily displaced patella under anesthesia; and/or a medial retinacular injury under arthroscopic surgery.

Surgical techniques used in the included studies were arthroscopic and open medial patellofemoral ligament reconstruction or repair, lateral retinacular release, and distal realignment. Nonsurgical treatment included patient education, immobilization with bracing, splinting or taping techniques, manual or physical therapy, and exercise-based rehabilitation.

Data Extraction

Two reviewers (K.Z., H.J.) independently extracted and analyzed the following data from included studies into an Excel (Microsoft) database: first author, journal title, publication year, number of participants, mean age of participants, type of surgical and nonsurgical intervention, duration of posttreatment follow-up, and outcomes. A third reviewer (J.L.) resolved any disagreements regarding data extraction. If a study did not report means and standard deviations, we contacted the authors or estimated values according to the reported median, range, and sample size.[10]

Quality Assessment

The Cochrane Collaboration's risk-of-bias tool for randomized trials[9] and the Newcastle-Ottawa scale[31] for non-RCTs and observational studies were used to assess the methodological quality of the included studies. The overall quality of evidence for each outcome was graded as *high*, *moderate*, *low*, or *very low* according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) guidelines.[26] Again, the 2 reviewers independently performed the quality assessment.

Statistical Analysis

The meta-analysis was performed using Review Manager software (version 5.3; Cochrane Collaboration). Pooled

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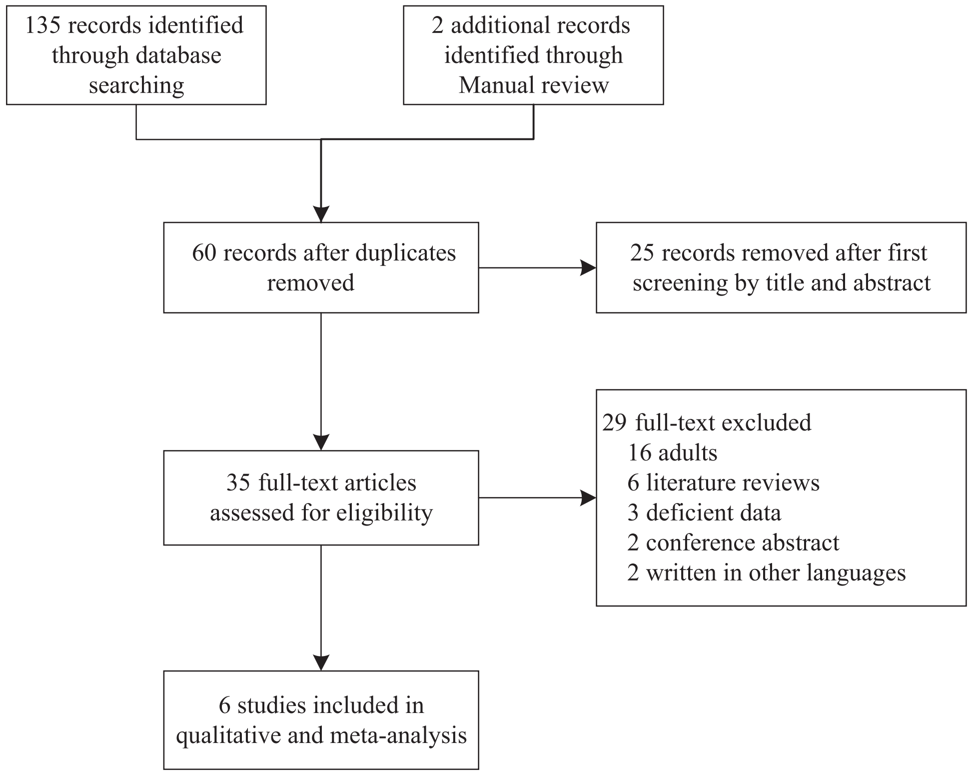

Figure 1. Flowchart of literature search and study inclusion.

results for dichotomous variables were expressed in terms of the risk ratio (RR) and 95% CI, while pooled results for continuous variables were expressed as the mean difference (MD) and 95% CI.

Heterogeneity was assessed in terms of I^2 and P values. According to the Cochrane Handbook,[9] heterogeneity was deemed to be unimportant if the I^2 value was <50% and the P value was >.1 and considerable if the I^2 value was >50% and the P value was <.1. We used a fixed-effects model for the meta-analysis of data showing unimportant heterogeneity and a random-effects model for data showing considerable heterogeneity.

Meta-analyses were performed for all outcomes regardless of follow-up length or for outcomes measured within 5 years of treatment (short term) or beyond 5 years (long term).

RESULTS

Included Studies

The literature search resulted in 137 potentially relevant studies (Figure 1). After the removal of duplicates and exclusion based on titles and abstracts, 3 RCTs,[2,23,25] 1 prospective study,[1] and 2 retrospective cohort studies[13,19] were included.

The included studies involved 339 patients who underwent nonsurgical treatment and 130 who underwent surgery (Table 1). The results of the risk-of-bias assessment for RCTs and for non-RCTs and retrospective cohort studies are shown in Tables 2 and 3. Clinical outcomes are summarized in Table 4.

Redislocations

Redislocations were reported in all 6 studies (N = 469 knees). The overall rate of recurrence was 41.8% (196/469); specifically, 43.1% (146/339) of knees that underwent nonsurgical treatment and 38.4% (50/130) that underwent surgery experienced a redislocation. Several studies reporting outcomes at follow-up times shorter[2,13,25] and longer than 5 years after the first treatment[1,19,23,25] were considered separately in the analyses of short- and long-term outcomes.

Using a fixed-effects model, the pooled meta-analysis across all studies showed that the surgery group had a significantly lower redislocation rate compared with the nonsurgical treatment group (RR, 0.75 [95% CI, 0.58-0.97]; $P = .03$; $I^2 = 23\%$) (Figure 2). The subgroup meta-analysis using a fixed-effects model showed that surgical treatment was associated with a significantly lower redislocation rate than nonsurgical treatment within 5 years after treatment (RR, 0.58 [95% CI, 0.37-0.91]; $P = .02$; $I^2 = 47\%$), but this result was not obtained beyond 5 years after treatment (RR, 0.80 [95% CI, 0.59-1.07]; $P = .14$; $I^2 = 34\%$) (Figure 3).

Kujala Score

The Kujala score was reported in 3 studies,[2,19,23] which included 174 patients (98 for nonsurgical treatment and

TABLE 1
Characteristics of Included Studies[a]

Author (Year)	Study Type	Age,[b] y	Initial No. of Patients (M/F)	Intervention	Follow-up,[c] y
Askenberger[2] (2018)	RCT				2
Nonsurgical		13.03 ± 1.14	37 (17/20)	4 wk of brace and physical therapy	
Surgical		13.19 ± 1.08	37 (19/18)	MPFL repair	
Regalado[25] (2016)	RCT				3 and 6
Nonsurgical		13.5 (8-16)	20 (9/11)	6 wk of brace and physical therapy	
Surgical		13.5 (8-16)	16 (5/11)	Isolated LRR and modified RG procedure	
Palmu[23] (2008)	RCT				7 and 14 (11-15)
Nonsurgical		13 ± 2	28 (9/19)	Immobilization and thigh muscle exercises	
Surgical		13 ± 2	32 (5/27)	MPFL repair and LRR or isolated LRR	
Apostolovic[1] (2011)	Non-RCT				6.1 (5-8)
Nonsurgical		14.26 (12-16)	23 (4/19)	3 wk of immobilization quadriceps exercises	
Surgical		13.07 (12-16)	14 (5/9)	MRR and capsular repair or LRR	
Moström[19] (2014)	RCS				
Nonsurgical		13.5 ± 1.3	33 (17/16)	Physical therapy	7.7 ± 1.5
Surgical		12.6 ± 2.3	7 (4/3)	Proximal realignment and LRR with RG or RET procedure	7.0 ± 1.4
Lewallen[13] (2013)	RCS				3.1
Nonsurgical		14.9 (9-18)	198 (—)	Closed reduction and immobilization with physical therapy	
Surgical		14.9 (9-18)	24 (—)	LRR, MPFL repair, and medial extensor mechanism imbrication	

[a]F, female; LRR, lateral retinacular release; M, male; MPFL, medial patellofemoral ligament; MRR, medial retinacular release; RCS, retrospective cohort study; RCT, randomized controlled trial; RET, Roux-Elmslie-Trillat; RG, Roux-Goldthwait.
[b]Presented as mean ± SD or median (range).
[c]Presented as mean, mean (range), or mean ± SD.

TABLE 2
Risk of Bias for Randomized Controlled Trials (Cochrane Risk-of-Bias Tool[9])

Author (Year)	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting	Other Source of Bias
Askenberger[2] (2018)	Low	Low	High	High	Low	Low	Low
Regalado[25] (2016)	High	High	High	High	Low	Low	Low
Palmu[23] (2008)	Unclear	Unclear	High	High	High	Unclear	High

TABLE 3
Risk of Bias for Non–Randomized Controlled Trials and Retrospective Cohort Studies (Newcastle-Ottawa Scale[31])

	Selection				Comparability		Outcome		
Author (Year)	Representativeness of Exposed Cohort	Selection of Nonexposed Cohort	Ascertainment of Exposure	Demonstration That Outcome of Interest Was Not Present at Start of Study	Selection of Most Important Factor	Study Controls for Any Additional Factor	Assessment of Outcome	Selection of Adequate Follow-up Period for Outcome of Interest	Adequacy of Follow-up of Cohort
Apostolovic[1] (2011)	1	1	0	1	0	0	1	1	1
Moström[19] (2014)	1	1	0	1	0	0	1	1	1
Lewallen[13] (2013)	1	1	0	1	0	0	1	0	0

TABLE 4
Clinical Outcomes Between Surgery and Nonsurgical Treatment for Primary Patellar Dislocations[a]

Author (Year)	No. of Redislocations	Kujala Score	No. of Reoperations	Subjective Satisfaction[b]	Tegner Score	Cincinnati Score	VAS Score	KOOS Subscore: Pain	KOOS Subscore: Symptoms	KOOS Subscore: ADL	KOOS Subscore: Sports	KOOS Subscore: QoL
Askenberger[2] (2018)												
Nonsurgical	16	95.9 ± 7.2	NR	NR	5.0 ± 1.4	NR	NR	89.3 ± 11.7	89.3 ± 13.0	96.4 ± 7.0	84.4 ± 16.5	74.9 ± 16.8
Surgical	8	90.9 ± 13	NR	NR	4.5 ± 2.0	NR	NR	83.1 ± 16.8	82.1 ± 16.1	92.2 ± 11.4	70.4 ± 25.5	62.7 ± 22.5
Regalado[25] (2016)[c]												
Nonsurgical	7	NR	4	NR	NR	NR	NR	NR	NR	NR	NR	NR
Surgical	0	NR	0	NR	NR	NR	NR	NR	NR	NR	NR	NR
Regalado[25] (2016)[d]												
Nonsurgical	11	NR	5	11	NR	NR	NR	NR	NR	NR	NR	NR
Surgical	5	NR	0	13	NR	NR	NR	NR	NR	NR	NR	NR
Palmu[23] (2008)[e]												
Nonsurgical	15	88.0 ± 8.0	NR	22	5.2 ± 2.1	NR	90 ± 9	NR	NR	NR	NR	NR
Surgical	18	81.0 ± 21.0	NR	21	4.7 ± 2.0	NR	83 ± 17	NR	NR	NR	NR	NR
Palmu[23] (2008)[f]												
Nonsurgical	20	84.0 ± 13.0	11	NR	6.0 ± 1.9	NR	91 ± 10	NR	NR	NR	NR	NR
Surgical	24	83.0 ± 18.0	16	NR	4.4 ± 1.4	NR	84 ± 18	NR	NR	NR	NR	NR
Apostolovic[1] (2011)												
Nonsurgical	1	NR	4	NR	NR	332.14 (210-420)[g]	NR	NR	NR	NR	NR	NR
Surgical	2	NR	4	NR	NR	362.87 (170-420)[g]	NR	NR	NR	NR	NR	NR
Moström[19] (2014)												
Nonsurgical	22	84 ± 10	NR	NR	NR	NR	NR	90 ± 14	82 ± 14	94 ± 12	77 ± 24	69 ± 20
Surgical	3	84 ± 7	NR	NR	NR	NR	NR	92 ± 8	82 ± 11	97 ± 4	79 ± 15	76 ± 19
Lewallen[13] (2013)												
Nonsurgical	76	NR	39	NR	NR	NR	NR	NR	NR	NR	NR	NR
Surgical	8	NR	7	NR	NR	NR	NR	NR	NR	NR	NR	NR

[a]Values are shown as mean ± SD unless otherwise noted. ADL, Activities of Daily Living; KOOS, Knee injury and Osteoarthritis Outcome Score; NR, not reported; QoL, Quality of Life; VAS, visual analog scale.

[b]Presented as number of patients reporting excellent and good outcomes.

[c]At 2 years after treatment.

[d]At 6 years after treatment.

[e]At 6 years after treatment.

[f]At 14 years after treatment.

[g]Presented as median (interquartile range).

Figure 2. Forest plot of the meta-analysis comparing the incidence of overall redislocations between surgery and nonsurgical treatment, regardless of follow-up time (fixed-effects model; Mantel-Haenszel [M-H] method). L, long term.

76 for surgery). One of these studies reported short- and long-term scores, and these were considered separately in the subgroup analysis.[23]

Surgery was associated with a significantly lower Kujala score in the RCTs by Askenberger et al[2] (follow-up of <5 years) and Palmu et al[23] (cohort with follow-up of 5-10 years). However, no significant difference in scores was seen in the Moström et al[19] study or in the Palmu et al cohort with over 10-year follow-up.

A subsequent meta-analysis using a fixed-effects model showed that surgical treatment was associated with a significantly lower Kujala score compared with nonsurgical treatment within 10 years after treatment (MD, 3.86 [95% CI, 0.38-7.34]; $P = .03$; $I^2 = 15.1\%$) (Figure 4).

KOOS Score

Overall, 2 studies[2,19] reported KOOS scores for 114 patients, including 70 for nonsurgical treatment and 44 for

Study or Subgroup	surgical Events	surgical Total	conservative Events	conservative Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.1.1 short term(<5 yrs)						
Askenberger 2018	8	37	16	37	40.9%	0.50 [0.24, 1.02]
Lewallen 2013	8	24	76	198	42.0%	0.87 [0.48, 1.57]
Regalado 2016(S)	0	16	7	20	17.1%	0.08 [0.01, 1.34]
Subtotal (95% CI)		**77**		**255**	**100.0%**	**0.58 [0.37, 0.91]**
Total events	16		99			
Heterogeneity: Chi² = 3.80, df = 2 (P = 0.15); I² = 47%						
Test for overall effect: Z = 2.38 (P = 0.02)						
1.1.2 long term（>5 yrs)						
Apostolovic 2011	2	14	1	23	1.8%	3.29 [0.33, 32.99]
Mostrom 2014	3	7	22	33	18.4%	0.64 [0.26, 1.56]
Palmu 2008	24	36	20	28	53.6%	0.93 [0.67, 1.30]
Regalado 2016(L）	5	15	11	15	26.2%	0.45 [0.21, 0.99]
Subtotal (95% CI)		**72**		**99**	**100.0%**	**0.80 [0.59, 1.07]**
Total events	34		54			
Heterogeneity: Chi² = 4.56, df = 3 (P = 0.21); I² = 34%						
Test for overall effect: Z = 1.49 (P = 0.14)						
Test for subgroup differences: Chi² = 1.31, df = 1 (P = 0.25), I² = 23.5%						

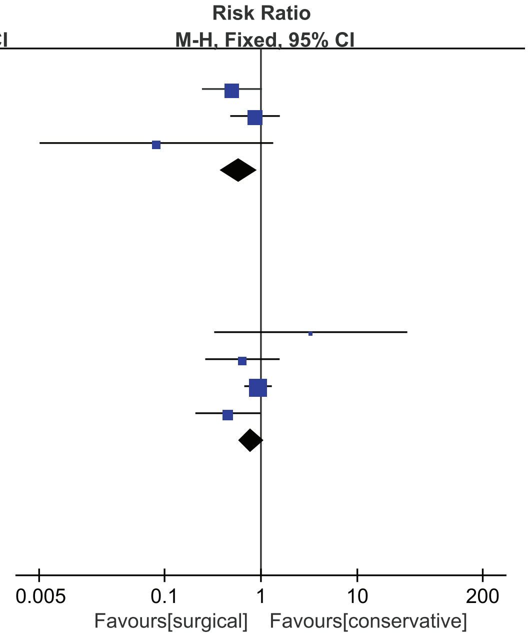

Figure 3. Forest plot of the meta-analysis comparing the incidence of redislocations between surgical and nonsurgical treatment, stratified by short- and long-term follow-up (fixed-effects model; Mantel-Haenszel [M-H] method). L, long term; S, short term.

Study or Subgroup	surgical Mean	surgical SD	surgical Total	conservative Mean	conservative SD	conservative Total	Weight	Mean Difference IV, Fixed, 95% CI
Askenberger 2018	90.9	13	34	95.9	7.2	29	46.8%	-5.00 [-10.10, 0.10]
Moström 2014	81	21	36	88	8	28	21.7%	-7.00 [-14.47, 0.47]
Palmu 2008	84	7	7	84	10	33	31.5%	0.00 [-6.21, 6.21]
Total (95% CI)			**77**			**90**	**100.0%**	**-3.86 [-7.34, -0.38]**
Heterogeneity: Chi² = 2.36, df = 2 (P = 0.31); I² = 15%								
Test for overall effect: Z = 2.17 (P = 0.03)								

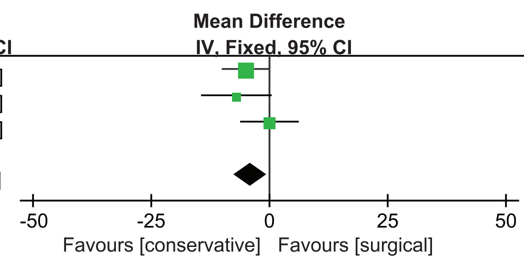

Figure 4. Forest plot of the meta-analysis comparing the Kujala score after surgical or nonsurgical treatment for all patients, regardless of follow-up time (fixed-effects models; inverse variance [IV] method).

surgery. The RCT by Askenberger et al,[2] reporting results within 5 years, showed that patients treated nonsurgically had a better knee function score on all 5 subscales of the KOOS compared with surgical treatment. In the Moström et al[19] study, with a follow-up beyond 5 years, all 5 subscores were similar except that surgery was associated with a significantly higher score on quality of life.

The meta-analysis showed a significantly higher KOOS score with nonsurgical treatment on 2 of 5 subscales: sports (MD, 11.10 [95% CI, 2.02-20.19]; $P = .02$; $I^2 = 18\%$) and quality of life (MD, 10.85 [95% CI, 2.60-19.10]; $P = .01$; $I^2 = 0\%$). The relatively higher score on the other 3 subscales indicated a tendency for supporting nonsurgical treatment, although there was no statistically significant difference. These meta-analyses were carried out using a fixed-effects model (Figure 5).

Reoperations

A total of 4 studies[1,13,23,25] (n = 355 patients, including 269 for nonsurgical treatment and 86 for surgical treatment), reported on the occurrence of reoperations. The overall rate of reoperations was 23.9% (85/355); specifically, 58 of 269 (21.6%) knees undergoing nonsurgical treatment and 27 of 86 (31.4%) undergoing surgery experienced subsequent surgery. Quantitative analysis using a fixed-effects model showed that the occurrence was similar after surgical or nonsurgical treatment among all patients (RR, 1.13 [95% CI, 0.75, 1.69]; $P = .56$; $I^2 = 15\%$) (Figure 6).

Risk of Bias and Quality of Evidence

All studies showed a relatively high risk of bias. In particular, blinding was lacking in all the studies for the nature of surgical trials, which might affect subjective outcomes such as the Kujala and KOOS scores. The high risk of bias also influenced the quality of evidence by the GRADE guidelines. Because of the lack of blinding for the Kujala and KOOS scores, the level of evidence was downgraded 2 points. The evidence for redislocation and reoperation rates was downgraded by just 1 point

Study or Subgroup	surgical Mean	surgical SD	surgical Total	conservative Mean	conservative SD	conservative Total	Weight	Mean Difference IV, Fixed, 95% CI
3.1.1 Pain								
Askenberger 2018	83.1	16.8	31	89.3	11.7	37	70.0%	-6.20 [-13.21, 0.81]
Moström 2014	90	14	7	92	8	33	30.0%	-2.00 [-12.72, 8.72]
Subtotal (95% CI)			**38**			**70**	**100.0%**	**-4.94 [-10.81, 0.93]**
Heterogeneity: Chi² = 0.41, df = 1 (P = 0.52); I² = 0%								
Test for overall effect: Z = 1.65 (P = 0.10)								
3.1.2 Symptoms								
Askenberger 2018	82.1	16.1	31	89.3	13	37	71.0%	-7.20 [-14.25, -0.15]
Moström 2014	82	14	7	82	11	33	29.0%	0.00 [-11.03, 11.03]
Subtotal (95% CI)			**38**			**70**	**100.0%**	**-5.11 [-11.05, 0.83]**
Heterogeneity: Chi² = 1.16, df = 1 (P = 0.28); I² = 14%								
Test for overall effect: Z = 1.69 (P = 0.09)								
3.1.3 ADL								
Askenberger 2018	92.2	11.4	31	96.4	7	37	79.2%	-4.20 [-8.80, 0.40]
Moström 2014	94	12	7	97	4	33	20.8%	-3.00 [-11.99, 5.99]
Subtotal (95% CI)			**38**			**70**	**100.0%**	**-3.95 [-8.05, 0.15]**
Heterogeneity: Chi² = 0.05, df = 1 (P = 0.82); I² = 0%								
Test for overall effect: Z = 1.89 (P = 0.06)								
3.1.4 Sports								
Askenberger 2018	70.4	25.5	31	84.4	16.5	37	75.9%	-14.00 [-24.43, -3.57]
Moström 2014	77	24	7	79	15	33	24.1%	-2.00 [-20.50, 16.50]
Subtotal (95% CI)			**38**			**70**	**100.0%**	**-11.10 [-20.19, -2.02]**
Heterogeneity: Chi² = 1.23, df = 1 (P = 0.27); I² = 18%								
Test for overall effect: Z = 2.40 (P = 0.02)								
3.1.5 QoL								
Askenberger 2018	62.7	22.5	31	74.9	16.8	37	74.0%	-12.20 [-21.79, -2.61]
Moström 2014	69	20	7	76	19	33	26.0%	-7.00 [-23.17, 9.17]
Subtotal (95% CI)			**38**			**70**	**100.0%**	**-10.85 [-19.10, -2.60]**
Heterogeneity: Chi² = 0.29, df = 1 (P = 0.59); I² = 0%								
Test for overall effect: Z = 2.58 (P = 0.010)								

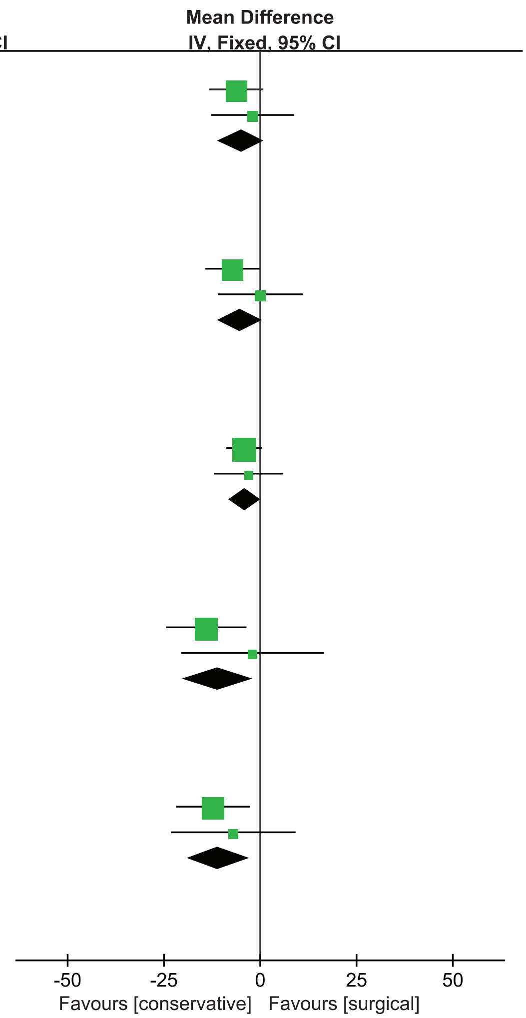

Figure 5. Forest plot of the meta-analysis comparing the Knee injury and Osteoarthritis Outcome Score (KOOS) score after surgical or nonsurgical treatment for all patients, regardless of follow-up time (fixed-effects models; inverse variance [IV] method).

Study or Subgroup	surgical Events	surgical Total	conservative Events	conservative Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Apostolovic 2011	4	14	4	23	10.7%	1.64 [0.49, 5.54]
Lewallen 2013	7	24	39	198	29.8%	1.48 [0.75, 2.93]
Palmu 2008	16	36	11	28	43.7%	1.13 [0.63, 2.04]
Regalado 2016(L）	0	15	4	15	15.9%	0.11 [0.01, 1.90]
Total (95% CI)		**89**		**264**	**100.0%**	**1.13 [0.75, 1.69]**
Total events	27		58			
Heterogeneity: Chi² = 3.54, df = 3 (P = 0.32); I² = 15%						
Test for overall effect: Z = 0.58 (P = 0.56)						

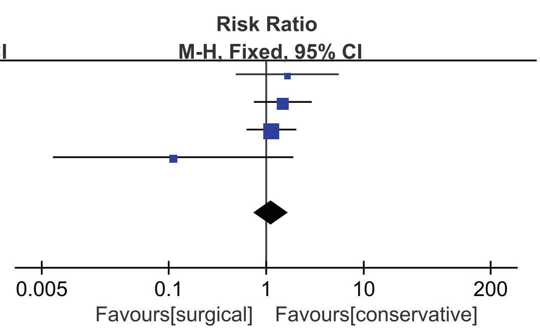

Figure 6. Forest plot of the meta-analysis comparing the incidence of reoperations between surgical and nonsurgical treatment, regardless of follow-up time (fixed-effects model; Mantel-Haenszel [M-H] method).

because lack of blinding had limited influence on objective outcomes. Regarding inconsistency, the heterogeneity of our study was relatively low except for the KOOS score, which entailed further downgrading for the KOOS score. No points were lost owing to the risk of publication bias (Figure 7). Thus, the level of evidence was moderate for redislocations and reoperations, low for the Kujala score, and very low for the KOOS score.

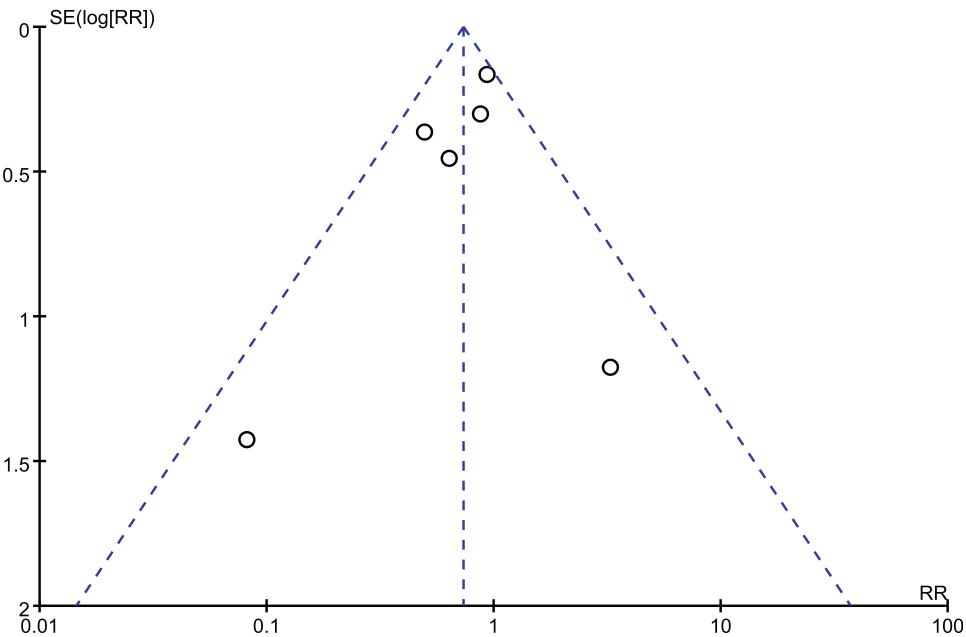

Figure 7. Funnel plot to assess publication bias for the redislocation rate. RR, risk ratio.

DISCUSSION

For adolescents with PPDs, surgery was superior to nonsurgical treatment in the short term with regard to the redislocation rate, whereas the outcome of knee function was favorable with nonsurgical treatment. However, the superiority of either surgery or nonsurgical treatment in adolescents did not appear to persist in the long term.

A few published systematic reviews and meta-analyses in the past 5 years have compared the efficacy of surgery versus nonsurgical treatment. There were 2 meta-analyses[15,33] that indicated that, when patient age and follow-up duration are not taken into account, surgery is associated with a lower recurrent dislocation rate and similar Kujala scores as nonsurgical treatment. When only considering the follow-up duration, 3 meta-analyses[27,29,34] further suggested a lower redislocation rate and better Kujala score with surgery than with nonsurgical treatment in the short term, but these benefits disappeared in the long term.

When separately analyzing skeletally immature patients, the present review also confirmed this tendency favoring surgery, although only in reducing the redislocation rate. To our surprise, none of our included studies reported a significant benefit of surgery over nonsurgical treatment on knee function in terms of the Kujala or KOOS score in either the short or long term, and some studies even observed worse Kujala and KOOS scores in the short term.[2,23] This result is different from what was reported by Nwachukwu et al[22] in their review of children and adolescents with acute patellar dislocation. They observed a lower redislocation rate, higher clinical scores, and better return-to-sport levels for patients who underwent surgery. However, their study included some uncontrolled studies and qualitatively analyzed them with other controlled studies. Moreover, they did not include the 2018 high-level RCT by Askenberger et al.[2]

Similar to our results, several original articles have also confirmed this conclusion.[2,23] This result may reflect overtightening or insufficient tissue integrity and weaker muscle function in adolescents, which likely do not match their accelerated growth.[2] The finding may also help explain why previous meta-analyses[27,33,35] involving both adults and adolescents made the paradoxical observation that surgery was associated with a lower rate of redislocations but not better Kujala scores than nonsurgical treatment.

The results of our meta-analysis remind us that surgery does not always work for adolescents. Before offering a treatment suggestion, we should take patients' comments into consideration, whether they are associated with worry about redislocation or poor knee function. According to our study, surgery may effectively help a patient with the former concern, while patients plagued by the latter should be informed of the risk of a poor prognosis in the short term and carefully weigh the pros and cons of surgery. Given the invasiveness and cost of surgery,[21] this consideration can maximize the benefits and reduce the risks of surgery for adolescents with PPDs.[12,14,32]

Limitations

Despite various strengths, this study exhibited several limitations. First, the number of included studies in each subgroup was relatively small. Second, 2 retrospective studies were included in the study, which may have increased the risk of bias or confounding. Third, the follow-up duration on adolescents was from 2 to 14 years, which may have contributed to heterogeneity and confounded results. Fourth, patients across the studies varied in their baseline characteristics, including age, sex, and family history, all of which are regarded as risk factors for primary and recurrent patellar dislocations.[8,11,13] Fifth, surgical methods differed across the studies, which could have affect outcomes.[16,30]

CONCLUSION

This study found that for adolescents with PPDs, surgery was superior to nonsurgical treatment in the short term to improve the redislocation rate but resulted in poorer outcomes of knee function based on the Kujala and KOOS scores. However, the superiority of either surgery or nonsurgical treatment in adolescents did not appear to persist in the long term. Our results should be confirmed through future large, high-quality RCTs.

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