



# Comparison of clinical outcomes associated with arthroscopic cyst wall preservation or resection in the treatment of popliteal cyst: a systematic review and meta-analysis

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## Abstract

**Objective** Arthroscopy is commonly used to treat popliteal cysts, but the influence of the cyst wall on treatment outcomes remains controversial. The goal of this study was to compare clinical outcomes associated with arthroscopic cyst wall resection versus preservation in patients undergoing treatment for popliteal cysts.

**Methods** We searched the PubMed, Embase, Web of Science, and Cochrane Library databases to identify all relevant articles published as of April 2020. STATA v15.1 was used for all statistical analyses. Relative risk (RR) and corresponding 95% confidence intervals (CIs) pertaining to study outcomes were calculated. Study heterogeneity was evaluated using the  $I^2$  statistic and the  $\chi^2$  test, with  $I^2 > 50\%$  and  $P < 0.10$  as respective significance threshold values. The risk of bias was gauged with the Cochrane Collaboration's risk of bias tool and the Newcastle–Ottawa Scale (NOS).

**Results** In total, 18 relevant studies were included in this meta-analysis, of which 16 were observational studies and 2 were randomized controlled trials (RCTs). These studies included 573 total patients, of whom 346 underwent arthroscopic cyst resection and 227 underwent arthroscopic cyst preservation. Pooled analyses revealed that clinical outcomes (RR = 0.98, 95% CI 0.94–1.00) and postoperative recurrence rates (RR = 0.90, 95% CI 0.85–0.95) were significantly better among patients that underwent cyst wall resection relative to those that underwent cyst wall preservation (RR = 0, 95% CI 0–0.02 and RR = 0.05, 95% CI 0.02–0.10, respectively). However, complications occurred more often in the cyst wall resection group relative to the cyst wall preservation group (RR = 0.05, 95% CI 0.01–0.12 vs. RR = 0.01, 95% CI 0–0.03). Sensitivity analyses confirmed the stability of these pooled results, and we detected no significant risk of publication bias.

**Conclusions** Relative to cyst wall preservation, popliteal cyst wall arthroscopic resection can yield more satisfactory clinical results and decrease rates of recurrence, but can also increase the incidence of complications. Future prospective studies comparing the outcomes associated with cyst wall resection and preservation will be required to validate our results.

**Keywords** Popliteal cyst · Arthroscope · Minimally invasive · Meta-analysis · Outcomes

## Introduction

Popliteal cysts, also referred to as Baker's cysts, are synovial cysts that manifest in the popliteal fossa. Clinically, these lesions are common and are associated with the gastrocnemio-semimembranosus bursa (GSB) expansion in the posteromedial region of the knee [1]. These cysts were first described by Baker et al. [2] in 1877, and are associated with

bursal retention of synovial fluid that is generally accompanied by internal diseases of the knee. Additional pathological analyses have found that the pathogenesis of popliteal cysts is closely associated with intra-articular pathology and with universal flow valve mechanisms in this tissue site [3–5].

Traditional posterior open surgery treatment of popliteal cysts is associated with high rates of recurrence, as this approach is unable to simultaneously treat primary intra-articular lesions [3, 6, 7]. An arthroscopic approach was first successfully employed to treat popliteal cysts in 199 by Sansone et al. [8], and further improved versions of this procedure have since been proposed [9–11]. Arthroscopy is generally favored for the treatment of popliteal cysts, as it

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causes minimal trauma, allows for rapid patient recovery, and can treat the cyst directly while also addressing intra-articular lesions.

Despite the promise of this approach; however, whether the inner cyst wall should be removed during surgical treatment and whether it can impact postoperative popliteal cyst recurrence remains controversial. No studies to date have directly compared recurrence rates associated with cyst wall resection relative to cyst wall preservation. Han et al. [12] conducted a systematic review and meta-analysis on this topic in 2019, but their study only included articles published through August 2016. At the same time, they acknowledged that the literature included in their study was solely derived from low-quality retrospective case series, potentially skewing their results. As many pertinent new studies [13–19], including randomized controlled trials [20, 21], have since been published, it is necessary to revisit and re-evaluate their conclusions. By incorporating a larger sample size and more high-quality research, the present systematic review and meta-analysis was therefore designed to compare clinical improvement, complications, and recurrence rates between arthroscopic cyst wall resection and cyst wall preservation in patients undergoing treatment for popliteal cysts.

## Methods

As this was a study of previously published studies, no ethical oversight or patient consent was required.

### Study design and search strategy

This meta-analysis was conducted in a manner consistent with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. We systematically searched the PubMed, Embase, Cochrane Library, and Web of Science databases for all relevant studies published as of April 2020 using the following search terms: “popliteal cyst” and “arthroscopy”. The search strategy consisted of combining these terms with “AND” or “OR”. No language restrictions were imposed during the search process. References of eligible studies and pertinent reviews were also assessed in order to identify other studies potentially eligible for inclusion in this analysis.

### Study selection

Studies identified via the above search strategy were eligible for inclusion in this analysis if they: (1) were studies of the arthroscopic treatment of popliteal cysts; (2) did not study patients with other diseases likely to impact arthroscopic efficacy; and (3) reported postoperative Rauschnig and

Lindgren grades, recurrence rates, and incidence of complications at a minimum. Studies were excluded from this meta-analysis if they: (1) were duplicate articles; (2) were reviews, meta-analyses, or case reports; or (3) did not provide data corresponding to the appropriate outcome indicators in a form that could be extracted.

### Data extraction

Two investigators independently extracted all relevant data from included studies and compiled this data in a pre-constructed Excel spreadsheet. Collected data included first author, publication year, country, sex, sample size, mean patient age, mean patient follow-up period, pre- and post-operative Rauschnig and Lindgren grades ( $\geq$  grade 2 was considered to indicate unsuccessful clinical remission), recurrence rate, and complication incidence. Any inconsistencies were resolved through consensus and discussion with a third author. When the data were not available, efforts were made to contact corresponding authors of the appropriate studies to obtain these missing items.

### Study quality assessment

For the two RCTs included in this study, the two authors independently assessed methodological quality using the Cochrane Collaboration’s “Risk of Bias” tool, which assesses studies based on criteria including blinding of participants, personnel, and outcome assessors, randomization (allocation concealment and sequence generation), selection of outcomes reported, and data completeness. Based on the tense scores, the risk of bias was determined to be low, high, or unclear [22]. For observational studies, the 9-point Newcastle–Ottawa Scale (NOS) was used to assess study quality, with higher scores corresponding to a lower risk of bias [23, 24]. NOS scores of  $\leq 5$  correspond to a high bias risk.

### Statistical analysis

STATA v15.1 (Statacorp LLC, College Station, TX, USA) was used for all statistical analyses. Pooled analyses of dichotomous variables were conducted by calculating the relative risk (RR) and 95% confidence interval (CIs). Cochran’s Q statistics and the  $I^2$  statistic were used to gauge heterogeneity among included studies, with respective thresholds of  $I^2 \leq 25\%$ ,  $25\text{--}75\%$ , and  $\geq 75\%$  corresponding to low, medium, and high heterogeneity [25]. For sensitivity analyses, individual studies were sequentially omitted from pooled analyses in order to assess the impact on the overall results. Funnel plots, Egger’s test, and Begg’s test were employed to assess the risk of publication bias [26–28].  $P < 0.05$  was the significance threshold for this study. Forest plots were used to express study outcomes.

## Results

### Study identification and inclusion

We began by searching the PubMed, Embase, Web of Science, and Cochrane Library databases, leading us to identify 181 potentially relevant articles. Following the removal of duplicate articles, 118 articles remained, of which 71, 12, and 5 were excluded following abstract review as they were irrelevant, case reports, and reviews, respectively. We then subjected the remaining 30 articles to full-text review. Of these, 10 were excluded due to the lack of consistent data and two were excluded due to the lack of available data. The remaining 18 studies were included in the present meta-analysis, including 16 observational studies and 2 RCTs. The

study selection process for this meta-analysis is outlined in Fig. 1.

### Study characteristics

In total, we evaluated 18 studies for the present meta-analysis, [8, 10, 11, 29–34] including 2 RCTs and 16 retrospective studies. These studies were conducted between 1999 and 2020 in six countries (Japan, Korea, China, India, Italy, and Poland), and involved 573 patients (346 that underwent arthroscopic cyst resection, and 227 that underwent arthroscopic cyst preservation). Patients were 42.6–62.6 years old, and average follow-up durations were between 12.5 and 36.1 months. Study clinical outcomes were primarily assessed based on Rauschnig and Lindgren grades,

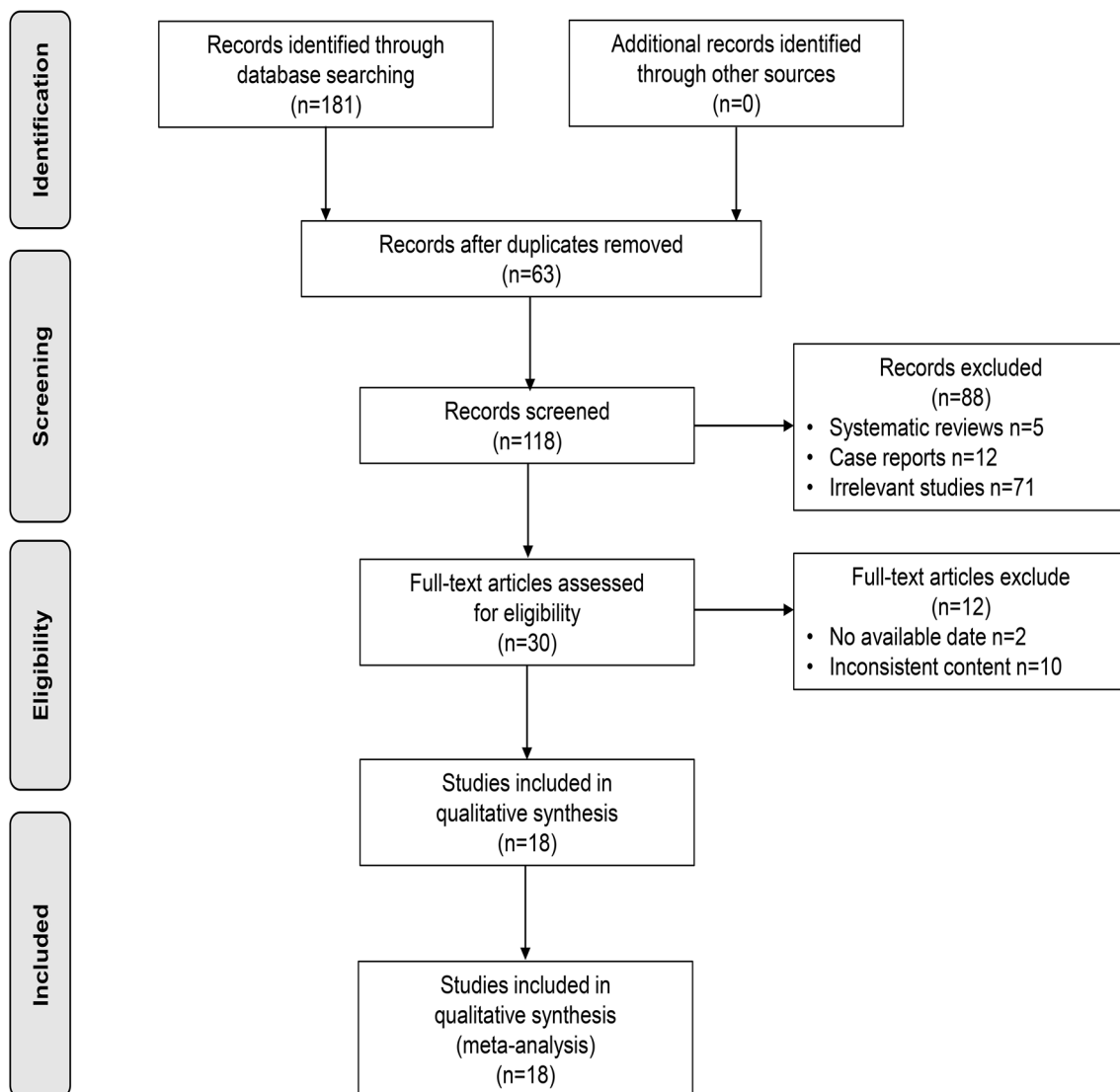


Fig. 1 PRISMA flowchart of eligible study selection

recurrence rates, and complication rates. For full details regarding the included studies, see Table 1.

### Assessment of study quality

The results of methodological quality assessments for the included studies are compiled in Fig. 2 and Table 2. Of the included RCTs, the study conducted by Yang et al. clearly described the random sequence generation by complete block design, but failed to discuss blinding and allocation concealment. For the study conducted by Shi et al., groups were randomly assigned, but the investigators failed to follow double-blind group assignments, and group allocation was not mentioned. The Newcastle–Ottawa Scale was used to assess observational studies according to participant selection criteria, comparability, exposure, and outcomes in order to gauge the risk of bias. All 16 studies scored between 6 and 8 points, consistent with a low risk of bias.

### Clinical outcomes

Postoperative Rauschnig and Lindgren grades were reported in all studies, with grades of 0 and I being considered to indicate successfully improved clinical outcomes, and grades II and II being indicative of unsuccessful clinical outcomes. Summary results (Fig. 3) revealed an improved success rate in both the cyst wall resection group (RR=0.98, 95% CI 0.94–1.00,  $P < 0.05$ ;  $I^2 = 59.57\%$ ,  $P = 0.01$ ) and the cyst wall preservation group (RR=0.90, 95% CI 0.85–0.95,  $P < 0.05$ ;  $I^2 = 26.58\%$ ,  $P = 0.22$ ). For all included studies (cyst wall resection and preservation group together) results,  $I^2 = 64.24\%$ ,  $z = 33.29$ ,  $P < 0.05$ . Sensitivity analyses did not indicate that any individual studies had an impact on the overall findings. In addition, no evidence of publication bias was detected as evidenced by a symmetrical funnel plot (Fig. 4), a Begg's test  $P = 0.674$ , and an Egger's test  $P = 0.322$ .

### Cyst recurrence rate

Postoperative cyst recurrence rates were described in all studies. Overall, the postoperative cyst recurrence rate was 1.2% (4 out of 346) in the cyst wall resection group and 7.5% (17 out of 227) in the cyst wall preservation group. Summary results (Fig. 5) were prepared for the cyst wall resection group (RR=0, 95% CI 0–0.02,  $P = 0.72$ ;  $I^2 = 29.39\%$ ,  $P = 0.17$ ) and the cyst wall preservation group (RR=0.05, 95% CI 0.02–0.10,  $P < 0.05$ ;  $I^2 = 37.83\%$ ,  $P = 0.13$ ). For all included studies (cyst wall resection and preservation group together),  $I^2 = 55.94\%$ ,  $Z = 2.58$ ,  $P < 0.05$ . Sensitivity analyses did not indicate that any individual studies had an impact on the overall findings. In addition, no evidence of publication bias was detected as evidenced by a symmetrical

funnel plot (Fig. 6), a Begg's test  $P = 0.059$ , and an Egger's test  $P = 0.31$ .

### Complication rate

In total, 16 of the included studies reported on the incidence of postoperative complications. Overall, 6.9% (22 out of 318) of the cyst wall resection group and 1.1% (2 out of 183) of the cyst wall preservation group experienced postoperative complications. Summary results (Fig. 7) were generated for the cyst wall resection group (RR=0.05, 95% CI 0.01–0.12,  $P = 0.72$ ;  $I^2 = 69.23\%$ ,  $P = 0.00$ ) and the cyst wall preservation group (RR=0.01, 95% CI 0–0.03,  $P = 0.85$ ;  $I^2 = 0\%$ ,  $P = 0.85$ ). For all included studies (cyst wall resection and preservation group together),  $I^2 = 59.63\%$ ,  $Z = 2.96$ , and  $P < 0.05$ . Sensitivity analyses did not indicate that any individual studies had an impact on the overall findings. In addition, no evidence of publication bias was detected as evidenced by a symmetrical funnel plot (Fig. 8), a Begg's test  $P = 0.095$ , and an Egger's test  $P = 0.359$ .

### Discussion

Several treatment approaches for popliteal cysts have been described to date. Although the pathogenesis of these cysts remains incompletely understood, anatomical and pathological evidence suggest that they should not be treated as local tumors. Popliteal cysts are frequently accompanied by intra-articular lesions that can manifest as degenerative surface cartilage changes and tearing of the medial meniscus [4, 35–37]. These lesions can serve as a primary source of synovial fluid; thus, supporting the development and persistence of popliteal cysts. The formation of these cysts is also facilitated by valve mechanisms governing unidirectional synovial fluid flow [38]. These mechanical factors together with intra-articular disorder; thus, drive popliteal cyst development.

Traditional posterior resection of popliteal cysts does not allow for the simultaneous treatment of primary intra-articular lesions, resulting in high rates of postoperative cyst recurrence [39]. In contrast, arthroscopy allows for the correction of these intra-articular lesions while also allowing for enlargement of the valve communication port so as to restore two-way communication between the bursa and the joint cavity via a minimally invasive approach, thereby eliminating the drivers of popliteal cysts. As arthroscopic technology has advanced, however, whether the cyst wall should be removed or preserved has been a matter of significant scholarly debate. Kongmalai et al. [40] determined that the wall of a popliteal cyst is composed of thickened hyaloid tissue and lacks synovial fluid-producing synovial cells, leading them to speculate that this wall primarily functions as a barrier

**Table 1** Characteristics of included studies

Study	Country	Type of study	No. of patients	Mean age (years)	Mean follow-up (months)	Management of popliteal cyst wall	Rauschnig and Lindgren grades	Recurrence	Complication	Type of complication
Gu et al. [17]	China	Retrospective study	34	55	15	Cyst wall resection	Grade 0:30 Grade 1:4	0 (0%)	0 (0%)	None
Yang et al. [21]	China	RCT	32	55	14	Cyst wall preservation	Grade 0+Grade 1:31	1 (3.1%)	NA	NA
Ahn et al. [11]	Korea	Retrospective study	31	48	36	Cyst wall resection	Grade 0:25 Grade 1:5 Grade 2:1	0 (0%)	0 (0%)	None
Calvisi et al. [10]	Italy	Retrospective study	22	56	24	Cyst wall preservation	Grade 0:14 Grade 1:5 Grade 2:2 Grade 3:1	2 (9%)	0 (0%)	None
Chen et al. [16]	China (Taiwan)	Retrospective study	21	NA	29	Cyst wall resection	Grade 0:11 Grade 1:9 Grade 2:1	1 (4.8%)	0 (0%)	None
Guo et al. [15]	China	Retrospective study	28	52	NA	CYST wall resection	Grade 0:24 Grade 1:4	0 (0%)	NA	NA
Lie et al. [30]	China (Hong Kong)	Retrospective study	10	60	NA	Cyst wall resection	Grade 0:7 Grade 1:3	0 (0%)	2 (20%)	Portal site infection: 1 Portal site discomfort: 1
Ko et al. [31]	Korea	Retrospective study	14	48	30	Cyst wall resection	Grade 0:14	0 (0%)	5 (35.7%)	Hematoma: 1 Pain and swelling: 2 Technical error: 2
Malinowski et al. [14]	Poland	Retrospective study	10	32	16	Cyst wall resection	Grade 0:4 Grade 1:5 Grade 2:1	3 (30%)	1 (10%)	Thrombophlebitis of deep veins: 1
Ji et al. [34]	Korea	Retrospective study	44	50	36	Cyst wall preservation	Grade 0:28 Grade 1:12 Grade 2:3 Grade 3:1	6 (13.6%)	1 (2.2%)	Discomfort: 1
Ohishi et al. [32]	Japan	Retrospective study	29	63	23	CYST wall preservation	Grade 0:26 Grade 1:1 Grade 2:1 Grade 3:1	1 (3.4%)	0 (0%)	None
Sansone et al. [8]	Italy	RCT study	30	56	32	Cyst wall preservation	Grade 0:19 Grade 1:10 Grade 2:1	1 (3.3%)	1 (3.3%)	Pain and swelling: 1

Table 1 (continued)

Study	Country	Type of study	No. of patients	Mean age (years)	Mean follow-up (months)	Management of popliteal cyst wall	Rauschnig and Lindgren grades	Recurrence	Complication	Type of complication
Xinxian et al. [13]	China	Retrospective study	31	55	33	Cyst wall preservation	Grade 0:19 Grade 1:6 Grade 2:4 Grade 3:2	6 (19.4%)	0 (0%)	None
Cho [29]	Korea	Retrospective study	111	57	24	Cyst wall resection	Grade 0:98 Grade 1:13	0b(0%)	5b(4.5%)	Hematoma: 4 Discomfort: 1
Pankaj et al. [19]	India	Retrospective study	12	50	28	Cyst wall preservation	Grade 0:6 Grade 1:5 Grade 2:0 Grade 3:1	0 (0%)	NA	NA
Wu et al. [18]	China	Retrospective study	41	43	18	Cyst wall resection	Grade 0:9 Grade 1:27 Grade 2:4 Grade 3:1	0 (0%)	7 (17.1%)	Pain and swellings: 7
Wang et al. [33]	China	Retrospective study	20	50	16	Cyst wall resection	Grade 0:14 Grade 1:6	0 (0%)	0 (0%)	None
Shi et al. [20]	China	RCT study	26	47.2	12.5	Cyst wall resection	Grade 0:16 Grade 1:6 Grade 2:4	0 (0%)	2 (7.7%)	Intermuscular venous thrombosis: 2
Shi et al. [20]	China	RCT	27	47	13	Cyst wall preservation	Grade 0:17 Grade 1:4 Grade 2:6	0 (0%)	0 (0%)	None

RCT randomized clinical trial, NA not reported



	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Shi et al. 2018	+	?	-	+	+	+	?
Yang et al. 2017	+	?	?	+	+	+	?

**Fig. 2** Risk of bias summary. A risk of bias tool incorporated the assessment of factors including randomization (sequence generation and allocation concealment), blinding (participants and outcome assessors), incomplete outcome data, selective outcome reporting, and other risk of bias. For each of these items, studies were considered to be of low, unclear, or high risk (green, yellow, and red, respectively)

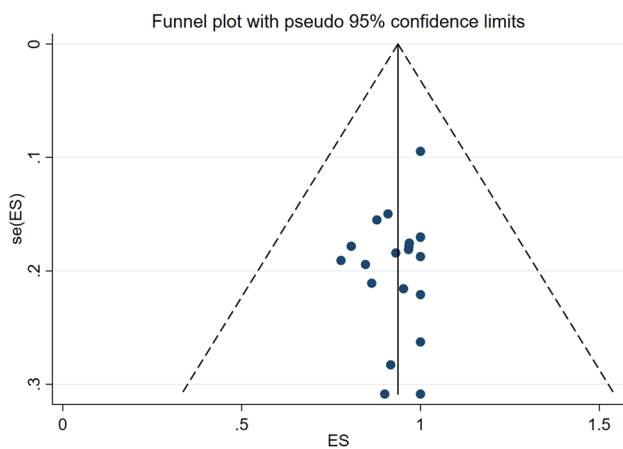
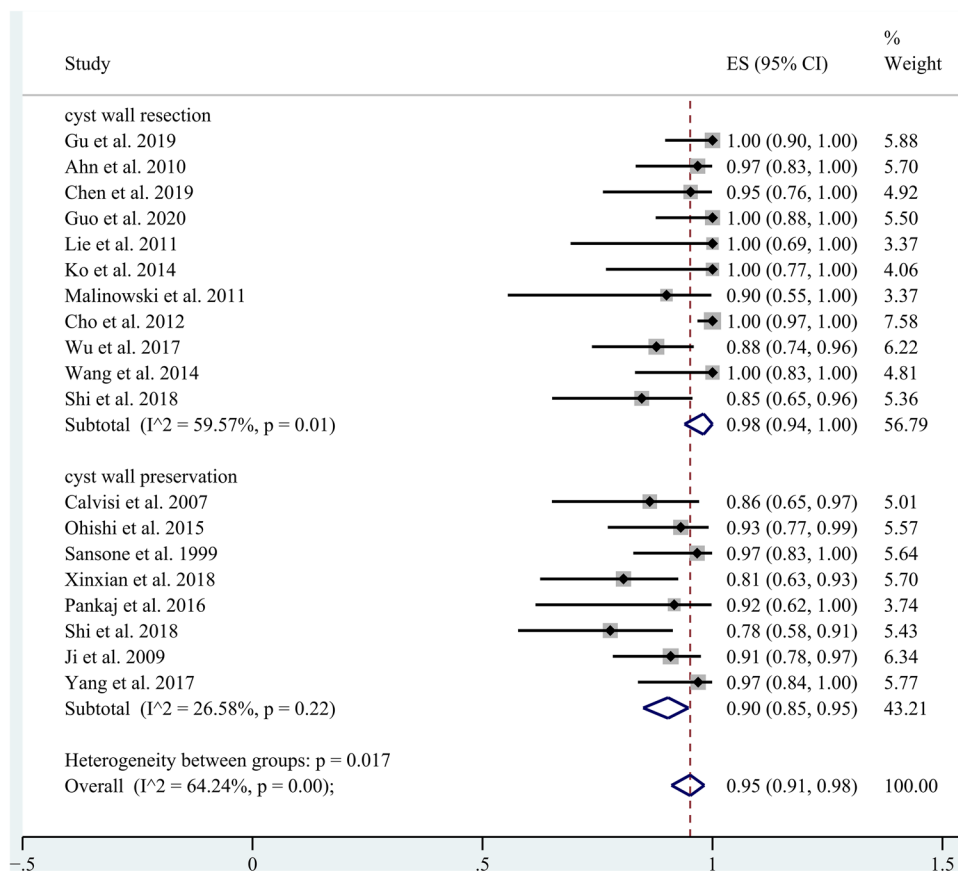
**Table 2** Newcastle–Ottawa Scale-based assessment of study quality

Study	Selection	Compa- rability	Exposure	Total score
Gu et al. [17]	3	2	2	7
Ahn et al. [11]	4	2	2	8
Calvisi et al. [10]	3	2	2	7
Chen et al. [16]	2	2	2	6
Guo et al. [15]	3	2	2	7
Lie et al. [30]	3	2	2	7
Ko et al. [31]	3	2	3	8
Malinowski et al. [14]	3	2	2	7
Ohishi et al. [32]	3	2	3	8
Sansone et al. [8]	3	2	3	8
Xinxian et al. [13]	3	2	2	7
Cho [29]	3	2	3	8
Pankaj et al. [19]	2	2	2	6
Wu et al. [18]	2	2	3	7
Wang et al. [33]	3	2	2	7
Ji et al. [34]	3	2	2	7

that permits cyst fluid storage, and thus does not require resection. This view has been reported by multiple other studies. For example, Billières et al. [41] determined that the inner cyst wall is not the source of synovial fluid, while Sansone and De Ponti [8] solely corrected the valve mechanism and intraarticular pathology via an arthroscopic approach without excising the capsule wall and achieved a success rate of 95%. Ohishi et al. [32] also reported a 93.1% clinical improvement rate when patients underwent arthroscopic expansion of unidirectional valvular slits via two posterior portals. Ahn et al. [11], in contrast, conducted cyst wall resection via adding an additional cystic portal in 24 patients with a fibrous structure in treated cysts, and found that all cysts shrank or disappeared over a 36.1-month follow-up period. Recently, Gu et al. [17] employed a dual-posteromedial port approach in combination with four-figure posture to completely dissect the capsule wall, achieving satisfactory outcomes in all 31 treated patients. Herein, we attempted to provide a rigorous overview of the relative advantages of these two surgical treatment strategies. However, we were unable to identify any strictly controlled studies comparing these two approaches in the course of our literature review. As such, we instead conducted a systematic evaluation and used corresponding statistical methods to better understand the outcomes associated with these two surgical strategies.

Our study serves as a valuable update of previous studies, incorporating many recent high-quality studies and thereby improving our overall statistical power to resolve meaningful differences between these two surgical approaches. Our key finding was that removal of the popliteal cyst wall is associated with better clinical efficacy and lower rates of recurrence (1.2% in the cyst wall resection vs 7.5% in the cyst wall preservation). This effect may be due to the role of the cyst wall in the incidence of symptoms and cyst recurrence, but the exact mechanistic basis for this finding remains unknown. These results are not completely consistent with the previous meta-analysis results generated by Han et al., although in their study they concluded that arthroscopic cystotomy after management of intra-articular pathological changes was associated with a low-risk rate, they did not observe any clear advantages in the cystostomy group relative to the non-cystotomy groups. In addition, we also found that cyst wall removal was associated with higher rates of complications (6.9%) than cyst wall preservation (1.1%). We thus recommend that arthroscopic operations be conducted carefully when shaving away the inner wall of the cyst. The neurovascular bundle of the popliteal fossa, which is located in the septum or slightly lateral portion of the popliteal fossa, is the main neurovascular structure at risk during this operation. For larger cysts extending to the posterolateral side of the knee joint, rates of associated vascular and nerve injury are elevated. Cho [29] found that arthroscopic cyst

**Fig. 3** Forest plot of clinical outcomes when comparing the cyst wall resection and preservation groups



**Fig. 4** Funnel plot of clinical outcomes when comparing the cyst wall resection and preservation groups

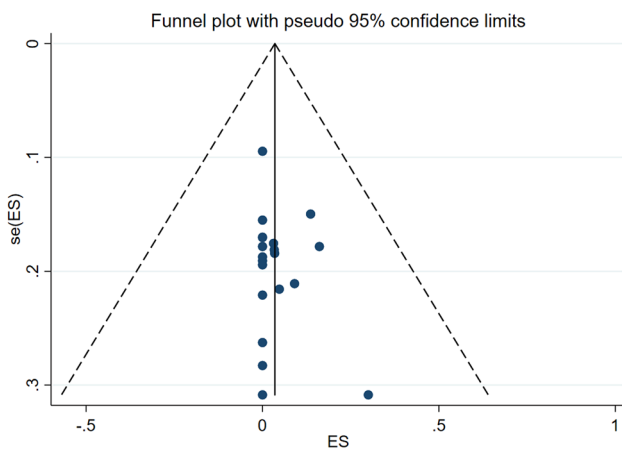
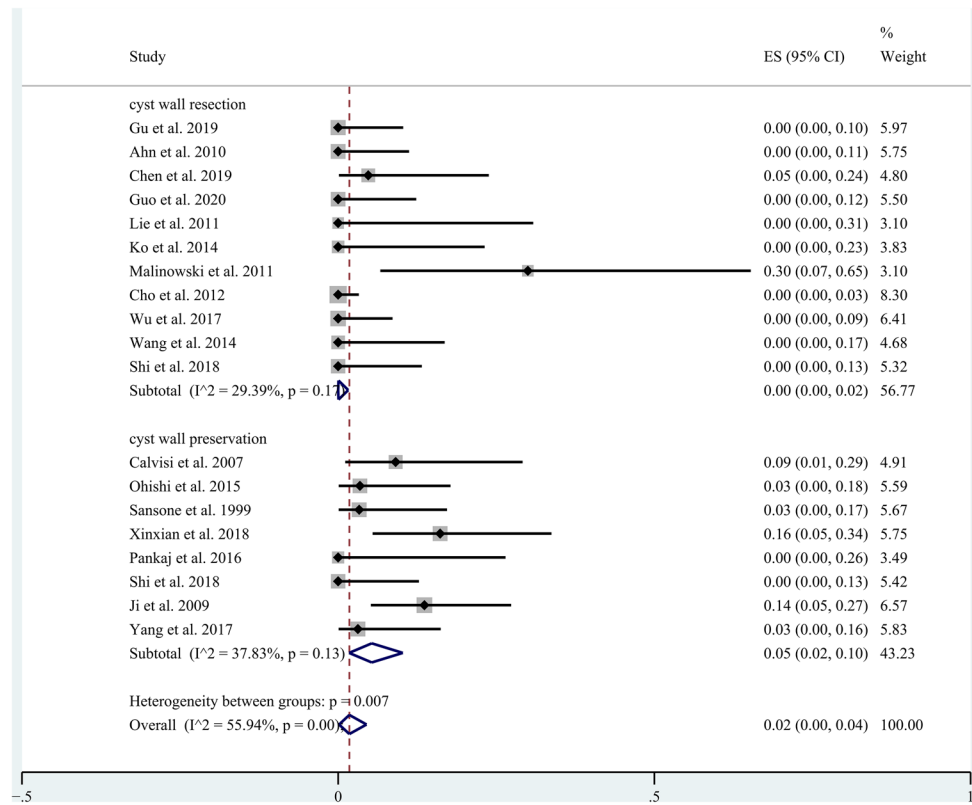
resection is associated with a 4.5% complication rate, with hematoma being the most common such complication. In a study published in 2009, Kp et al. [42] found that at two months post-arthroscopic cyst wall resection, one patient developed a pseudoaneurysm of the popliteal artery. As such, these authors recommended against the planning of

the lateral wall of the cyst to avoid injuring the popliteal artery.

There are multiple limitations to this meta-analysis. For one, while we have sought to incorporate all relevant studies in our systematic review, the majority of the included studies are from China. This may be a consequence of regional differences in morbidity, but also has the potential to influence our findings as a consequence of such regional and ethnic variability. We attempted to overcome such variation through subgroup analyses, but our sample sizes were too limited to facilitate such an approach. In addition, some of the included studies failed to report certain relevant results. Although we attempted to contact the corresponding authors of these studies to obtain the missing data, we did not receive any responses. As such, these omitted data may inadvertently bias our findings. Furthermore, most included studies were retrospective analyses rather than RCTs, introducing a high risk of selection bias. Future large-scale multi-center RCTs of high quality will thus be essential to validate and expand upon our present findings.



**Fig. 5** Forest plot of recurrence rates when comparing the cyst wall resection and preservation groups

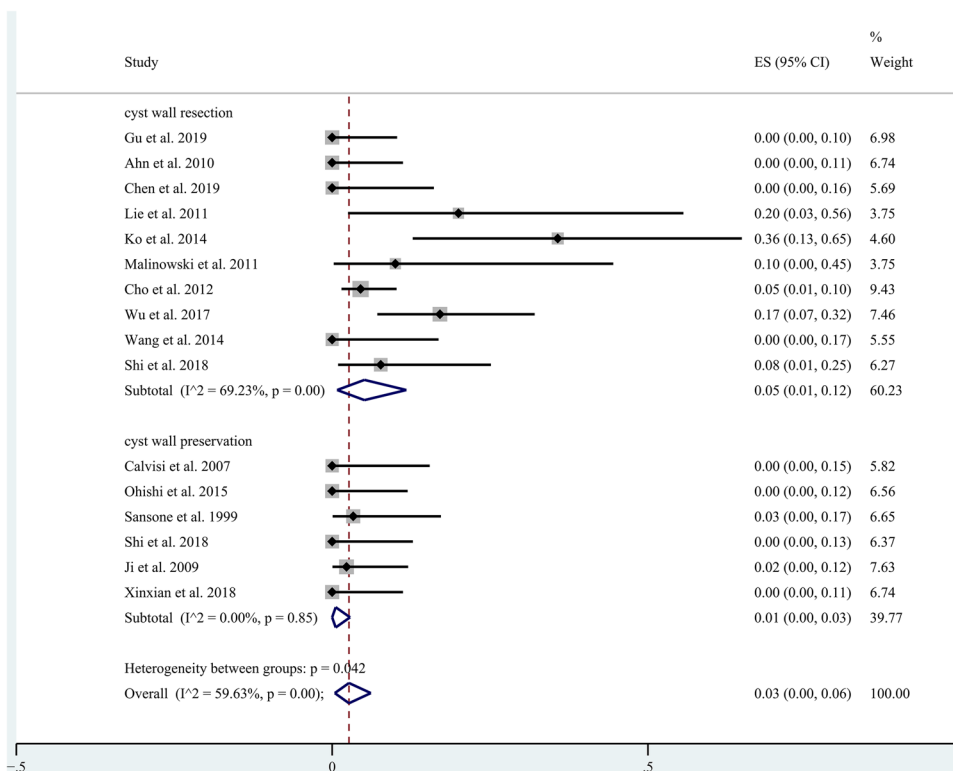


**Fig. 6** Funnel plot of recurrence rates when comparing the cyst wall resection and preservation groups

### Conclusion

In summary, relative to cyst wall preservation, arthroscopic cyst wall resection can yield more satisfactory clinical outcomes and lower recurrence rates, but is associated with higher rates of complications.

**Fig. 7** Forest plot of complication rates when comparing the cyst wall resection and preservation groups



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**Author contributions** HL and YKL have made substantial contributions to conception and design of the study, written the manuscript; HL and HHW searched literature, extracted data from the collected literature and analyzed the data; MZ revised the manuscript; All authors approved the final version of the manuscript.

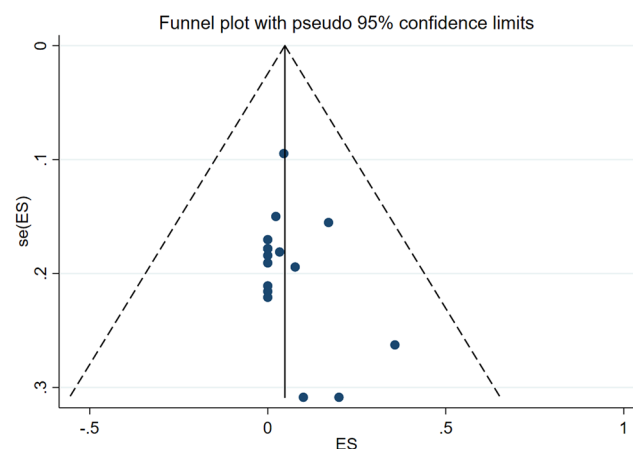
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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

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**Fig. 8** Funnel plot of complication rates when comparing the cyst wall resection and preservation groups

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