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Review Article

Incidence and complication rate of arthroplasty in Perthes disease management: A systematic review and meta-analysis

Abdulsalam M. Aleid, MD [a], Saud N. Aldanyowi, MD [a,*], Hasan A. AlAidarous, MD [b], Zainab M. Aleid, MD [a], Abdulaziz S. Alharthi, MD [c] and Abbas Al Mutair, MD [d]

[a] *Department of Surgery, Medical College, King Faisal University, Hofuf, Ahsa, KSA*
[b] *Department of Surgery, Faculty of Medicine, Albaha University, KSA*
[c] *Department of Orthopedic Surgery, Alhada Armed Military Hospital, Taif, KSA*
[d] *Department of Research Center, Almoosa Specialist Hospital, Almoosa College of Health Sciences, Al-Ahsa, KSA*

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الملخص

أهداف البحث: يمثل مرض بيرثس تحديا في العلاج العظمي، حيث يتطلب غالبا تدخلا جراحيا مثل استبدال المفصل. يهدف هذا التحليل التجميعي إلى تقييم منهجي لمعدل حدوث ومضاعفات استبدال المفصل في مرض بيرثس.

طرق البحث: تم إجراء بحث شامل في قواعد بيانات بابميد، ويب أوف ساينس، سكوبس، ومكتبة كوكرين لتحديد الدراسات ذات الصلة. شملت معايير الإدراج الدراسات التي تقيم نتائج استبدال المفصل في مرضى بيرثس. تم استخراج البيانات وتقييم الجودة بشكل مستقل من قبل مراجعين اثنين. تم تجميع النتائج باستخدام نماذج التأثيرات العشوائية، وتم تقييم التباين باستخدام إحصائيات. تم تضمين ثمان وعشرين دراسة رصدية بإجمالي 1737 مريضا، مع وجود تباين متوسط.

النتائج: وجدت الدراسة أن معدل حدوث استبدال المفصل بين الدراسات الثماني عشرة المدرجة في التحليل التجميعي كان 7% (فترة الثقة 95%، 0.045-0.95، مؤشر التباين = 58%). كانت المضاعفات بعد استبدال المفصل كبيرة بمعدل حدوث 22.9% بين 283 مريضا. باختصار، وجد تحليل 30 دراسة رصدية معدل حدوث 7% لاستبدال المفصل مع مضاعفات بعد الجراحة تؤثر على ما يقرب من 23% من المرضى.

الاستنتاجات: تشير هذه الدراسة إلى أن استبدال المفصل إجراء غير شائع نسبيا في علاج مرض بيرثس. تعد المضاعفات بعد استبدال المفصل مصدر قلق كبير، حيث تؤثر على ما يقرب من ربع المرضى.

الكلمات المفتاحية: مرض بيرثس؛ استبدال المفصل؛ مرض ليج-كالفيه-بيرثس؛ مضاعفات ما بعد استبدال المفص؛ ل

Abstract

Background: Perthes disease presents a challenge in orthopedic management, often necessitating surgical intervention such as arthroplasty. This meta-analysis systematically evaluated the rate of occurrence and complications associated with arthroplasty in Perthes disease.

Methods: A comprehensive search was conducted across PubMed, Web of Sciences, Scopus, and Cochrane Library databases to identify relevant studies. Inclusion criteria encompassed studies evaluating arthroplasty outcomes in patients with Perthes disease. Data extraction and quality assessment were performed independently by two reviewers. Results were synthesized using random effects models, and heterogeneity was assessed using I^2 statistics. Twenty-eight observational studies were included with a total of 1737 patients, reporting moderate heterogeneity.

Results: We found that the incidence of arthroplasty among the 18 studies included in the meta-analysis was 7 % (95 % confidence interval [CI]: 0.045–0.95, I^2 = 58 %). Complications following arthroplasty were significant with an incidence of 22.9 % among 283 patients. In summary, an analysis of 30 observational studies found a 7 % incidence of arthroplasty with complications following surgery affecting nearly 23 % of patients.

* Corresponding address: Department of Surgery, Medical College, King Faisal University, Hofuf, Ahsa, 31982, KSA.
E-mail: saldanyowi@kfu.edu.sa (S.N. Aldanyowi)
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Conclusion: The results of this study suggest that arthroplasty is a relatively uncommon procedure for Perthes disease management. Complications following arthroplasty are a significant concern, affecting nearly one-quarter of patients. Although the use of arthroplasty in Perthes is uncommon, the rate of complications has raised concerns, indicating its use is relatively unsafe. Therefore, in patients with Perthes disease who undergo arthroplasty, attention should be given to the risk of complications, and preventive measures need to be investigated to overcome this risk.

Type of study: Systematic review and meta-analysis.

Level of evidence: II.

Keywords: Arthroplasty; Legg-Calve-Perthes disease; Perthes disease; Post-arthroplasty complications

Introduction

Perthes disease, commonly known as Legg-Calvé-Perthes disease (LCPD), is a devastating juvenile orthopedic syndrome characterized by avascular necrosis of the femoral head, resulting in deformity and dysfunction of the hip joint.[1–3] First described by Arthur Legg in 1910, it represents a significant challenge in orthopedic practice due to its complex etiology, varied clinical manifestations, and need for tailored management strategies.[4] The frequency of LCPD varies across age groups and ethnicities. Furthermore, socioeconomic factors have been implicated in influencing disease incidence, with research indicating a correlation between deprivation levels and LCPD occurrence. Globally, diverse incidence rates have been reported, ranging from 0.2 per 100,000 children aged under 15 years to 19.1 per 100,000.[2,5,6]

The risk factors associated with Perthes disease encompass various demographic, genetic, and environmental influences. Typically, the condition manifests between the ages of 4 and 10, with boys being four times more susceptible than girls. Additionally, white children exhibit a higher predisposition compared to their black counterparts. While certain genetic mutations have been linked to Perthes disease, further research is required to fully elucidate these genetic predispositions.[2,6–8]

Historically, the management of Perthes disease has significantly evolved over the past century, reflecting advancements in surgical techniques, rehabilitation protocols, and our understanding of disease pathophysiology. While conservative measures such as observation, physiotherapy, and bracing remain integral components of management, surgical intervention is often indicated in cases of advanced disease, persistent symptoms, or structural deformity that predisposes to long-term complications such as osteoarthritis (OA).[7,9–12]

Arthroplasty, encompassing various surgical procedures aimed at reconstructing or replacing the hip joint, has emerged as a valuable therapeutic option in the management of advanced Perthes disease. This includes procedures such as femoral head reshaping, osteotomy, and total hip replacement, each tailored to the individual patient's age, disease severity, and functional goals. The rationale behind arthroplasty in Perthes disease lies in restoring hip joint congruency, improving biomechanical alignment, and alleviating pain, thereby enhancing function and quality of life.[8,9,13–17]

However, the decision to pursue arthroplasty in Perthes disease must be carefully weighed against the potential risks and benefits, considering factors such as patient age, skeletal maturity, disease stage, and surgeon expertise. Complications associated with arthroplasty in this population include infection, implant loosening, limb length discrepancy, and dislocation, underscoring the importance of a meticulous surgical technique and postoperative care.[11,18–22] Patients with Perthes disease undergoing arthroplasty may face higher complication rates due to their altered hip morphology and possibly reduced bone quality. There is gap in knowledge regarding risk of complications (e.g., dislocation, wear, aseptic loosening) and risk factors specific to this patient population, as well as effective strategies for minimizing these risks.

In this context, the current meta-analysis sought to answer key issues about the efficacy and complications of arthroplasty in Perthes disease therapy. By pooling data from relevant studies and employing rigorous statistical methods, we determined the overall rate of arthroplasty use in improving clinical outcomes, identified potential risk of complications, and investigated the impact of various surgical techniques on treatment success. Identifying the use of arthroplasty in Perthes disease and demonstrating the risk of complications will help clinicians focus on the use of arthroplasty in Perthes management and select specific individuals for this surgery who are not at high risk of complications. Preventive strategies for complications should be investigated in future studies.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for reporting the methodology and results of this meta-analysis.[23] This study was registered with PROSPERO (CRD42024528685).

Literature search strategy

We conducted a comprehensive literature search using electronic databases including PubMed, Scopus, Web of Sciences, and Cochrane Library. The search strategy utilized a combination of keywords and Medical Subject Headings terms related to Perthes disease, arthroplasty, and relevant surgical interventions. The search was restricted to studies published in the English language without any geographical restrictions due to the common use of English as the language of research in the included databases, as well as to prevent errors in translating different languages that may limit the robustness of our findings.

Study selection criteria

Studies were included if they were randomized controlled trials, cohort studies, case–control studies, or case series involving patients with Perthes disease undergoing arthroplasty or related surgical procedures. The focus was on arthroplasty interventions, including femoral head reshaping and total hip replacement, compared to either conservative management or other surgical treatments. Primary outcomes assessed the incidence of arthroplasty among patients with Perthes and complication rates, whereas secondary outcomes included radiographic parameters and functional scores. Studies were excluded if they involved non-human subjects, case reports, letters, editorials, or conference abstracts. Case reports and letters are typically excluded from meta-analyses because they often lack the methodological rigor and standardization needed for reliable statistical synthesis. Also, both of them are more susceptible to various biases, including selection bias, publication bias, and reporting bias. Conference abstracts are not subjected to peer review so they are the major cause of bias.

Study selection process

Two independent reviewers screened the titles and abstracts of the retrieved citations to identify potentially eligible studies. Then full-text articles were assessed for eligibility based on the predetermined inclusion and exclusion criteria. Discrepancies between reviewers were resolved by discussion and in consultations with a senior author if disagreement persisted.

Data extraction

Data extraction was performed independently by two reviewers using a standardized data extraction form. Extracted data included study characteristics (author, year, study design), patient demographics (age, sex), follow-up duration, and outcome measures. Any discrepancies in extracted data were resolved through consensus or consultation with a third reviewer.

Quality assessment

The National Institutes of Health (NIH) tool was used to assess the quality of the included studies.[24] It is composed of 14 yes/no questions where "not reported" or "not applicable" can be selected. For every yes, a score of 1 is provided; otherwise no score is provided. A score of 1–6 is considered poor, 7–10 is considered fair, and 11–14 is considered good.

Data synthesis and analysis

Meta-analysis was performed through open Meta-analyst software using appropriate statistical methods based on the nature of the included studies and outcome measures. For dichotomous outcomes (e.g., complication rates), pooled estimates with 95 % confidence intervals (CIs) were calculated. Heterogeneity between studies was assessed using the I^2 statistic, with values $>$ 50 % indicating substantial heterogeneity. Random effects models were utilized for meta-analysis due to anticipated clinical and methodological heterogeneity. A systematic review was done for incomplete data with a high level of inconsistency.

Results

Study selection

A total of 345 citations were identified through electronic database searches. After removing duplicates, 141 unique articles were screened based on title and abstract. Subsequently, 41 full-text articles were assessed for eligibility. Following the application of inclusion and exclusion criteria, 31 studies were included in the present systematic review and meta-analysis as mentioned in Figure 1.

Study characteristics

The included studies were published between 1980 and 2023, with sample sizes of about 1737 patients. Most studies were retrospective cohort studies, while a few articles were prospective analyses. Patient demographics varied across studies, with mean age ranging from 6.6 to 55 years. The most performed arthroplasty procedure was total hip replacement. Characteristics of the included studies are summarized in Table 1.

Quality assessment

Overall, most of the observational studies included in the analysis exhibited fair to good quality based on NIH assessment, indicating robustness in their methodological approach and reporting (Table 2).

Meta-analysis outcomes and heterogeneity

A meta-analysis of 18 studies[10,12,13,19,26,30,36–46,49] revealed an incidence of 7 % arthroplasty among patients

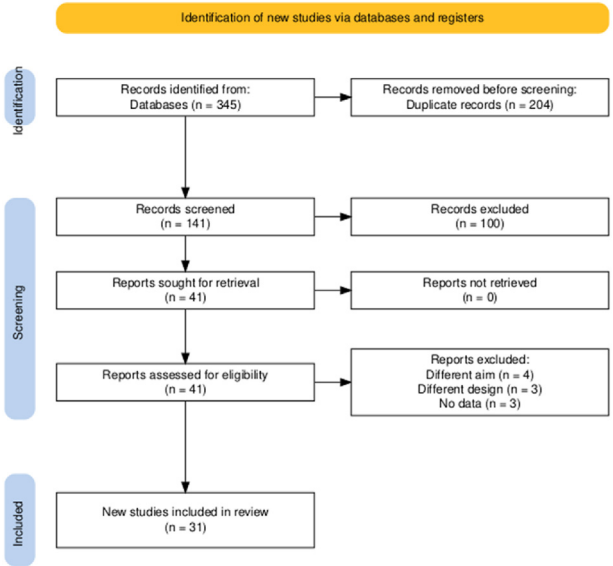

Figure 1: PRISMA flow diagram for searching and screening.

Table 1: Summary and baseline characteristics.

Study ID	Study design	Country	Key findings	Patients	Age mean (SD)	Males, n	Follow-up time mean (SD)	Body mass index
Sansanovicz et al. 2021[20]	Case-control	Spain	Significant differences in functional impairment and intraoperative femoral periprosthetic fractures were noted between LCPD-related and patients with primary hip OA.	25	Exper: 47.3 (7.4) Control: 53.2 (4.4)	Exper: 17 Control: 12	Exper: 62.2 (18.9) Control: 65.3 (15.3)	
Hasler et al. 2023[25]	Cohort	Switzerland	Comparable outcomes between direct anterior and non-anterior approaches for treating LCPD sequelae.	29	42.3 (10.5)	15	8.6 (5.2)	27.6 (6.1)
				30	50.8 (6.9)	17	8.1 (2.2)	26.2 (3.9)
Tan et al. 2023[26]	Cohort	Canada	Comparable THA rates in patients with LCPD with and without prior surgery.	22	33.9 (9.4)	17		
				180	46.3 (13.5)	135		
Lee et al. 2017[27]	Cohort	South Korea	Comparable outcomes between Anterolateral Approach to Total Hip Arthroplasty THA and osteonecrosis of the femoral head, with higher intraoperative femoral fracture rate in the LCPD group.	68	48 years (16–73)	35	Mean: 8.5 years; 5.2 to 10	24.4 (18.3–32.9)
Jeroen et al. 2022[28]	Case series	Belgium	Improved biomechanics and leg length restoration observed post-relative femoral nerve lengthening (RFNL) before total hip replacement in LCPD patients.	20	RFNL THR: 41.8 ± 10.6 RFNL: 30.8 ± 10.1	RFNL THR: 7 RFNL: 3	RFNL THR: 14.7 ± 13.6 RFNL: 4.2 ± 2.1	7.1 % were obese
Yang et al. 2021[29]	Cohort	China	Direct anterior approach (DAA)-THA reduced postoperative hip pain compared to the posterolateral approach (PLA)-THA. Operative time longer and incision length shorter in DAA-THA.	20	Anterior approach: 49.4 ± 13.3 Posterior: 49.4 ± 13.3	15	24.1 ± 2.6	
				20	Posterior: 15		24.1 ± 2.6	
Froberg et al. 2011[30]	Case-control	Denmark	Increased risk of total hip replacement and radiographic osteoarthritis in patients with LCPD.	156	6 ± 2	11		
Al-Khateeb et al. 2013[18]	Cohort	UK	Custom-made implants for painful end-stage hip OA yielded satisfactory outcomes.		32.8 (23–55)	10.1 (5–15)		
Anthony et al. 2021[31]	Cohort	Not provided	Acceptable complication rate and excellent patient-reported outcomes post-THA in patients with LCPD.	61	42 years (range, 11–78 years)	Not provided	5.6 years (range, 2–13 years)	29.1 kg/m^2 (range, 17.5–48.4)
Traina et al. 2011[32]	Cohort	Italy	THA yielded a high survival rate and improved Harris hip scores.	27	37.8 (19–65)		0.3 (4.8–20.6)	
Baghdadi et al. 2013[33]	Cohort	USA		95	48 (33–63)		8 (2–20)	30 ± 7

			Cementless hip implants showed a high survival rate at 8 years post-implant revision.			
Lim et al. 2014[34]	Cohort	South Korea	Improved HHS post-THA with minimal complications.	23	49.2 ± 13.1	3.4 (2−7)
Seufert and McGrory 2015[17]	Cohort	USA	Improved HHS and functional outcomes post-THA.		51.6 (22−74)	8.2 (2−14)
Masrouha et al. 2018[35]	Case series	USA	Majority showed acetabular component lucency and femoral cortical hypertrophy post-THA.	19	55.1 years (range, 36.5 −73.3)	18.3 years (range, 10.1 −36.2 years)
Kelly et al. 1980[36]	Retrospective study	Not provided	Good outcomes in the majority of patients, especially those with specific disease characteristics.	80	6.3 (2−11)	22.4 (NA)
Stulberg et al. 1981[12]	Retrospective study	Not provided	Identified specific clinical and radiographic courses related to femoral head-acetabulum congruency.	88	NA (6.0−10.4)	40 (30−60)
Perpich et al. 1983[37]	Retrospective study	Not provided	Majority achieved good outcomes, with certain factors influencing results.	40	6.6 (3−10)	29.4 (14−40)
McAndrew and Weinstein 1984[38]	Retrospective study	Not provided	Certain disease characteristics and age correlated with clinical outcomes.	35	8.2 (4.7−15)	47.7 (39−64)
Ippolito 1985[39]	Retrospective study	Italy	Disabling outcomes noted in adolescent patients with LCPD, with potential for OA.	13	14 (13−15)	27.6 (7−42)
Lecuire 2002[40]	Retrospective study	France	Shape of femoral head at skeletal maturity identified as prognostic indicator.	57	NA (NA)	34 (30−44)
Onishi et al. 2011[10]	Retrospective study	Japan	Higher risk of OA and poorer outcomes post-treatment.	28	7.1 (3.9−10.3)	34 (11.2−49.7)
Larson et al. 2012[41]	Retrospective study	USA	Identified association between femoroacetabular impingement and pain in patients with LCPD.	56	6.1 (3.5−12)	20.4 (16.3−41 24.5)
Heesakkers et al. 2015[42]	Prospective study	Not provided	Not specified.	32	NA (NA)	35.5 (25−42)
Dammerer et al. 2021[13]	Prospective study	Not provided	Not specified.	12	9.1 (5.9−17)	14 (7.6−21.3)
Mohan et al. 2018[43]	Retrospective study	Not provided	Not specified.	88	7.9 (NA)	12 (6−26)
Mosow et al. 2017[44]	Retrospective study	Germany	Improved outcomes in younger patients with LCPD, but combined osteotomies did not improve outcomes.	52	6.9 (2−13)	10.8 (4.6−17.6)
Shoshat et al. 2016[45]	Retrospective study	Not provided	Not specified.	22	7.5 (3.2−12)	42.5 (32−56)
Aydin et al. 2016[46]	Retrospective study	Not provided	Not specified.	20	NA (NA)	25 (20−30)

Table 2: Quality assessment using the NIH tool.

Study ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Total score	Quality
Kelly et al. 1980[36]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Stulberg et al. 1981[12]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Perpich et al. 1983[37]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
McAndrew and Weinstein 1984[38]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Ippolito 1985[39]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Kruse et al. 1991[19]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Yrjonen et al., 1992[47]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Lecuire 2002[40]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Onishi et al. 2011[10]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Larson et al. 2012[41]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Heesakkers et al. 2015[42]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Dammerer et al. 2021[13]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Mohan et al. 2018[43]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Mosow et al. 2017[44]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Shoshat et al., 2016[45]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Froberg et al. 2011[30]	Yes	NR	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	11	Good
Sansanovicz et al. 2021[20]	Yes	NR	Yes	Yes	No	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	9	Fair
Hasler et al. 2023[25]	Yes	NR	Yes	Yes	No	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	9	Fair
Tan et al. 2023[26]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	11	Good
Baghdadi et al. 2013[33]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Yang et al. 2021[29]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	11	Good
Al-Khateeb et al. 2013[18]	Yes	Yes	Yes	Yes	No	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	NR	9	Fair
Anthony et al. 2021[31]	Yes	Yes	Yes	Yes	No	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	10	Fair
Lim et al. 2014[34]	Yes	Yes	Yes	Yes	No	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	10	Fair
Lee et al. 2016[48]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	11	Good
Lee et al. 2017[27]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	11	Good
Traina et al. 2011[32]	Yes	Yes	Yes	Yes	No	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	10	Fair
Seufert and McGrory 2015[17]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Masrouha et al. 2018[35]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good
Lee et al. 2016[48]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	NR	Yes	Yes	11	Good
Jeroen et al. 2022[28]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	NR	Yes	Yes	12	Good

Question 1 is about whether the aim of the study was clear and obviously stated by the authors.
Question 2 is about the population participating in the study and if it was specific and clearly defined.
Question 3 is about the eligibility of the participating population and its percent.
Question 4 is about whether the study population was chosen according to inclusion and exclusion criteria and about the similarities among the chosen people of the population.
Question 5 is about whether any effect size or measure of variation or a reason for sample size choosing was stated.
Question 6 is about whether the exposure factor was measured at the beginning of the study before measuring the outcome.
Question 7 is about whether the time between measuring the relation among exposure factors and outcome was adequate.
Question 8 is about whether the different exposure levels were compared and related to the outcome.
Question 9 is about whether the exposure factor was applied and measured among all the study participants.
Question 10 is about whether the exposure was measured and subjected to assessment more than one time.
Question 11 is about whether the outcome was measured and applied to all study participant equally.
Question 12 is about whether the assessors of the outcome of interest has been blinded to exposure of the participants or not.
Question 13 is about the percentage of follow up loss if it was 20 % or less.
Question 14 is about whether the variables which have impact on outcome were adjusted and measured according to statistics or not.

with Perthes disease (95 % CI: 0.045−0.95, $p < 0.001$). Moderate heterogeneity was found among the included studies with $I^2 = 58$ %, and a random effects model was conducted (Figure 2).

To reduce the level of heterogeneity, we found that excluding a number of studies[30,38,26] revealed a significant reduction in heterogeneity with $I^2 = 0$ % and $p = 0.663$ (Figure 3). These studies may have contributed to the heterogeneity due to the patient age in these studies, as they were conducted in a pediatric population.

The overall incidence of complications among patients who underwent arthroplasty was 22.9 % among seven[17,27,28,31−33,48] included studies (95 % CI: 0.104−0.354, $p < 0.001$). Significant heterogeneity was found with $I^2 = 89.42$ % and $p < 0.001$ (Figure 4).

The systematically collected data from various studies[18,20,31,27−29,32,34,35,48,25] encompassing the Lequesne evaluation scores, mean acetabular component inclination, femoral canal (centralization), Harris Hip Score (HHS), Western Ontario and McMaster University Arthritis Index (WOMAC) score, blood loss, and leg lengthening are summarized in Table 3.

The Lequesne evaluation scores ranged from 9.1 to 4.8, with corresponding standard deviations (SDs) varying from

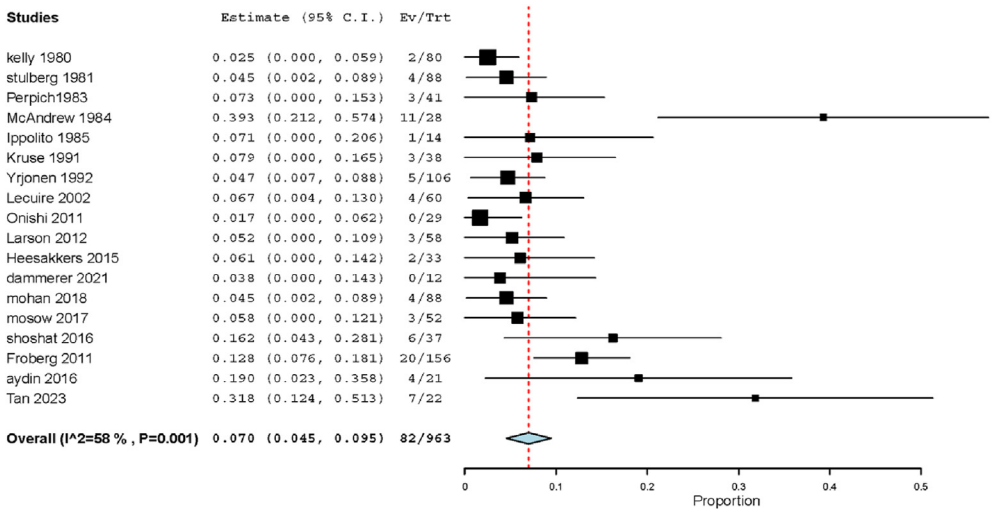

Figure 2: Forest plot showing the incidence of arthroplasty use in patients with Perthes disease.

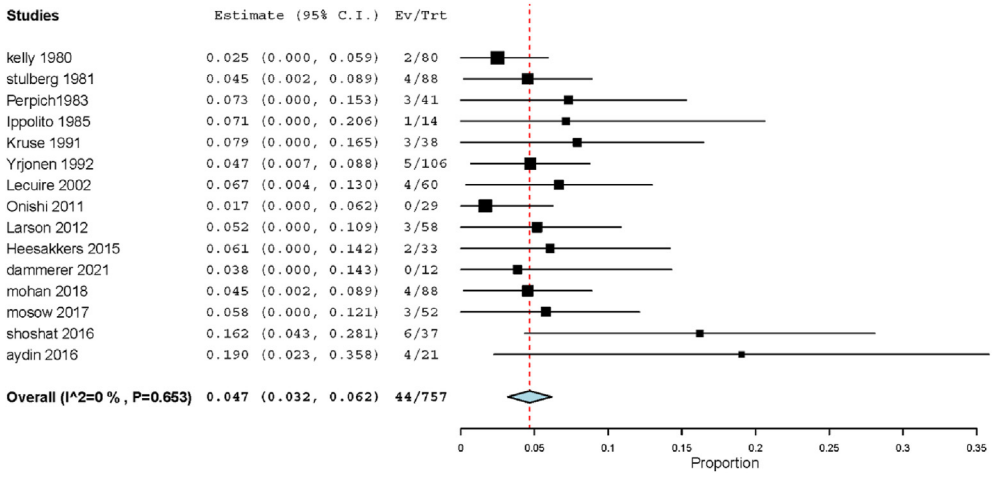

Figure 3: Leave-one-out analysis of incidence of arthroplasty use in Perthes disease.

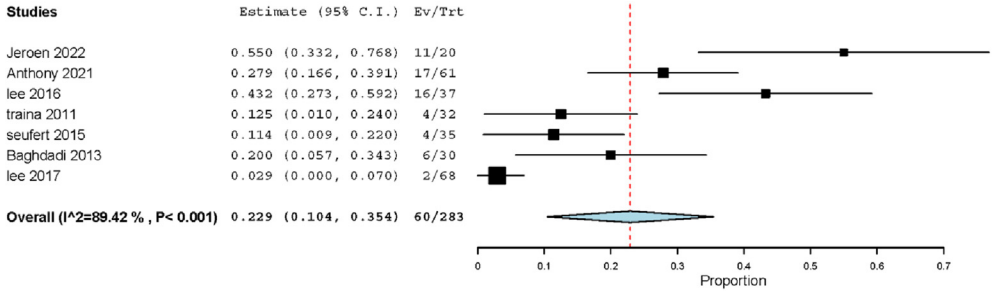

Figure 4: Forest plot showing risk of complications associated with arthroplasty in patients with Perthes disease.

4.7 to 8.8 across different studies. The mean acetabular component inclination values ranged from −0.9 to 58.3, with SDs ranging from 6.06 to 9.7. Femoral canal (centralization) measurements have been reported in a limited number of studies, with values ranging from 34.75 to 90.1, accompanied by SDs ranging from 11.4 to 15.311.

HHS assessments showed wide variability, with scores ranging from 1.4 to 95 and SDs from 0.9 to 17.65. WOMAC scores ranged from 1.75 to 49, with SDs from 0.463 to 30. Blood loss measurements varied considerably, with values ranging from 4.1 to 127.05 and SDs from 3.3 to 30. Leg lengthening data indicated changes ranging from 1.7 to 582.3, with SDs from 0.9 to 338.4.

Notably, several studies did not provide data for specific parameters, as indicated by the dashes in Table 3. These findings show the variability in reporting and measuring

Table 3: Table of systematically collected data.

Study ID	Lequesne evaluation (m1, sd1, t1, m2, sd2, t2)	Mean acetabular component inclination (m1, sd1, t1, m2, sd2, t2)	Femoral canal (Centralization) (m1, sd1)	HHS (m1, sd1, t1, m2, sd2, t2)	WOMAC (m1, sd1, t1, m2, sd2, t2)	Blood loss (m1, sd1, t1, m2, sd2, t2)	Leg lengthening (m1, sd1, t1, m2, sd2, t2)
Sansanovicz et al. 2021[20]	9.1/4.7/25/4.8/25	−0.9/9.4/25/−0.8/8.8/25	–	–	–	–	–
Hasler et al. 2023[25]	–	40.8/6.06/29/41/4.8	–	86.7/17.65/29/95/9.2	49/19/29/23/21/30	80.7/299.2/488/263/30	11.7/9.9/29/4.1/3.3/30
Jeroen et al. 2022[28]	–	–	–	90.1/11.4/18	–	–	–
Yang et al. 2021[29]	–	58.3/9.7/20	–	56.9/9.1/20	–	–	–
Al-Khateeb et al. 2013[18]	–	–	–	34.75/15.311/14	–	–	–
Anthony et al. 2021[31]	–	–	–	1.4/0.9/61	–	–	–
Lim et al. 2014[34]	–	38.8/9.16/23	–	–	1.75/0.463/23	–	–
Masrouha et al. 2018[35]	–	–	–	–	–	127.05/19.06/20	–
Lee et al. 2016[48]	–	38.9/11.9/37	–	–	–	–	1.7/0.9/37
Lee et al. 2017[27]	–	–	–	–	–	–	582.3/338.4/68
Traina et al. 2011[32]	–	–	–	–	–	–	4.56/3.09/30

across research, which must be addressed when evaluating the results.

Discussion

Our meta-analysis sheds light on the incidence of arthroplasty among patients with Perthes disease, as well as the post-surgery complications that may arise. Our research comprised 18 relevant papers that covered a wide period and various patient populations. According to the data, about 7 % of patients with Perthes disease undergo arthroplasty, demonstrating the importance of this operation in managing the condition. However, it is important to emphasize the moderate variability reported among the included studies, which may influence our interpretation of the results. To address this heterogeneity, we conducted sensitivity analysis and excluded three papers, resulting in a considerable reduction in heterogeneity. This emphasizes the necessity of considering individual study characteristics and methodology when interpreting meta-analysis findings. Heterogeneity results from different age groups including pediatrics and adults, different conditions of patients, disease progression, associated comorbidities, time of diagnosis, and other factors.

A recent meta-analysis by Zhi et al.[22] revealed that the overall rates of total hip arthroplasty (THA) were 6.8 % and 5.14 % among patients who underwent conservative and surgical treatment, respectively. It is noteworthy that individuals aged over 7 years old at disease onset exhibited elevated THA rates compared to those under 7 years old. Additionally, prolonged follow-up periods were linked to increased THA occurrences, particularly evident in patients receiving conservative treatment over extended durations. Interestingly, the Stulberg classification did not directly correlate with THA incidence, indicating that other factors may contribute to the necessity for THA in patients with LCPD.[22]

Furthermore, our analysis revealed a notable incidence of complications among patients who underwent arthroplasty, with 22.9 % experiencing complications. This finding highlights the importance of careful patient selection and thorough preoperative evaluation to minimize the risk of adverse outcomes associated with arthroplasty in patients with Perthes disease. This can be done through detailed imaging such as computed tomography or magnetic resonance imaging to understand the specific anatomical changes in the hip joint, including femoral head deformity, acetabular dysplasia, and limb length discrepancies. Patients with Perthes disease may have altered bone quality due to the disease effects on bone growth and structure. Preoperative bone density assessments (dual X-ray absorptiometry scans) can guide decisions regarding implant fixation, such as cemented versus uncemented options, to ensure optimal implant stability. Addressing limb length discrepancies preoperatively can improve post-surgical function and reduce compensatory gait patterns, which could otherwise contribute to complications.

Psychological assessment is also important as these patients may have experienced chronic pain and functional limitations over the years. Evaluating their expectations, educating them about potential functional improvements,

and discussing realistic outcomes can enhance satisfaction and adherence to postoperative care.

Arthroplasty, while often effective in alleviating pain and restoring function, carries inherent risks of complications.[50,51] Surgical site infections, long-term stability of artificial joint components, dislocation of prosthetic joints, thrombosis, and nerve damage during surgery are significant concerns. Prompt medical attention is needed to prevent further issues, and comprehensive monitoring and proactive management strategies are crucial for optimal patient outcomes.[13,22,33,25]

A study by D'Apolito et al.[52] on THA outcomes in patients with hip septic arthritis revealed a low postoperative infection rate of 1 %, alongside significant complications affecting 11 % of cases, including nerve palsies and fractures. Revision surgeries were common, with 8 % of patients undergoing revisions primarily due to aseptic loosening. Despite improvements in HHS postoperatively, the study highlighted limitations such as retrospective designs, variable reporting quality, and biases, suggesting the need for more robust research to understand THA risks and outcomes better.

It is critical to assess all clinical parameters used to evaluate arthroplasty outcomes holistically. These metrics include critical elements such as Lequesne evaluation scores, which assess pain and function in people with hip or knee OA. Furthermore, mean acetabular component inclination is critical for hip arthroplasty, influencing joint stability and function, whereas femoral canal (centralization) alignment during THA affects implant biomechanics and durability. The commonly used HHS measures outcomes based on pain, function, deformity, and range of motion, whereas the WOMAC score evaluates pain, stiffness, and physical function in patients with OA. Monitoring blood loss during surgery is vital to avoiding problems, and determining leg length equality after arthroplasty is critical for patient satisfaction and functional outcomes.[50,51,53,54]

The systematic collection and analysis of various clinical parameters, including Lequesne evaluation scores, mean acetabular component inclination, femoral canal (centralization), HHS, WOMAC score, blood loss, and leg lengthening, provide valuable insights into the functional outcomes and surgical success rates associated with arthroplasty in this patient population. However, it is essential to acknowledge the variability in reporting and measuring these parameters across studies, which may introduce bias and affect the generalizability of our findings as shown in Table 3.

A study comparing anterior versus posterior THA discovered that individuals undergoing direct anterior THA showed better early results than posterior THA up to 6 weeks postoperatively. Patients in the direct anterior THA group had decreased length of stay, increased distance walked on postoperative days 1 and 2, lower pain scores, required fewer narcotics, improved PROMIS Physical Function scores, and modified HHS up to 5 weeks postoperatively, and returned to driving, leaving home, and discontinuing their assistive device sooner than patients in the posterior THA group.[51]

Age varied strongly across the included studies. Although, Perthes disease is frequently diagnosed in older age, which is associated with advanced disease that is preferably managed by nonoperative management, some studies have reported that arthroplasty is more effective with increasing age.[55,56] Regarding the complications that occur following arthroplasty in Perthes disease, conducting arthroplasty in individuals with sequelae of Perthes disease is recognized as an operation with relatively significant risk. Baghdadi et al.[33] reported a 16 % complication rate, with intraoperative fractures (eight femoral and one acetabular) occurring in 99 patients, resulting in an overall fracture rate of 9 %, which was the predominant significant complication. In their study, three individuals (3 %) experienced sciatic nerve palsy, with one patient suffering a permanent disability. A case series by Traina et al.[32] with 32 patients indicates a significant incidence of neurologic deficit (6 %) in individuals with Perthes disease following arthroplasty. Their research was one of two that identified an increased risk of femoral fracture, quantified at 3 %.[32] The total complication rate was 12.5 %. The consequences comprised two persistent sciatic nerve palsies (6 %) and one surgical fracture. Seufert and McGrory[17] detailed their experience with arthroplasty in cases of OA resulting from Perthes disease. The study involved 35 hips in 28 patients, with one reoperation due to profound hematogenous infection occurring nearly 4 years postoperatively, which was addressed with head and liner exchange. The authors documented one superficial infection managed with oral antibiotics, two patients with asymptomatic Brooker grade 2 ectopic ossification, one patient with a single posterior dislocation, and no problems related to nerve injury.[17]

Anthony et al.[31] identified three significant problems, one of which necessitated the revision of the femoral component due to early instability. No neurologic or vascular damage was observed in their series. The absence of neurovascular damage in their series should be interpreted considering the reported average leg lengthening of 1.4 cm, and the fact that 26 % of the patients previously had ipsilateral hip surgery. Their lack of nerve impairment is significant and may result from less aggressive lengthening, particularly following prior surgery. Most of the documented grade I problems lacked significant clinical relevance; however, they are reportedly due to the stringent data gathering approach employed. The grade 1 complications comprised the majority of the total complication rate. Nevertheless, certain studies indicate that multiple lower grade problems may be equally impactful as a singular higher grade complication regarding outcomes.[31]

This meta-analysis comprehensively assesses the frequency, outcomes, and complications of arthroplasty procedures in patients with Perthes disease, providing valuable insights for future research and treatment optimization. However, this study had several limitations. First, the studies included in the analysis may have been inherently different from each other. Second, there may be a bias towards publishing studies with positive results. Third, the way outcomes were reported may have varied across studies. Fourth, because many studies were retrospective and relied on observational data, we could not definitively determine cause-and-effect relationships or fully account for

confounding factors. To strengthen the evidence base, we recommend conducting more high-quality double-randomized clinical trials.

Conclusion

This meta-analysis offers valuable insights into the frequency of arthroplasty procedures in patients with Perthes disease. It also provides a comprehensive analysis of associated outcomes and potential complications. While study inconsistencies and variations in reporting outcomes presented challenges, our findings emphasize the need for further research to refine treatment strategies and improve outcomes for patients with Perthes disease undergoing arthroplasty. Collaborative efforts are crucial to achieve this goal. These efforts should focus on standardizing treatment protocols, enhancing data collection methods, and conducting high-quality prospective studies. This will ultimately lead to a deeper understanding and more effective management of this complex orthopedic condition. Although the use of arthroplasty in Perthes is uncommon, the rate of complications has raised concerns, indicating its use is relatively unsafe. Therefore, in patients with Perthes who undergo arthroplasty, attention should be paid to the risk of complications, and preventive measures need to be investigated to overcome this risk. Future research should focus on patient selection criteria, optimal timing of surgery, rehabilitation following surgery, complication rates and risk reduction strategies, and other treatment methods that may be better than arthroplasty and lead to a lower incidence of complications and more efficacious outcomes.

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Conflict of interest:

The authors have no conflicts of interest to declare.

Ethical approval

As this systematic review and meta-analysis did not entail data collection from human or animals, there was no question of ethics that arose from the process of research. Thus, this study did not need clearance from an institutional review board. All data in this study were collected from the open source, whereas all studies included in the research had passed through their own ethical clearances. The study was done following the guidelines of systematic review and meta-analysis available in the guidelines of the International Committee of Medical Journal Editors.

Author contributions

Concept: AMA, SNA; Literature Search: HAA, ZMA, ASA, AAM; Data Collection and Processing: HAA, ZMA, ASA, AAM; Analysis and Interpretation: HAA, ZMA, ASA, AAM. Writing: AMA, SNA, HAA, ZMA; Critical Review: AMA, SNA, HAA, ZMA; Approval: SNA, AMA, HAA, ZMA, ASA, AAM. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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