Review Article

Total Hip Replacement in Dysplasia of the Hip: A Systematic Review and Meta-analysis

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Abstract

Background: Total hip arthroplasty (THA) is maintained as the conventional therapy when advanced osteoarthritis (OA) causes considerable pain and functional impairment. **Methods:** This essay research presents an overview of the present understanding regarding THA in hips affected by developmental dysplasia. In assessing the effect of THA on developmental dysplasia of the hip (DDH), numerous outcome metrics were utilized, such as the frequency of revision procedures, the rate of dislocations, and the reasons for treatment failure. With regard to revision surgeries, individuals with DDH have a 1.66 times higher likelihood of needing revisions compared to those with OA. **Results:** Aseptic loosening and periprosthetic joint infection (PJI) were the only failure modes analyzed quantitatively, with three studies each reporting these outcomes. DDH patients were 1.69 times more probable to experience aseptic loosening and 0.76 times less probable to have PJI, but both rates were not statistically significant. Three studies provided data on hospitalization and costs, with stays ranging from 3 to 11 days. One study reported no revisions or loosening of components over a follow-up of 5–10 years, suggesting that cementless THA with double-chevron subtrochanteric osteotomy can effectively restore anatomic hip center and safely lengthen limbs. **Conclusion:** The investigation elucidated a conspicuously heightened rate of revision in subjects diagnosed with DDH subsequent to THA. Albeit, the incidences of dislocation, aseptic loosening, and PJI did not achieve statistical significance. This observation necessitates cautious interpretation, considering the diversity inherent within the patient cohort and the potential influence of confounding variables.

Keywords: Developmental dysplasia of the hip, dysplasia, hip, total replacement

Introduction

Total hip arthroplasty (THA) represents a frequently executed surgical procedure aimed at mitigating hip discomfort and dysfunction when nonsurgical strategies have proven ineffective.[1] Hip arthritis in young people is predominantly attributed to developmental dysplasia of the hip (DDH). While various nonarthroplasty options, such as proximal femoral and periacetabular osteotomies, are available before end-stage osteoarthritis (OA), THA remains the definitive therapy for severe pain and impaired function due to end-stage OA. Instances of abnormal contact stresses in the dysplastic hip elevate the likelihood of early arthritic changes in individuals with DDH compared to those without dysplasia. Difficulties arise when contemplating THA for patients with DDH on account of variables such as youthful age, atypical anatomical features, and elevated failure and revision rates.[2]

The substantial variability observed in dysplastic hip morphology necessitates the implementation of a classification framework to ensure the consistent use of terminology and facilitate outcome comparisons. Among the different classification systems, the one proposed by Crowe *et al*.[3] stands out for categorizing dysplastic hips determined by the degree of upward displacement of the femoral head in relation to the vertical height of the pelvis. Following this, based on their significant anatomical aberrations, Hartofilakidis classification's scheme classifies dysplastic hips into three distinct groups: minimally dysplastic, low dislocation, and high dislocation.[4] These classification schemes have been applied in both clinical settings and scholarly investigations, underscoring their utility and relevance in understanding and managing dysplastic hip conditions.[5]

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DDH patients typically manifest as youthful patients experiencing progressively worsening groin pain or lateral hip discomfort associated with their activities. Leg length difference is a prevalent feature observed among these patients, with the development of a limp being frequently cited as the most prevalent functional impairment within this cohort.[6]

Radiographic evaluation is essential for surgical planning in patients with DDH. An anteroposterior pelvic image and a false profile hip view often compose the standard radiography series.[7]

THA offers pain relief and enhanced functionality for numerous patients suffering from end-stage arthritis resulting from developmental dysplasia. Nevertheless, THA, particularly acetabular cup replacement, encounters substantial challenges attributed to the abnormal morphology of the acetabulum. Thus, it becomes of utmost importance to classify the acetabular defect and adjust available acetabular bone stock accurately (pre- and intraoperatively) in order to overcome this difficult technical challenge to the orthopedic surgeon.[8]

The objective of this essay research is to present an overview of introduction, classification, pathoanatomy, operative planning, challenges, and different surgical approaches to operate and to summarize the current knowledge about THA in dysplastic hips.

Methods

This systematic review was executed in strict adherence to the standards that were specified by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Search strategy

An extensive and meticulous search methodology was employed to cross-reference numerous scholarly databases, such as PubMed/Medline, Google Scholar, and Cochrane Library, to encompass the full spectrum of literature up to the cutoff date of February 2024. This search strategy employed a carefully chosen combination of specific keywords and their permutations, with a focus on terms such as "Total hip replacement" OR "Total hip arthroplasty," "Developmental dysplasia of the hip," and "Outcomes." The initial screening of search outcomes was conducted independently by two researchers, who meticulously determined the pertinence of each article predicated on a careful examination of their title and/or abstract. In instances of disagreement, a third senior author was engaged in a consultative process to adjudicate and reconcile any differences. Following the initial screening, a comprehensive examination was performed on the full-text papers that met the rigorous qualifying requirements. Furthermore, a thorough manual examination was conducted on the reference lists of the chosen papers to guarantee the incorporation of all potentially pertinent studies into the analysis.

Outcomes of interest

Of the National Joint Registry, which is "Any surgical intervention undertaken to change, delete, or add to one or more joint replacement components." Secondary outcomes included the incidence of dislocations, the range of failure mechanisms (such as aseptic loosening, instability, periprosthetic joint infection [PJI], and periprosthetic fractures [PPF]), the challenges faced, the variety of surgical techniques employed, and a comprehensive review of the existing literature on THA in dysplastic hips. Additionally, the study considered the duration of hospital stays and the associated financial costs as secondary outcomes.

Selection criteria

Inclusion criteria

Included in the study are original comparative, observational studies and randomized controlled trials that document the outcomes of total hip replacement (THR) in patients with hip dysplasia, include all types of THR prosthesis designs, and include a minimum follow-up time of 1 year.

Exclusion criteria

Excluded from the study are studies focusing on uses of THR outside of hip dysplasia, those that fail to report outcomes or failures by specific subgroups, those published in languages other than English, as well as those having data that are insufficient or unextractable.

Data extraction and items

A Microsoft Excel data extraction template that had been predefined was used by two impartial reviewers to carefully gather pertinent data. The gathered information covered different demographic features, comprising the lead authors' names, the year of the research, its design and geographic location, the average age of patients, participants' number and hips, the age distribution, the specific kind of THR employed, the average duration of follow-up, the number of revision surgeries, complications encountered, the approaches used for revisions, the duration of hospital stay, financial costs, statistical techniques applied, and the key findings of each research.

Qualitative assessment (risk of bias)

Two researchers evaluated the methodological integrity among the studies that are included by employing Newcastle–Ottawa instrument, which consists of 3 principal domains: patient selection, comparability, and findings. An elevated aggregate score signifies a diminished bias risk; conversely, a score of 5 or below (on a scale of 9) is indicative of a heightened bias risk.

Quantitative analysis

An extensive meta-analysis was carried out employing R software (version 4.0.2, R Core Team, Vienna, Austria, 2020), utilizing the functionalities of the meta package, such as Meta-analysis of binary outcome data. This analysis included the computation of odds ratios (ORs) and their respective 95% confidence intervals (CIs) for binary outcomes (e.g., rates of revision) across the included studies. The heterogeneity among the effect sizes was assessed employing *I*-squared statistics, with levels of heterogeneity categorized based on Cochrane Handbook criteria: >25% as mild, 25%–50% as moderate,

and >50% as severe. Due to significant heterogeneity observed in the binary outcomes, a random-effects model was employed to address this variability adequately. Furthermore, publication bias was determined utilizing both a funnel plot and Egger's test of asymmetry to ensure the reliability and accuracy of the meta-analysis findings.

Results

Study selection

The Rayyan AI interface was utilized to orchestrate the outcomes of the literature search. The interrogation of the databases produced 257 articles, from which 119 duplicates were excised, resulting in 138 records subjected to screening by title and abstracts. From this subset, 122 were deemed irrelevant and excluded. Following this filtration, 18 papers warranted an exhaustive full-text review. In the final analysis, 15 studies fulfilled the stipulated eligibility criteria and were assimilated into both the qualitative and quantitative syntheses. PRISMA flowchart is exhibited in Figure 1.

Study characteristics

A total of 15 articles, elucidating the surgical technique, complications, and outcomes of THA, while also examining THA effect on patients with DDH and occasionally juxtaposed with OA patients, were encompassed in this analysis. The encompassed studies spanned the publication period from 2006 to 2022. The publications included in the study predominantly

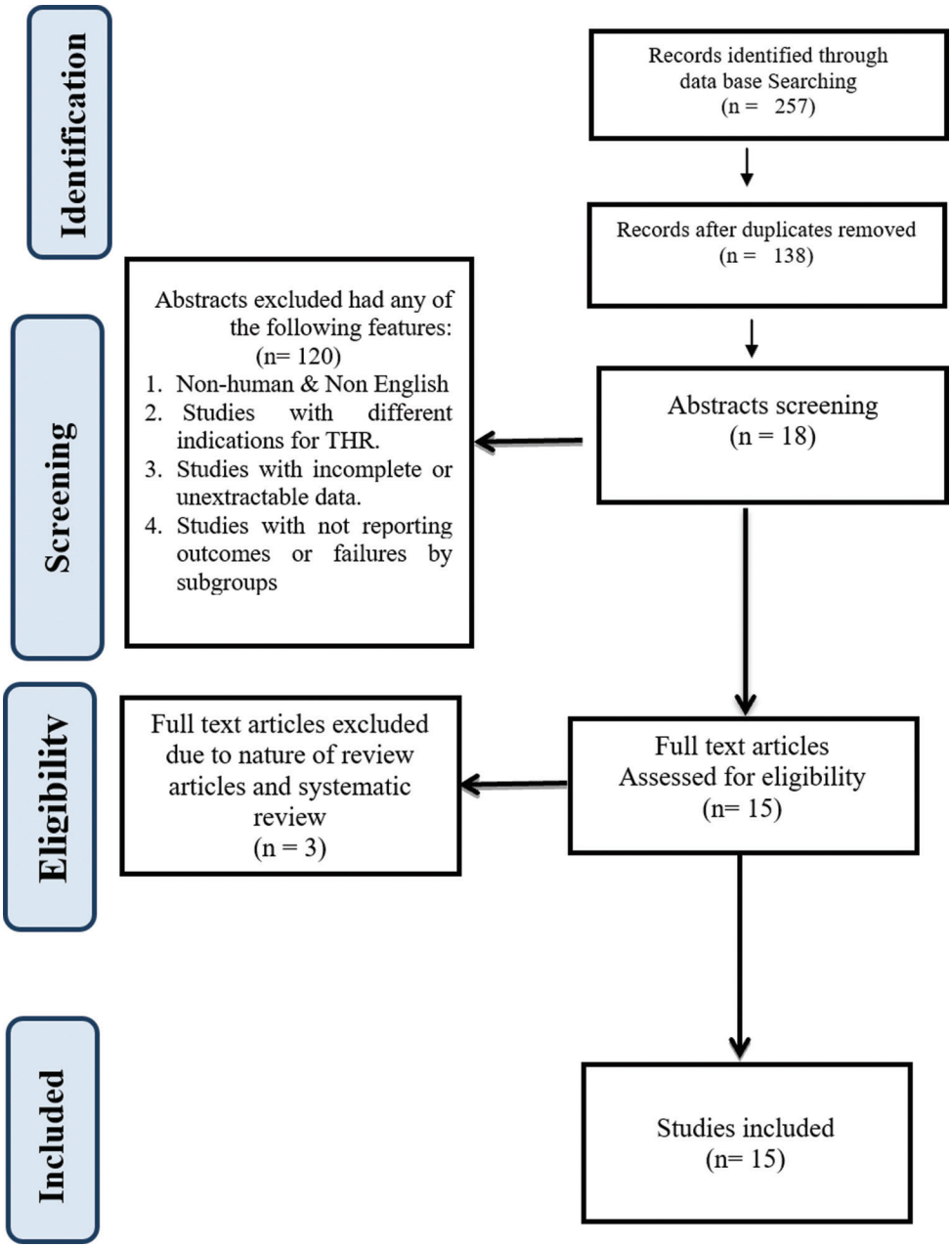

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for selection included studies. THR: Total hip replacement

featured the USA (n = 4), followed by Denmark, Norway, and Sweden (n = 3), New Zealand (n = 2), Greece (n = 1), and singular studies from Edinburgh, Turkey, China, and Iran (n = 1 each). The majority of these investigations were cohort based, with 9 being retrospective in nature and 1 prospective, alongside 2 review articles and cross-sectional studies [Table 1].

Overall, the included investigations documented a sum of 583,125 THA procedures. Out of these, 491,114 hips were analyzed, with 23,072 of them being affected by DDH. The average age of participants with DDH was 45.8 years, and they were followed up for a period ranging from 1 to 12 years.

Quality assessment (risk of bias and level of evidence)

Following the Oxford Centre for Evidence-Based Medicine criteria, 5 studies were classified as level 2b and 11 as level 3a, leading to an overall grade B recommendation for the review. In all nine observational studies, the Newcastle–Ottawa scores varied between 6 and 8, with an average score of 6.7 ± 0.87, which suggests a relatively low risk of bias in the entire analysis. A synopsis of the qualitative evaluation is presented in Table 2. A greater cumulative score indicates a reduced likelihood of bias, whereas a Newcastle–Ottawa scale score of 5 or less (out of 9) signifies an elevated risk of bias.

Outcome results

The comprehensive analysis of THA effect on DDH covered various outcomes, including revision rates, dislocation occurrences, and modes of treatment failure such as aseptic loosening, PJI, instability, and PPF. A 1.66-fold increased likelihood of revision operations was seen among individuals with DDH in comparison to those with OA (OR = 1.66; 95% CI = 1.11–2.48; P = 0.0251). Nevertheless, a statistical analysis of dislocation rates across four studies revealed that individuals with DDH had a 1.78-fold increased probability of encountering dislocations; nevertheless, this disparity failed to reach significance (OR = 1.78; 95% CI = 0.58–5.51; P = 0.200).

Only PJI and aseptic loosening were subjected to quantitative analysis with respect to failure modes, drawing from three investigations each. Patients who had DDH had a 0.76-fold lower likelihood of having PJI (OR = 0.76; 95% CI = 0.56–1.03) and a 1.69-fold increased risk of aseptic loosening (OR = 1.69; 95% CI = 0.26–10.84), but these differences were not statistically significant (P = 0.346 and P = 0.063, respectively). There was an absence of data about instability in all the research examined, and PPFs were only addressed in one study. Thillemann *et al*.[11] observed 4 PPF incidents among 1455 DDH patients compared to 109 PPF incidents among 53,694 OA patients. Three studies[1,19,22] reported hospital stays and costs related to THA, with hospitalization durations ranging from 3 to 11 days.

An investigation was carried out by Li *et al*.[21] revealed that no acetabular nor femoral component loosening nor revision occurred during the 5–10-year follow-up period. This implies that the combination of cementless THA with double-chevron subtrochanteric osteotomy is effective in reestablishing the anatomical center of the hip and promoting functional limb elongation in a safe manner [Table 3].

Table 1: A summary of baseline study characteristics

References	Design	Country	Number of hips	THA type	Data source
Papachristou *et al*., 2006[9]	Retrospective	Greece	38	NR	Springer Nature Group, International Orthopaedics Journal
Engesaeter *et al*., 2008[10]	Cohort	Norway	66,909	Cemented, cementless	NAR
Thillemann *et al*., 2008[11]	Retrospective	Denmark	56,099	Cemented, cementless, hybrid	Danish Hip Arthroplasty Registry
Gaston *et al*., 2009[12]	Reliability study	Edinburgh	50	NR	SAGE registry, Hip International Journal
Boyle *et al*., 2012[13]	Retrospective	New Zealand	41	Cemented, cementless, hybrid	New Zealand National Joint Registry
Yang and Cui, 2012[14]	Review article	Virginia	NR	NR	World J Orthopedic, Baishideng
Kose *et al*., 2012[15]	Cross sectional	Turkey	141	NR	Archives of Orthopaedic and Trauma Surgery, Springer registry
Boyle *et al*., 2013[16]	Retrospective	New Zealand	1054	NR	Regional joint registry records
Engesæter *et al*., 2013[17]	Retrospective	Denmark, Sweden	300,502	NR	NARA Registry
Hartofilakidis *et al*., 2013[18]	Retrospective	Greece	84		Clinical Orthopaedics and Related Research
Ashraf *et al*., 2014[19]	Retrospective	USA	1383	NR	OCHEUD/Institutional Data Registry
Aggarwal *et al*., 2019[20]	Retrospective	USA	836		Institutional electronic medical records
Li *et al*., 2017[21]	Retrospective	China	20	Cementless	Springer Nature
Siddiqi *et al*., 2020[22]	Retrospective	USA	115,796		National Surgical Quality Improvement Program database
Mortazavi *et al*., 2022[23]	Retrospective	Iran	368		Tehran University of Medical Sciences

THA: Total hip arthroplasty, NARA: Norwegian and Swedish Hip Arthroplasty Registers, NAR: Norwegian Arthroplasty Register, NR: Norwegian Register

Discussion

DDH encompasses a range of abnormalities from a shallow acetabulum to complete femoral head dislocation, leading to altered hip anatomy and biomechanics. DDH is a major reason for secondary hip OA necessitating THA, accounting for about 20% of all THA surgeries in individuals under 50 years old.[27] The complexities of DDH have sparked ongoing debates about the long-term outcomes, complications, and efficacy of THA in these cases, with some studies reporting satisfactory results and others indicating suboptimal long-term outcomes and higher revision rates.[22] Our study conducted a thorough evaluation of THA's impact on DDH, focusing on revision frequency, dislocation occurrences, and treatment failure modes such as aseptic loosening, PJI, instability, and PPF.

The primary findings of this systematic review underscored a notably elevated rate of revisions subsequent to THA for DDH. Another noteworthy discovery was the increased likelihood of dislocations and aseptic loosening among patients with DDH; however, these differences did not achieve statistical significance. Furthermore, the study observed comparable durations of hospital stays and associated costs between patient groups.

This research revealed a notable rise in revision surgeries, with DDH patients being 1.66 times more probable to require revisions than OA patients (OR = 1.66; 95% CI = 1.11–2.48; $P = 0.0251$), aligning with previous research.[16]

Engesæter *et al*.[25] noted a higher risk of revision for DDH patients throughout the initial 6 months postsurgery compared to OA patients, but this difference diminishes after 6 months, primarily due to a higher incidence of dislocations in DDH patients during this period. Thillemann *et al*.[11] and Boyle *et al*.[16] also documented significant revision rates, but the underlying reasons for these outcomes remain unclear. Heterogeneity among studies may stem from combining mild and severe dysplasia groups, possibly underestimating revision

Table 2: Risk of bias was determined employing the Newcastle–Ottawa Scale

References	Selection	Comparability	Score
Papachristou *et al*., 2006[9]	III	I	8
Engesæter *et al*., 2013[17]	IV	I	7
Thillemann *et al*., 2008[11]	III	I	7
Gaston *et al*., 2009[12]	III	0	6
Boyle *et al*., 2012[13]	III	I	6
Yang and Cui, 2012[14]	III	I	6
Kose *et al*., 2012[15]	IV	I	7
Boyle *et al*., 2013[16]	III	I	8
Engesæter *et al*., 2013[17]	III	0	7
Hartofilakidis *et al*., 2013[18]	III	I	7
Ashraf *et al*., 2014[19]	III	I	7
Agarwal *et al*., 2019[24]	IV	I	7
Li *et al*., 2017[21]	IV	I	8
Siddiqi *et al*., 2020[22]	IV	0	6
Mortazavi *et al*., 2022[23]	IV	I	6

Table 3: Comparison of all reported outcomes between developmental dysplasia of the hip and osteoarthritis patients

Study	DDH events	OA events	OR	95% CI	Weight (%)
Overall revision					
Engesaeter *et al*., 2008[10]	219/7135	686/59,774	2.73	2.34–3.18	24.4
Thillemann *et al*., 2008[11]	76/1455	2204/53,694	1.29	1.02–1.63	22.3
Boyle *et al*., 2012[13]	42/1205	1031/40,589	1.39	1.01–1.9	19.9
Engesæter *et al*., 2012[25]	706/12,086	11,214/288,435	1.54	1.42–1.66	25.8
Siddiqi *et al*., 2020[22]	13/557	9/557	1.46	0.62–3.43	7.7
Overall dislocation					
Engesaeter *et al*., 2008[10]	19/7135	104/59,774	1.53	0.94–2.5	26.1
Thillemann *et al*., 2008[11]	23/1455	699/53,694	1.22	0.8–1.85	27.1
Engesæter *et al*., 2012[25]	138/12,068	2485/288,435	1.33	1.12–1.58	29.5
Hartofilakidis *et al*., 2013[18]	44/84	-	-	-	43.1
Papachristou *et al*., 2021[26]	34/55	-	-	-	23.9
Mortazavi *et al*., 2022[23]	21/171	4/197	6.75	2.27–20.1	17.3
Aseptic loosening					
Engesaeter *et al*., 2008[10]	173/7135	394/59,774	3.73	3.34–4.49	34.4
Thillemann *et al*., 2008[11]	19/1455	822/53,694	0.95	0.52–1.43	31.3
Engesæter *et al*., 2012[25]	325/12,086	5407/288,435	1.45	1.29–1.62	35.8
Hartofilakidis *et al*., 2013[18]	24/84	-	-	-	13.1
PJI					
Engesaeter *et al*., 2008[10]	7/7135	80/59,774	0.73	0.34–1.49	9.4
Thillemann *et al*., 2008[11]	5/1455	346/53,694	0.53	0.22–1.43	7.3
Engesæter *et al*., 2012[25]	57/12,086	1734/288,435	0.78	0.69–1.62	82.8

DDH: Developmental dysplasia of the hip, OA: Osteoarthritis, OR: Odds ratio, CI: Confidence interval, PJI: Periprosthetic joint infection

risks for severe dysplasia and affecting comparisons between studies.[10] Furthermore, DDH patients are often younger and more active, with higher postoperative expectations, which may lead to a greater propensity for revision surgery in this group.

Conversely, four studies addressed the incidence of dislocations, revealing that DDH patients are 1.78 times more probably suffer from dislocations; however, the difference was not significant (OR = 1.78; 95% CI = 0.58–5.51; $P = 0.200$).

The increased propensity for dislocation following THA in DDH patients is a complex phenomenon rooted in the unique anatomical features of this patient population. These individuals often present with marked anteversion of the proximal femur, necessitating a careful positioning of the femoral component to mitigate the risk of anterior dislocation. Mortazavi *et al*.[23] observed a significantly greater dislocation rate in DDH patients compared to their counterparts. Furthermore, a univariate analysis within the same study revealed a correlation between the dislocation rate and the severity and grade of DDH. This association is likely influenced by the presence of a dysplastic acetabulum, a narrower femur, limb shortening, rotational deformities, and previous surgical interventions, all of which contribute to an increased susceptibility to dislocation. The inherent challenges posed by the altered anatomical structures in DDH patients render THA technically demanding, further amplifying the risk of dislocation in this population.

Regarding the modes of failure, a quantitative analysis was conducted on aseptic loosening and PJI based on data from three studies each. Patients diagnosed with DDH demonstrated a 1.69-fold increased likelihood of experiencing aseptic loosening (OR = 1.69; 95% CI = 0.26–10.84) and were 0.76 times less likely to develop PJI (OR = 0.76; 95% CI = 0.56–1.03). However, these observed differences did not reach statistical significance ($P = 0.346$ and $P = 0.063$, respectively).

Previous investigations have indicated a heightened risk of aseptic loosening of the acetabular component following THA in DDH patients.[28] This trend suggests a potential decline in the risk of aseptic loosening over time, possibly attributable to advancements in surgical techniques and prosthetic designs.

Moreover, no studies addressed instability, while only one study touched upon PPF. Thillemann *et al*.[11] documented 4 and 109 PPF incidents among 1455 patients with DDH.

Three studies, authored by Ashraf *et al*.,[19] Aggarwal *et al*.,[1] and Siddiqi *et al*.,[22] contributed data on the duration of hospitalization and associated expenses linked to THA procedures. The length of hospital stays for patients undergoing THA varied between 3 and 11 days.

Additionally, a solitary study conducted by Li *et al*.[29] documented no instances of revision or loosening of the acetabular or femoral components throughout a follow-up period spanning 5–10 years. This suggests that employing a cementless THA approach with double-chevron subtrochanteric osteotomy can effectively restore the anatomic hip center while allowing for safe functional limb lengthening.

Our systematic review findings are consistent with those of Salman *et al*.,[30] who concluded that patients with DDH undergoing THA exhibit a higher revision rate compared to those with OA. However, both groups showed similar rates of dislocation, aseptic loosening, and PJI.

Limitations

This systematic review has inherent limitations that warrant recognition. First, the analysis of the DDH cohort included a wide spectrum of cases, from mild dysplasia to complete dislocation. The possibility of reducing heterogeneity in this condition and its impact on THA outcomes through subgroup analyses based on the severity of DDH morphology was limited due to a lack of studies and inconsistent reporting of DDH in the literature. Another issue is the underreporting of variables such as implant type and surgical parameters that could affect the outcome of THA. In order to properly account for these confounding variables and more precisely evaluate this problem, future research should concentrate on prospective studies.

Conclusion

This study highlights a substantial increase in the need for revision surgeries among patients with DDH who underwent THA. Despite this, the incidence of dislocations, aseptic loosening, and PJI did not show statistically significant differences. These results underscore the importance of considering the diverse patient characteristics and potential confounding variables when interpreting the findings.

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Conflicts of interest

There are no conflicts of interest.

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