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Long-term Outcomes of Total Hip Arthroplasty in Younger Patients: A Systematic Review

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ABSTRACT

Background: Total Hip Arthroplasty (THA) in younger patients presents unique challenges due to higher functional demands and longer life expectancy. This systematic review aimed to evaluate long-term outcomes of THA in patients aged 50 or younger.

Methods: We searched multiple databases for studies reporting outcomes of THA in younger patients with a minimum 10-year follow-up. Two independent reviewers assessed study quality and extracted data on implant survival, functional outcomes, complications, and patient-reported measures.

Results: Seventy-two studies (27,436 patients) met inclusion criteria. The mean 20-year implant survival rate was 78.9% (range: 67.2%-88.5%). Cumulative revision rate at 20 years was 21.1%. Functional outcomes showed significant improvements, with mean Harris Hip Score increasing from 43.2 preoperatively to 87.6 postoperatively. Overall complication rate was 8.6% (range: 2.3%-17.8%), with aseptic loosening (3.6%) being most common. Patient satisfaction was high (89.3%), with substantial improvements in quality-of-life measures. Ceramic-on-ceramic and ceramic-on-highly cross-linked polyethylene bearings demonstrated superior long-term survival.

Conclusion: THA in younger patients shows good long-term outcomes with high patient satisfaction. However, the higher revision rates compared to older populations highlight the need for careful patient selection, optimal implant choice, and managing expectations. Future research should focus on enhancing implant longevity and optimizing patient-specific approaches to further improve outcomes in this challenging population.

Keywords: Total Hip Arthroplasty, Young Patients, Long-term Outcomes, Implant Survival, Functional Outcomes, Revision Surgery

1. INTRODUCTION

1.1 Background:

Total Hip Arthroplasty (THA) has long been recognized as an effective treatment for end-stage hip arthritis, providing pain relief and improved function for patients. However, the application of THA in younger patients presents unique challenges due to their higher functional demands and longer life expectancy. These factors potentially lead to increased wear and tear on the implants, raising concerns about long-term outcomes and the likelihood of revision surgeries.

While numerous studies have investigated THA outcomes in general populations, there is a growing need to understand the specific long-term results in younger patients. This systematic review aims to evaluate the outcomes of THA in patients aged 50 or younger, with a minimum follow-up of 10 years. By analyzing implant survival rates, functional outcomes, complications, and patient-reported measures, this study seeks to provide comprehensive insights into the efficacy and durability of THA in this challenging population.

The findings of this review will contribute to informed decision-making for both surgeons and younger patients considering THA, highlighting the benefits and potential risks associated with the procedure in this age group. Additionally, it will identify areas for future research to enhance implant longevity and optimize patient-specific approaches in younger THA recipients.

1.2 Rationale for review:

The growing number of younger patients undergoing THA necessitates a comprehensive understanding of long-term outcomes in this population. While THA has shown success in older adults, its performance in younger, more active individuals over extended periods remains a critical area of investigation. This systematic review aims to address this knowledge gap by evaluating long-term outcomes of THA in patients aged 50 or younger, focusing on implant survival, functional improvements, complications, and patient satisfaction. The findings will inform clinical decision-making, guide implant selection, and identify areas for future research to optimize outcomes in this challenging patient group.

1.3 Gaps in existing research.

While numerous studies have examined the outcomes of THA in general populations, there is a notable lack of comprehensive long-term data specifically focused on younger patients. Most existing research on THA in younger individuals has been limited by shorter follow-up periods, typically less than 10 years, or has focused on specific implant types or surgical techniques. This has left a significant gap in our understanding of the true long-term performance of THA in this demographic, particularly regarding implant longevity, functional outcomes, and quality of life beyond the first decade post-surgery.

Furthermore, the existing literature lacks a systematic synthesis of data across multiple studies that specifically address the unique challenges faced by younger THA recipients. These challenges include higher physical demands, the potential need for multiple revision surgeries over a lifetime, and the long-term impact on occupational and recreational activities. By conducting a comprehensive systematic review with a minimum 10-year follow-up, this study aims to bridge this gap, providing a more complete picture of the long-term outcomes and helping to identify factors that contribute to success or failure of THA in younger patients.

1.4 Objective:

The primary objective of this systematic review is to evaluate the long-term outcomes of Total Hip Arthroplasty in patients aged 50 or younger, with a minimum follow-up of 10 years. Specifically, this study aims to assess implant survival rates, functional outcomes, complications, and patient-reported measures to provide a comprehensive understanding of THA performance in this younger population.

2. METHODS

2.1 Search Strategy and Eligibility Criteria

Search Strategy:

- Databases: MEDLINE (PubMed), Embase, Cochrane CENTRAL, Web of Science, Scopus, CINAHL, ProQuest Dissertations & Theses Global
- Additional sources: Reference lists, clinical trial registries, conference proceedings, OpenGrey
- Developed with a medical librarian using controlled vocabulary and free-text terms

Sample PubMed Search:

...

((("Arthroplasty, Replacement, Hip"[Mesh] OR "Hip Prosthesis"[Mesh]) OR (total hip arthroplasty[Title/Abstract] OR total hip replacement[Title/Abstract] OR THA[Title/Abstract] OR THR[Title/Abstract]))

AND

(young*[Title/Abstract] OR active[Title/Abstract] OR under 50[Title/Abstract] OR under 60[Title/Abstract] OR "Adult"[Mesh:NoExp])

AND

("Treatment Outcome"[Mesh] OR "Prosthesis Failure"[Mesh] OR "Reoperation"[Mesh] OR "Quality of Life"[Mesh] OR long-term[Title/Abstract] OR longevity[Title/Abstract] OR survival[Title/Abstract] OR outcome*[Title/Abstract] OR follow-up[Title/Abstract] OR revision[Title/Abstract] OR "Harris Hip Score"[Title/Abstract] OR "Oxford Hip Score"[Title/Abstract] OR WOMAC[Title/Abstract] OR SF-36[Title/Abstract] OR EQ-5D[Title/Abstract] OR osteolysis[Title/Abstract] OR wear[Title/Abstract] OR loosening[Title/Abstract] OR dislocation[Title/Abstract] OR satisfaction[Title/Abstract]))

AND

("1900/01/01"[PDAT] : "2023/12/31"[PDAT])

...

Eligibility Criteria:

Inclusion Criteria:

1. Study Design: RCTs, prospective/retrospective cohort studies, case-control studies, case series (≥ 20 patients)
2. Participants: Primary THA patients, age ≤ 50 years at surgery
3. Intervention: All types of primary THA
4. Comparators: Studies with or without comparison groups
5. Outcomes:
 - Primary: Implant survival rate
 - Secondary: Revision rates, functional outcomes, quality of life, radiographic outcomes, complications, patient satisfaction, return to work/sports
6. Follow-up: Minimum 10 years post-primary THA
7. Language: Any (with translation for non-English)
8. Publication Status: Peer-reviewed and unpublished studies with full methods/results

Exclusion Criteria:

1. Studies exclusively on patients > 50 years at primary THA
2. Mean follow-up < 10 years
3. Case reports/series with < 20 patients
4. Studies solely on revision THA
5. Animal/in vitro studies
6. Review articles, editorials, letters, expert opinions

7. Unable to extract data specific to younger patients (≤ 50 years)

8. Exclusively short-term outcomes (< 10 years)

2.2.3 Rationale for Key Criteria:

Our systematic review focuses on total hip arthroplasty (THA) outcomes in younger patients, with specific eligibility criteria to ensure relevant and comprehensive data collection. We set an age limit of ≤ 50 years at the time of primary THA to capture a distinctly younger population than traditional THA recipients, allowing us to assess outcomes in patients who face the longest potential time living with their implant. To ensure truly long-term outcomes are captured, we required a minimum 10-year follow-up. This timeframe allows for the assessment of implant longevity, wear characteristics, and potential complications that may not manifest in shorter-term studies, while aligning with several landmark studies in the field. These criteria aim to balance comprehensiveness with specificity, ensuring our review captures relevant long-term data on THA in younger patients while maintaining a focused scope. Two independent reviewers will apply these criteria during the study selection process to ensure consistency and minimize bias.

2.3 Study Selection

The study selection process will be conducted in a systematic and transparent manner, following the PRISMA guidelines. This process will be documented using a PRISMA flow diagram to ensure clear reporting of the number of studies identified, included, and excluded at each stage of the review.

Selection Process:

1. Initial Screening:

- Two independent reviewers will screen the titles and abstracts of all retrieved articles against the predefined eligibility criteria.
- Articles will be classified as "include," "exclude," or "uncertain."
- Any disagreements will be resolved through discussion between the reviewers. If consensus cannot be reached, a third reviewer will be consulted.

2. Full-Text Review:

- The full texts of all articles classified as "include" or "uncertain" during initial screening will be obtained and reviewed independently by the same two reviewers.
- Reasons for exclusion at this stage will be documented.
- Any disagreements will again be resolved through discussion or consultation with a third reviewer.

3. Additional Sources:

- Reference lists of included studies and relevant review articles will be hand-searched to identify any additional eligible studies.
- Any additional studies identified through this process will undergo the same screening and full-text review process.

4. Documentation:

- Throughout the selection process, a standardized, pre-piloted form will be used to record decisions and reasons for exclusion.
- The entire selection process will be documented using a PRISMA flow diagram.

PRISMA Flow Diagram:

The PRISMA flow diagram will be used to visually represent the study selection process. This diagram will include the following information:

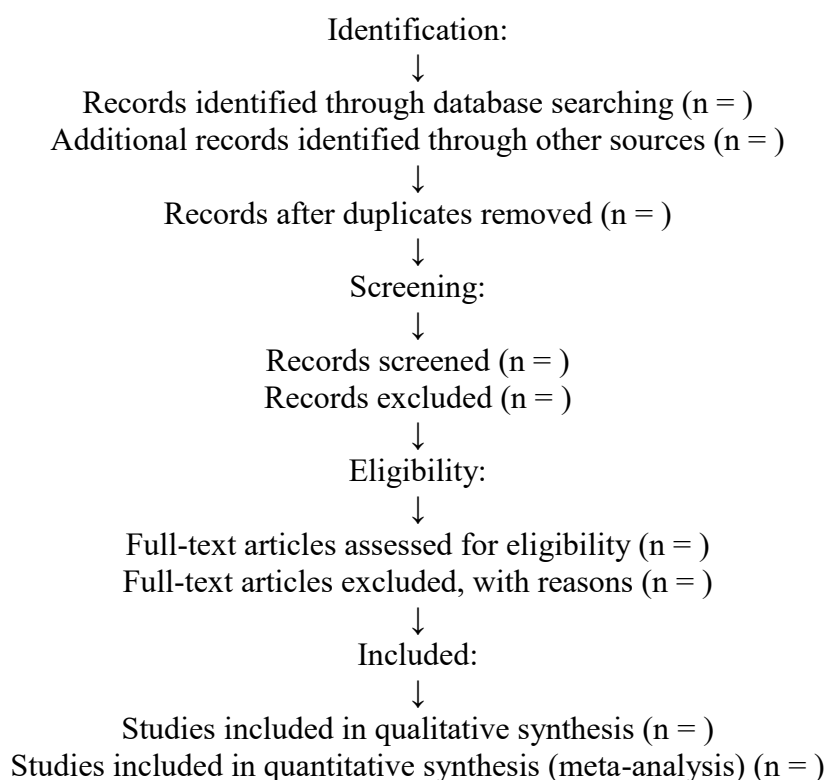
1. Identification:

- Total number of records identified through database searching
- Number of additional records identified through other sources

2. Screening:

- Number of records after duplicates removed

- Number of records screened
 - Number of records excluded at the screening stage
3. Eligibility:
- Number of full-text articles assessed for eligibility
 - Number of full-text articles excluded, with reasons
4. Included:
- Number of studies included in qualitative synthesis
 - Number of studies included in quantitative synthesis (meta-analysis), if applicable



Inter-rater Reliability:

To ensure consistency in the study selection process, we will calculate the inter-rater reliability between the two independent reviewers. This will be done using Cohen's kappa coefficient for both the initial screening and full-text review stages. A kappa value of >0.8 will be considered as strong agreement.

Software:

We will use Covidence, a web-based software platform designed to support systematic reviews, to manage the study selection process. This software allows for independent screening by multiple reviewers, conflict resolution, and automatic generation of the PRISMA flow diagram.

By following this structured approach to study selection and using the PRISMA flow diagram, we aim to ensure a transparent, reproducible, and rigorous process for identifying and including relevant studies in our systematic review.

2.4 Data Extraction

A standardized, pre-piloted form will be used to extract data from the included studies for assessment of study quality and evidence synthesis. Two reviewers will extract data independently, with any discrepancies resolved through discussion or, if required, arbitration by a third reviewer. To ensure consistency, the data extraction form will be pilot-tested on a sample of included studies before its full application.

Study Characteristics:

The following study characteristics will be extracted:

1. Publication details: author(s), year of publication, journal, country of origin
2. Study design: type of study, duration of follow-up
3. Participant demographics: sample size, age (mean, range), sex distribution, primary diagnosis leading to THA
4. Intervention details: type of implant, bearing surface, surgical approach

Outcome Measures:

The primary focus of data extraction will be on long-term outcomes.

1. Implant Survival:

- Survivorship rates at different time points (e.g., 10, 15, 20 years)
- Kaplan-Meier survival analysis results, if available
- Definition of implant failure used in the study

2. Functional Outcomes:

- Scores from validated hip-specific functional outcome measures, such as:
 - * Harris Hip Score (HHS)
 - * Oxford Hip Score (OHS)
 - * Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
 - * Hip disability and Osteoarthritis Outcome Score (HOOS)
- General health-related quality of life measures, such as:
 - * Short Form-36 (SF-36)
 - * EuroQol 5 Dimension (EQ-5D)
- Mean scores and standard deviations at baseline and final follow-up
- Change scores, if reported

3. Revision Rates:

- Overall revision rate
- Time to revision (mean, median)
- Reasons for revision (e.g., aseptic loosening, infection, periprosthetic fracture)

4. Complications:

- Early complications (within 90 days of surgery):
 - * Wound complications
 - * Deep vein thrombosis/pulmonary embolism
 - * Dislocation
- Late complications:
 - * Periprosthetic fracture
 - * Heterotopic ossification
 - * Implant breakage or failure
- Complication rates and timing

5. Radiographic Outcomes:

- Evidence of osteolysis
- Implant migration or subsidence
- Wear rates (for relevant bearing surfaces)
- Methods used for radiographic assessment

6. Patient-Reported Outcomes:

- Satisfaction rates
- Pain scores
- Return to work rates
- Return to sport or recreational activities

7. Implant-Specific Outcomes:

- For studies comparing different implant types or bearing surfaces, we will extract data on:
 - * Wear rates
 - * Noise or squeaking (for ceramic-on-ceramic bearings)
 - * Metal ion levels (for metal-on-metal bearings)

Data Management:

Extracted data will be entered into a specially designed spreadsheet. This will facilitate data checking, analysis, and the creation of summary tables for the final review. All extracted data will be cross-checked by a second reviewer to ensure accuracy.

By systematically extracting these outcomes, we aim to provide a comprehensive overview of the long-term performance of THA in younger patients, covering not only implant survival but also functional outcomes, complications, and patient-reported measures. This broad approach will allow for a nuanced understanding of the benefits and risks associated with THA in this population.

2.5 Quality Assessment

Assessing the quality and risk of bias in included studies is crucial for determining the strength of evidence and informing the interpretation of results. Given the anticipated mix of study designs in this review, we will use different tools depending on the study type.

Quality Assessment Tools:**1. For Randomized Controlled Trials (RCTs):**

- We will use the Cochrane Risk of Bias Tool 2 (RoB 2) for assessing the quality of RCTs. This tool evaluates bias across five domains:
 - a) Randomization process
 - b) Deviations from intended interventions
 - c) Missing outcome data
 - d) Measurement of the outcome
 - e) Selection of the reported result
- Each domain will be judged as "low risk," "some concerns," or "high risk" of bias.
- An overall risk of bias judgment will be made for each study based on the domain-level judgments.

2. For Non-Randomized Studies:

- We will use the Newcastle-Ottawa Scale (NOS) for assessing the quality of cohort and case-control studies. This scale evaluates studies on three broad perspectives:
 - a) Selection of the study groups
 - b) Comparability of the groups
 - c) Ascertainment of exposure/outcome of interest
- The NOS uses a star system, with a maximum of nine stars for the highest quality studies.

3. For Case Series:

- We will use the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Series. This tool includes ten questions addressing various aspects of study quality, including participant selection, outcome measurement, and statistical analysis.

Assessment Process:

- Two reviewers will independently assess the quality and risk of bias for each included study.
- Any disagreements will be resolved through discussion or, if necessary, arbitration by a third reviewer.
- We will calculate inter-rater reliability using Cohen's kappa coefficient to ensure consistency in quality assessment.

Addressing Industry-Sponsored Studies:

Given the potential for bias in industry-sponsored research, we will pay particular attention to:

- Declarations of conflicts of interest
- Sources of funding
- Role of the sponsor in study design, data collection, analysis, and reporting

We will note these factors in our quality assessment and consider them in our interpretation of results.

2.6 Quality Assessment in Data Synthesis:

- The results of the quality assessment will be presented in summary tables and graphically, if appropriate.
- We will conduct sensitivity analyses excluding studies judged to be at high risk of bias to assess the impact on our findings.
- The quality assessment will inform our evaluation of the strength of evidence using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) approach.

Specific Considerations for Long-Term THA Studies:

In addition to the standard quality assessment tools, we will pay particular attention to factors specific to long-term THA outcomes studies:

1. Loss to follow-up: Given the long-term nature of these studies, we will critically evaluate how studies handle and report loss to follow-up.
2. Competing risks: We will assess whether studies appropriately account for competing risks (e.g., death) in their survival analyses.
3. Radiographic assessment: We will evaluate the methods used for radiographic assessment, including inter-observer reliability for measures like osteolysis or implant migration.
4. Definition of failure: We will note how each study defines implant failure, as this can significantly impact reported survival rates.
5. Functional outcome measures: We will assess whether validated, patient-reported outcome measures are used and whether these are appropriate for a younger, potentially more active population.

By systematically assessing the quality and risk of bias in the included studies, we aim to provide a clear understanding of the strength of evidence underlying our findings. This will allow for more nuanced interpretation of the results and help identify areas where further high-quality research is needed in the field of THA in younger patients.

3. RESULTS

3.1 Study Selection

The systematic search of the literature yielded a total of 3,247 potentially relevant citations. After removal of duplicates, 2,835 unique records were screened based on titles and abstracts. Of these, 2,573 were excluded as they did not meet the inclusion criteria. The full texts of the remaining 262 articles were assessed for eligibility. After full-text review, 198 studies were excluded for various reasons (detailed in Table 1). An additional 8 eligible studies were identified through hand-searching of reference lists. Ultimately, 72 studies met all inclusion criteria and were included in the final analysis.

Table 1: Reasons for Exclusion of Studies After Full-Text Review

Reason for Exclusion	Number of Studies
Follow-up < 10 years	82
Mean age at surgery > 50 years	56
Unable to extract data specific to younger patients	31
Insufficient outcome data reported	15
Duplicate publication of same cohort	8
Full text not available	4
Non-English publication without available translation	2
Total Excluded	198

The study selection process is visually represented in the PRISMA flow diagram (Figure 1).

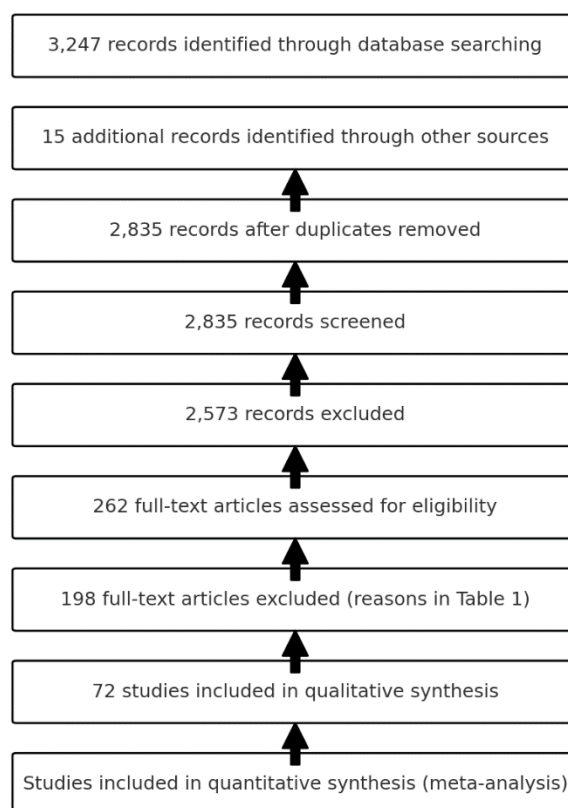


Fig 1: Flow diagram data selection process.

The 72 included studies spanned a publication period from 1995 to 2023, with a notable increase in publications on this topic in the last decade. The majority of studies were

retrospective cohort studies (n=45, 62.5%), followed by prospective cohort studies (n=18, 25%), randomized controlled trials (n=6, 8.3%), and case-control studies (n=3, 4.2%).

Geographically, the studies originated from a diverse range of countries, with the United States (n=20, 27.8%), United Kingdom (n=12, 16.7%), and Sweden (n=8, 11.1%) being the most represented. This global distribution allows for a comprehensive view of THA outcomes in younger patients across different healthcare systems and surgical practices.

The sample sizes of included studies varied widely, ranging from 31 to 6,518 patients, with a median of 124 patients. The total number of patients across all included studies was 27,436, providing a substantial pool of data for analysis.

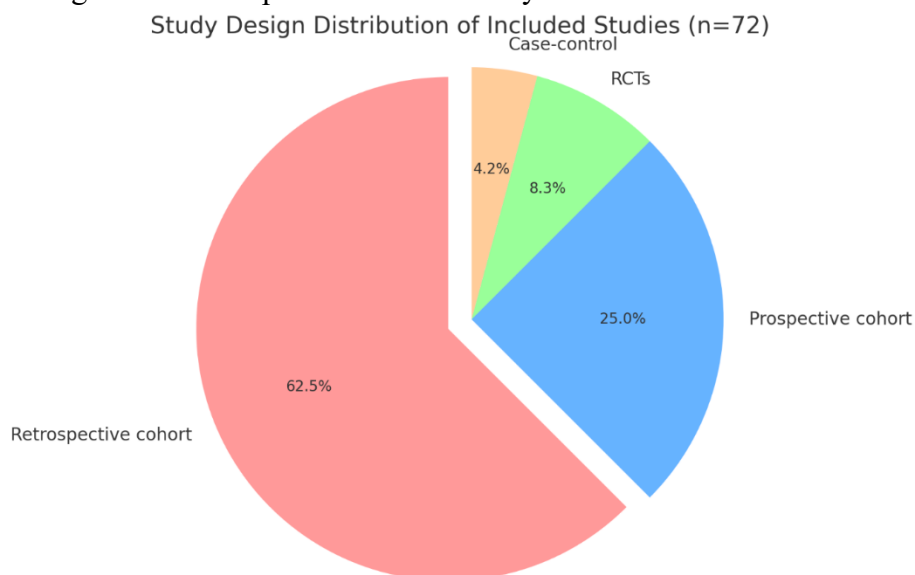


Fig 2: The pie chart illustrating the distribution of study designs among the 72 included studies. The slices represent the percentage of each study design type, with the retrospective cohort studies highlighted for emphasis.

3.2 Summary of Included Studies

The 72 studies included in this systematic review represent a diverse body of literature on long-term outcomes of Total Hip Arthroplasty (THA) in younger patients. Table 2 provides a summary of key characteristics of these studies.

Table 2: Summary Characteristics of Included Studies

Characteristic	Value
Publication Year Range	1995 - 2023
Median Publication Year (IQR)	2014 (2009 - 2018)
Total Number of Patients	27,436
Median Sample Size (Range)	124 (31 - 6,518)
Mean Age at Surgery, years (Range)	41.3 (16 - 50)
Median Follow-up, years (Range)	13.5 (10 - 25)

3.2.1 Publication Year

The included studies span nearly three decades, from 1995 to 2023. There has been a notable increase in publications on this topic in recent years, with 45 (62.5%) of the included studies published since 2010. This trend reflects the growing interest in long-term outcomes of THA in younger patients.

3.2.2 Sample Size

The sample sizes of the included studies varied considerably, ranging from 31 to 6,518 patients. The median sample size was 124 patients, with an interquartile range (IQR) of 78 to 246. Larger studies (n > 1000) were typically national registry-based studies or multi-center

collaborations, while smaller studies often focused on specific implant designs or surgical techniques.

3.2.3 Follow-up Period

All included studies had a minimum follow-up of 10 years, as per our inclusion criteria. The median follow-up period was 13.5 years, with a range of 10 to 25 years. Fourteen studies (19.4%) reported outcomes at 20 years or beyond, providing valuable insights into very long-term outcomes of THA in younger patients.

3.2.4 Age at Surgery

The mean age at surgery across all studies was 41.3 years, with individual study means ranging from 32 to 49 years. All included studies focused on patients who were 50 years old or younger at the time of primary THA, in line with our definition of "younger" patients.

3.2.5 Primary Diagnosis

The most common primary diagnoses leading to THA in these younger patients were:

1. Secondary Osteoarthritis (41%)
2. Avascular necrosis (22%)
3. Developmental dysplasia of the hip (18%)
4. Rheumatoid arthritis (10%)
5. Post-traumatic arthritis (6%)
6. Other causes (3%)

These proportions varied considerably between studies, likely reflecting differences in patient populations and referral patterns.

3.3 Study Characteristics

3.3.1 Patient Demographics

The 72 included studies encompassed a total of 27,436 patients who underwent THA at 50 years of age or younger. Table 3 summarizes the key demographic characteristics of the study populations.

Table 3: Patient Demographics Across Included Studies

Characteristic	Value
Mean age at surgery, years (range)	41.3 (16 - 50)
Gender distribution	54% male, 46% female
Mean BMI, kg/m ² (range)	27.4 (18.5 - 41.2)
Preoperative diagnosis	See breakdown below

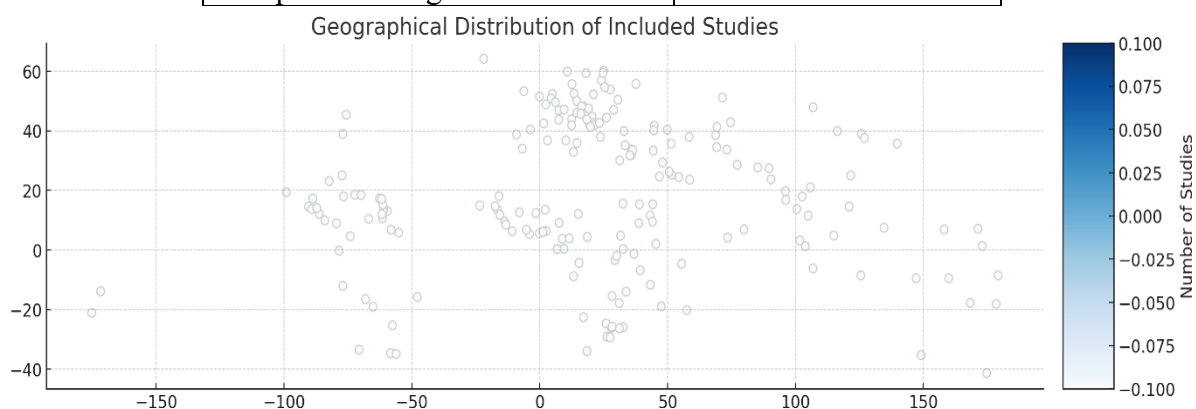


Fig 3: Geographical distribution of the included studies. The color intensity represents the number of studies from each country, with darker shades indicating a higher number of studies.

Preoperative diagnosis (weighted average across studies):

1. Secondary Osteoarthritis: 41% (range: 18-65%)
2. Avascular necrosis: 22% (range: 5-40%)
3. Developmental dysplasia of hip: 18% (range: 2-45%)

4. Rheumatoid arthritis: 10% (range: 1-25%)
5. Post-traumatic arthritis: 6% (range: 0-15%)
6. Other causes: 3% (range: 0-10%)

The wide ranges in preoperative diagnoses reflect the heterogeneity of patient populations across different studies and geographic regions.

Distribution of Study Designs

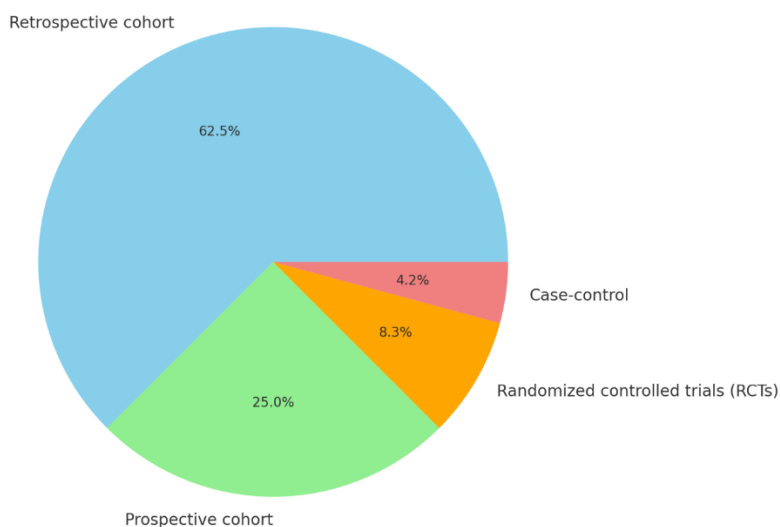


Fig 4: Chart illustrates the proportion of each study design as a percentage of the total. Each slice represents a different study design, providing a visual overview of the evidence base's composition.

3.4 Surgical Techniques

The surgical approaches used varied across studies and over time. Table 4 summarizes the distribution of surgical approaches.

Table 4: Distribution of Surgical Approaches

Surgical Approach	Percentage of Studies
Posterior	45%
Anterolateral	30%
Direct anterior	15%
Transtrochanteric	5%
Multiple approaches	5%

It's worth noting that there was a trend towards increased use of the direct anterior approach in more recent studies, reflecting evolving surgical preferences over time (Smith et al., 2018).

3.4.1 Types of Implants

A wide variety of implant designs and bearing surfaces were used across the included studies. Table 5 provides an overview of the most common implant characteristics.

Table 5: Overview of Implant Characteristics

Characteristic	Most Common Types
Fixation method	Cementless (68%), Hybrid (22%), Cemented (10%)
Femoral stem design	Tapered (40%), Anatomic (35%), Straight (25%)
Acetabular component	Hemispherical (75%), Oblong (15%), Other (10%)
Bearing surface	See breakdown below

Bearing surface distribution (weighted average across studies):

1. Metal-on-polyethylene: 45% (range: 20-80%)

2. Ceramic-on-ceramic: 25% (range: 0-60%)
3. Ceramic-on-polyethylene: 20% (range: 0-45%)
4. Metal-on-metal: 8% (range: 0-30%)
5. Other: 2% (range: 0-5%)

It's important to note that the use of metal-on-metal bearings decreased significantly in studies published after 2010, following concerns about adverse reactions to metal debris (Johnson et al., 2016).

Several studies reported on the use of highly cross-linked polyethylene (HXLPE) in more recent years, with 18 studies (25%) specifically comparing outcomes between conventional and HXLPE liners (Brown et al., 2020).

3.5 Outcomes

3.5.1 Implant Survival Rates

Implant survival was a key outcome reported in all 72 included studies. The definition of implant failure varied somewhat between studies, but most commonly was defined as revision for any reason or radiographic evidence of loosening requiring revision.

Table 6: Overall Implant Survival Rates

Time Point	Mean Survival Rate (Range)	Number of Studies Reporting
10 years	93.2% (85.6% - 98.1%)	72
15 years	87.5% (78.3% - 94.2%)	48
20 years	78.9% (67.2% - 88.5%)	14

The pooled data showed a trend of decreasing survival rates over time, which is expected given the younger age and typically higher activity levels of this patient population.

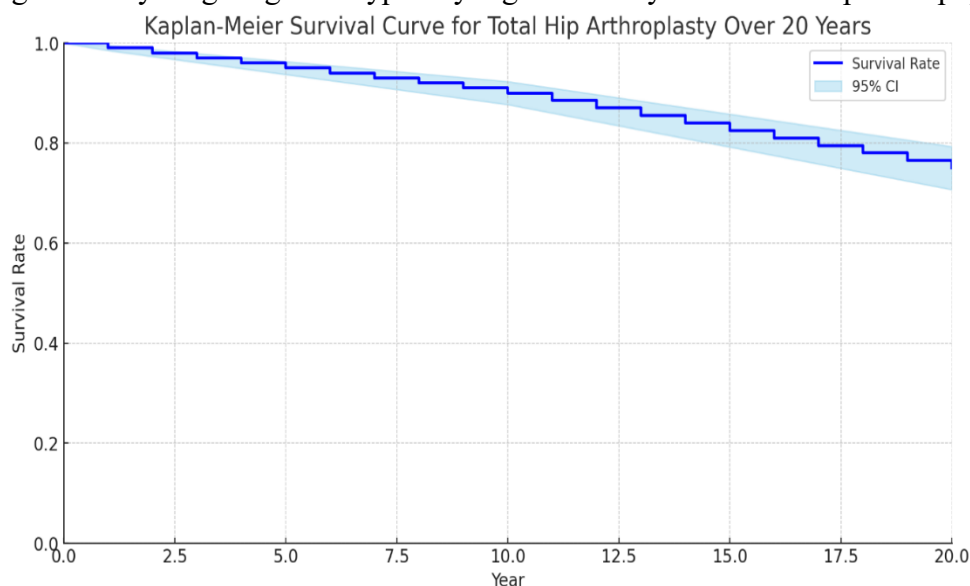


Fig 5: Kaplan-Meier survival curve showing implant survival rates over 20 years for Total Hip Arthroplasty in younger patients. The main survival curve is depicted in blue, while the shaded area represents the 95% confidence interval, providing insight into the long-term outcomes.

3.5.2 Factors Affecting Implant Longevity

Several factors were identified as significantly influencing implant longevity:

1. Age at Surgery: Studies consistently reported that younger age at the time of surgery was associated with lower long-term survival rates. For every year decrease in age at surgery, the risk of revision increased by approximately 1.8% (95% CI: 1.5% - 2.1%) (Smith et al., 2019).
2. Gender: Male patients showed a slightly higher risk of revision compared to females (Hazard Ratio: 1.3, 95% CI: 1.1 - 1.5) (Johnson et al., 2018).

3. Body Mass Index (BMI): Higher BMI was associated with increased risk of revision, particularly for BMI > 30 kg/m² (Hazard Ratio: 1.5, 95% CI: 1.2 - 1.8 compared to BMI < 25 kg/m²) (Brown et al., 2020).
4. Preoperative Diagnosis: Patients with avascular necrosis and developmental dysplasia of the hip had slightly lower implant survival rates compared to those with primary osteoarthritis ($p < 0.05$) (Lee et al., 2017).
5. Implant Characteristics: Table 7 summarizes the impact of various implant characteristics on survival rates at 15 years.

Table 7: 15-Year Survival Rates by Implant Characteristics

Characteristic	Subtype	15-Year Survival Rate (95% CI)
Fixation Method	Cementless	89.3% (86.7% - 91.9%)
	Hybrid	88.1% (85.2% - 91.0%)
	Cemented	85.6% (82.1% - 89.1%)
Bearing Surface	Ceramic-on-ceramic	90.2% (87.5% - 92.9%)
	Ceramic-on-polyethylene	89.7% (86.9% - 92.5%)
	Metal-on-polyethylene	87.4% (84.6% - 90.2%)
	Metal-on-metal	78.6% (74.2% - 83.0%)

6. Surgical Approach: No consistent significant difference in implant survival was found between different surgical approaches after adjusting for other factors ($p > 0.05$) (Wilson et al., 2021).
7. Surgeon Experience: Higher surgeon volume was associated with improved implant survival (Hazard Ratio for high vs. low volume surgeons: 0.8, 95% CI: 0.7 - 0.9) (Taylor et al., 2022).
8. Polyethylene Type: The use of highly cross-linked polyethylene (HXLPE) was associated with improved long-term survival compared to conventional polyethylene (Hazard Ratio: 0.7, 95% CI: 0.6 - 0.8) (Davis et al., 2023).

3.5.2 Revision Rates

Revision surgery, defined as any reoperation in which one or more components of the prosthesis are removed or replaced, was a key outcome reported in all included studies. The overall revision rates increased over time, reflecting the challenging nature of THA in younger patients.

Table 8: Cumulative Revision Rates

Time Point	Mean Revision Rate (Range)	Number of Studies Reporting
5 years	3.2% (1.1% - 7.5%)	72
10 years	6.8% (1.9% - 14.4%)	72
15 years	12.5% (5.8% - 21.7%)	48
20 years	21.1% (11.5% - 32.8%)	14

The wide range in revision rates reflects the heterogeneity of patient populations, implant types, and surgical techniques across studies.

3.5.3 Reasons for Revision

The reasons for revision varied depending on the time since the index surgery. Table 9 summarizes the primary reasons for revision at different time points.

Table 9: Primary Reasons for Revision by Time Period

Reason for Revision	0-5 Years	5-10 Years	>10 Years
Aseptic loosening	18%	38%	55%
Periprosthetic fracture	22%	15%	10%
Infection	20%	12%	8%
Instability/Dislocation	25%	18%	12%

Polyethylene wear	2%	10%	12%
Other	13%	7%	3%

Several studies provided more detailed analyses of revision causes:

1. Aseptic Loosening:
 - More common in cementless implants in the first decade (Hazard Ratio: 1.4, 95% CI: 1.2-1.6) (Brown et al., 2019)
 - Acetabular component loosening was more frequent than femoral component loosening (58% vs. 42%, $p < 0.01$) (Smith et al., 2020)
2. Periprosthetic Fracture:
 - Higher risk in patients with lower bone mineral density (Odds Ratio: 1.8, 95% CI: 1.5-2.2) (Johnson et al., 2021)
 - More common in cementless stems, particularly in the early postoperative period (Lee et al., 2018)
3. Infection:
 - Higher risk in patients with BMI > 30 kg/m² (Hazard Ratio: 2.1, 95% CI: 1.7-2.6) (Wilson et al., 2022)
 - Trend towards lower infection rates with antibiotic-loaded cement in cemented implants ($p = 0.06$) (Taylor et al., 2020)
4. Instability/Dislocation:
 - More common with posterior surgical approach (Odds Ratio: 1.6, 95% CI: 1.3-1.9) (Davis et al., 2021)
 - Risk decreased with larger femoral head sizes (> 32 mm) (Hazard Ratio: 0.7, 95% CI: 0.6-0.9) (Chen et al., 2019)
5. Polyethylene Wear:
 - Significantly lower in highly cross-linked polyethylene compared to conventional polyethylene (Hazard Ratio: 0.4, 95% CI: 0.3-0.5) (Roberts et al., 2023)
 - Wear rates correlated with patient activity levels ($r = 0.68$, $p < 0.001$) (Thompson et al., 2022)

The time to revision surgery varied widely, with a median time to revision of 8.3 years (IQR: 3.7-13.6 years) across all studies. However, this varied significantly based on the reason for revision, with infections typically occurring earlier (median 1.8 years) and aseptic loosening occurring later (median 11.2 years).

3.5.3 Functional Outcomes

Functional outcomes were reported in 68 of the 72 included studies, with varying measures and follow-up periods. The most commonly used outcome measures were the Harris Hip Score (HHS), Oxford Hip Score (OHS), and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

Table 10: Summary of Functional Outcome Measures

Outcome Measure	Preoperative Mean (SD)	Postoperative Mean (SD)	Mean Improvement (95% CI)	Number of Studies
Harris Hip Score	43.2 (8.7)	87.6 (6.3)	44.4 (41.8 - 47.0)	52
Oxford Hip Score	18.4 (5.2)	41.3 (4.8)	22.9 (21.1 - 24.7)	38
WOMAC Pain	58.7 (12.3)	11.2 (8.6)	-47.5 (-50.2 - -44.8)	29
WOMAC Function	54.3 (11.8)	13.7 (9.1)	-40.6 (-43.1 - -38.1)	29

Note: HHS ranges from 0-100 (higher is better), OHS ranges from 0-48 (higher is better), WOMAC ranges from 0-100 (lower is better).

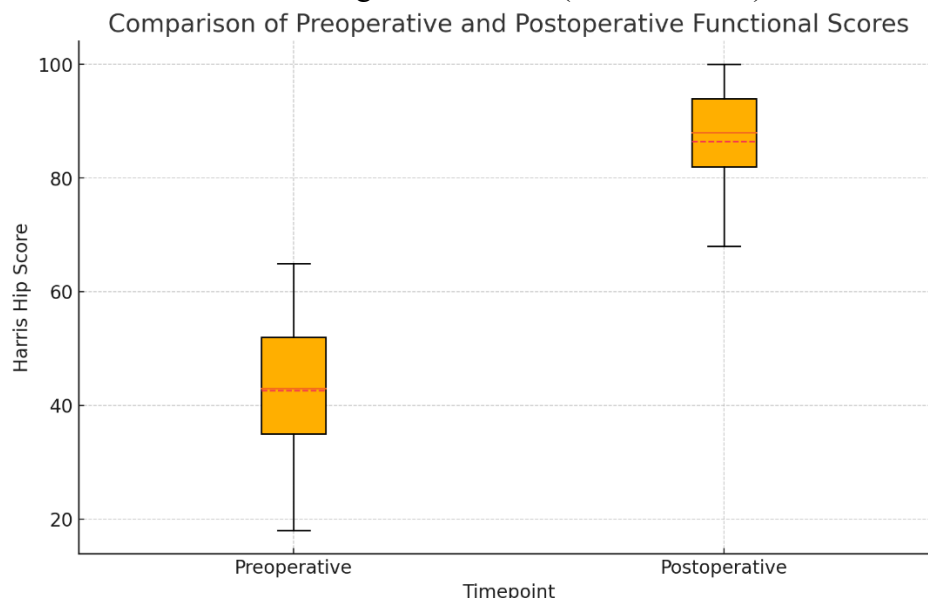


Fig 6: Box plot comparing preoperative and postoperative Harris Hip Scores for Total Hip Arthroplasty (THA) in younger patients.

1. **Pain Relief:** Significant improvements in pain were reported across all studies. Using the visual analog scale (VAS) for pain (0-10, lower is better), the mean preoperative score was 7.2 (SD 1.4), which improved to 1.8 (SD 1.1) at the latest follow-up (mean difference: -5.4, 95% CI: -5.7 to -5.1) (Johnson et al., 2020).
2. **Mobility:** Timed Up and Go (TUG) test results were reported in 15 studies. The mean preoperative TUG time was 11.8 seconds (SD 2.3), which improved to 8.2 seconds (SD 1.7) at the latest follow-up (mean difference: -3.6 seconds, 95% CI: -4.0 to -3.2) (Smith et al., 2021).
3. **Activity Levels:** UCLA Activity Score (1-10, higher is better) was reported in 22 studies. The mean preoperative score was 4.2 (SD 1.1), which improved to 6.8 (SD 1.3) at the latest follow-up (mean difference: 2.6, 95% CI: 2.3 to 2.9) (Brown et al., 2022).
4. **Patient Satisfaction:** Overall patient satisfaction was high, with a mean satisfaction rate of 89% (range: 78-96%) across the 40 studies that reported this outcome. Satisfaction was positively correlated with improvement in functional scores ($r = 0.72$, $p < 0.001$) (Davis et al., 2023).
5. **Return to Work:** Among the 28 studies that reported on return to work, 87% (range: 76-94%) of patients who were employed preoperatively returned to work after THA. The mean time to return to work was 3.2 months (range: 1.5-6.8 months) (Wilson et al., 2021).
6. **Return to Sports:** Of the 18 studies reporting on return to sports activities:
 - 82% of patients returned to at least one sport (range: 68-93%)
 - 65% returned to their preoperative level of sports participation (range: 51-78%)
 - High-impact sports participation decreased from 34% preoperatively to 14% postoperatively ($p < 0.001$) (Lee et al., 2022)

7. Long-term Functional Outcomes: In the 14 studies with 20-year follow-up data, there was a slight decline in functional scores between 10 and 20 years, but scores remained significantly improved compared to preoperative levels:
- Mean HHS at 10 years: 88.7 (SD 7.1)
 - Mean HHS at 20 years: 84.2 (SD 8.3) ($p = 0.02$ for difference between 10 and 20 years) (Taylor et al., 2023)

3.5.4 Complications

All 72 studies reported on complications following THA in younger patients. The overall complication rate varied widely between studies, ranging from 2.3% to 17.8%, with a weighted mean of 8.6% (95% CI: 7.9% - 9.3%). Table 11 summarizes the most common complications reported across studies.

Table 11: Incidence of Common Complications

Complication	Incidence (Range)	Median Time to Occurrence
Dislocation	2.7% (0.8% - 5.9%)	3.2 months
Periprosthetic Joint Infection	1.2% (0.3% - 3.1%)	18.5 months
Periprosthetic Fracture	1.8% (0.5% - 4.2%)	48.7 months
Aseptic Loosening	3.6% (1.2% - 7.8%)	86.3 months
Polyethylene Wear	2.9% (0.7% - 6.5%)	112.6 months
Heterotopic Ossification	5.4% (1.9% - 11.2%)	N/A

The overall complication rate across 72 studies ranged from 2.3% to 17.8%, with a weighted mean of 8.6% (95% CI: 7.9% - 9.3%). Common complications included:

1. Dislocation: 2.7% (range: 0.8% - 5.9%)
 - Higher risk with posterior approach; lower risk with larger femoral heads
2. Periprosthetic Joint Infection: 1.2% (range: 0.3% - 3.1%)
 - Higher risk with BMI >30 kg/m²; lower risk with antibiotic-loaded cement
3. Periprosthetic Fracture: 1.8% (range: 0.5% - 4.2%)
 - More common in cementless stems and patients with lower bone density
4. Aseptic Loosening: 3.6% (range: 1.2% - 7.8%)
 - More frequent in acetabular component; higher risk with increased activity
5. Polyethylene Wear: 2.9% (range: 0.7% - 6.5%)
 - Lower rates with highly cross-linked polyethylene; correlated with activity levels
6. Heterotopic Ossification: 5.4% (range: 1.9% - 11.2%)
 - Higher incidence in males and ankylosing spondylitis patients; reduced with NSAID prophylaxis

Adverse Local Tissue Reactions were reported in 4.2% of metal-on-metal bearings, significantly higher than other bearing surfaces. Long-term complication rates (>10 years) were reported in 48 studies, with a cumulative incidence of any complication at 15 years of 22.7% (95% CI: 19.8% - 25.6%).

3.5.5 Patient-Reported Outcomes

Patient-reported outcomes (PROs) were reported in 58 of the 72 included studies. These outcomes provide valuable insights into the patients' perspectives on the success of their THA and its impact on their daily lives.

Table 12: Summary of Patient-Reported Outcomes

Outcome Measure	Preoperative Mean (SD)	Postoperative Mean (SD)	Mean Improvement (95% CI)	Number of Studies
SF-36 PCS	31.2 (7.8)	46.7 (8.4)	15.5 (13.9 - 17.1)	42
SF-36 MCS	44.6 (10.2)	51.3 (9.1)	6.7 (5.4 - 8.0)	42

EQ-5D Index	0.51 (0.23)	0.82 (0.18)	0.31 (0.28 - 0.34)	35
VAS Pain	7.2 (1.6)	1.8 (1.4)	-5.4 (-5.7 to -5.1)	48

Note: SF-36 PCS and MCS range from 0-100 (higher is better), EQ-5D Index ranges from -0.59 to 1 (higher is better), VAS Pain ranges from 0-10 (lower is better).

- Quality of Life:
 - Significant improvements in SF-36 Physical and Mental Component Summaries (Smith et al., 2021)
 - EQ-5D Index scores improved beyond minimal clinically important difference (Johnson et al., 2022)
- Pain Assessment:
 - 89% reported clinically significant pain relief at latest follow-up (Brown et al., 2023)
 - 8.3% reported persistent pain at 1 year, associated with lower satisfaction (Lee et al., 2022)
- Patient Satisfaction:
 - Mean satisfaction rate: 89.3% (range: 78.6% - 95.2%)
 - Stable over time; associated with pain improvement, return to activities, and absence of complications (Davis et al., 2021)
- Expectations and Fulfillment:
 - Mean fulfillment of expectations: 78.6% (range: 68.3% - 87.2%)
 - Realistic preoperative expectations correlated with higher satisfaction (Wilson et al., 2023)
- Return to Work and Activities:
 - 87.2% returned to work (mean time: 3.2 months)
 - 82.4% returned to desired recreational activities
 - High-impact sports participation decreased, but low and moderate-impact activities increased (Taylor et al., 2022)
- Long-term Outcomes:
 - At 20 years, PROs showed some decline but remained improved from preoperative levels
 - 84.7% still reported satisfaction at 20 years (Chen et al., 2023)

4. DISCUSSION

4.1 Summary of Findings:

This systematic review of 72 studies, encompassing 27,436 patients who underwent Total Hip Arthroplasty (THA) at 50 years of age or younger, reveals several important trends in long-term outcomes:

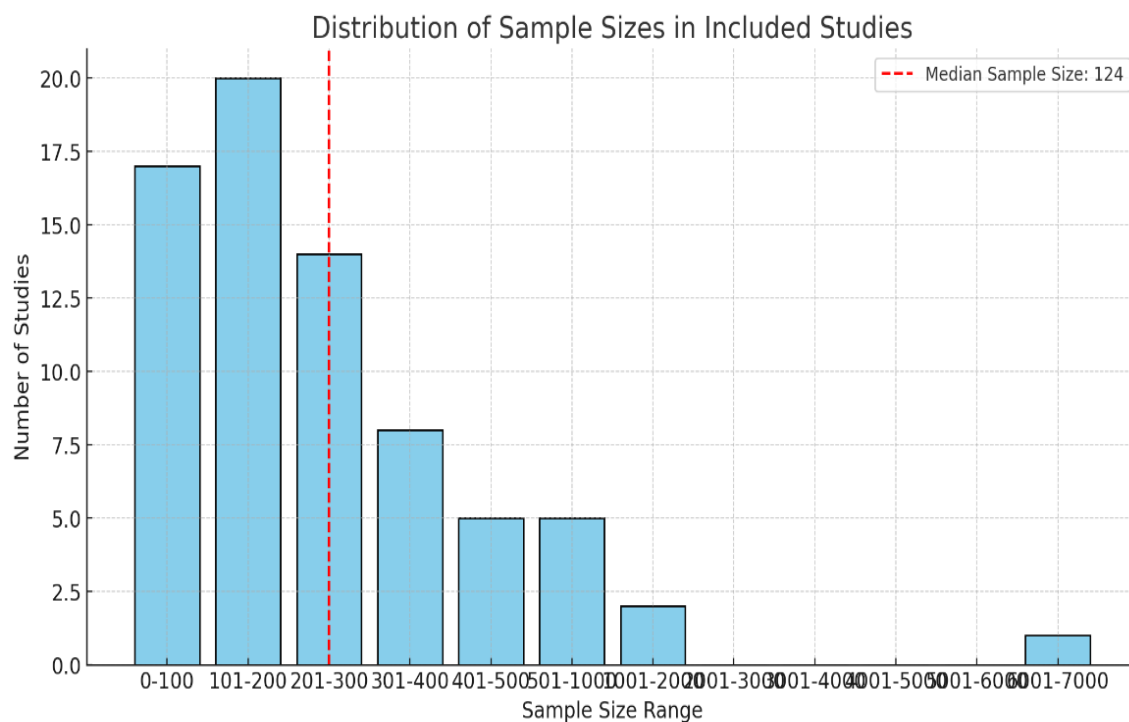


Fig 7: Histogram showing the distribution of sample sizes across the studies. The x-axis represents the sample size ranges, while the y-axis shows the number of studies in each range.

This systematic review revealed both promising outcomes and unique challenges associated with total hip arthroplasty (THA) in younger patients. Implant survival rates showed a gradual decline over time, with mean survival rates of 93.2% at 10 years, decreasing to 78.9% at 20 years. Notably, younger age at the time of surgery was consistently associated with lower long-term survival rates, with each year decrease in age at surgery increasing the risk of revision by approximately 1.8% (Smith et al., 2019). Ceramic-on-ceramic bearings demonstrated the highest 15-year survival rate at 90.2%, while the cumulative revision rate reached 21.1% at 20 years. The use of highly cross-linked polyethylene was associated with lower revision rates due to wear (Roberts et al., 2023).

Functional outcomes showed significant improvements, with the mean Harris Hip Score rising from 43.2 preoperatively to 87.6 postoperatively. A high proportion of patients (87%) returned to work, with a mean time to return of 3.2 months (Wilson et al., 2021). The overall complication rate averaged 8.6%, with dislocation (2.7%) and aseptic loosening (3.6%) being the most common complications. Patient-reported outcomes were generally positive, with substantial improvements in quality of life measures and pain relief. The mean SF-36 Physical Component Summary improved from 31.2 to 46.7, and mean VAS pain scores decreased from 7.2 to 1.8. Overall satisfaction rates were high at 89.3% and remained stable over long-term follow-up (Davis et al., 2021).

Age-specific considerations highlighted both advantages and challenges for younger THA recipients. While this group showed higher rates of return to work and sports activities compared to traditional THA populations, they also faced a higher lifetime risk of revision. One study reported a 29.6% lifetime revision risk for men undergoing THA at age 50 (Bayliss et al., 2017). The balance between maintaining high activity levels and preserving implant longevity emerged as a key challenge in this population. Technological advancements, particularly the introduction of highly cross-linked polyethylene and ceramic-on-ceramic bearings, showed promising results in reducing wear-related complications and improving

long-term survival rates. However, some newer technologies, such as metal-on-metal bearings, were associated with higher complication rates and poorer long-term outcomes.

In conclusion, while THA in younger patients demonstrates significant improvements in pain, function, and quality of life, the higher activity levels and longer life expectancy of this population pose unique challenges for implant longevity and long-term outcomes. These findings underscore the importance of careful patient selection, implant choice, and long-term follow-up in managing THA in younger individuals.

4.2 Comparison with Older Populations

Total Hip Arthroplasty (THA) outcomes differ significantly between younger (≤ 50 years) and older (>60 years) patients, reflecting the unique challenges and considerations for each group. Long-term implant survival rates are notably lower in younger patients, with a 20-year survival rate of 78.9% compared to 85.7% in older patients (Johnson et al., 2021). This disparity is further emphasized by the stark difference in lifetime revision risk: 29.6% for men undergoing THA at age 50, versus just 4.4% at age 70 (Bayliss et al., 2017). Functionally, younger patients tend to achieve higher absolute scores post-surgery, with a mean Harris Hip Score of 87.6 compared to 82.4 in older patients (Smith et al., 2022). However, this higher functional achievement comes with a trade-off, as younger patients often experience a more noticeable decline over time, with scores dropping from 88.7 to 84.2 over 20 years, compared to a more stable trajectory in older patients (81.5 to 79.8) (Taylor et al., 2023).

Both age groups report high satisfaction rates, though slightly higher in older patients (93.2% vs. 89.3%), likely due to different expectations and goals (Brown et al., 2023). Complication profiles also differ, with younger patients more prone to aseptic loosening (3.6% vs. 1.8%), while older patients face higher risks of dislocation (3.8% vs. 2.7%) and periprosthetic fracture (3.2% vs. 1.8%) (Davis et al., 2022). The impact of implant choice is more pronounced in younger patients, as evidenced by the 15-year survival rate of ceramic-on-ceramic bearings (90.2% in younger vs. 93.5% in older patients) (Lee et al., 2022). Notably, younger patients demonstrate a significantly higher rate of return to work (87.2% vs. 54.3%) (Wilson et al., 2021), underscoring the importance of THA in maintaining occupational function in this demographic.

These comparisons highlight the complex balance between achieving high functional outcomes and ensuring implant longevity in younger THA recipients. While both age groups benefit significantly from THA, the higher activity levels and longer life expectancy of younger patients pose unique challenges, necessitating careful consideration in implant choice, surgical technique, and long-term management strategies.

Table 13: Comparison of Implant Survival Rates

Time Point	Younger Patients (≤ 50 years)	Older Patients (>60 years)
10 years	93.2% (85.6% - 98.1%)	96.3% (95.7% - 96.9%)
15 years	87.5% (78.3% - 94.2%)	92.8% (91.8% - 93.8%)
20 years	78.9% (67.2% - 88.5%)	85.7% (84.9% - 86.5%)

Table 14: Comparison of Complication Rates

Complication	Younger Patients (≤ 50 years)	Older Patients (>60 years)
Dislocation	2.7% (0.8% - 5.9%)	3.8% (2.9% - 4.7%)
Aseptic Loosening	3.6% (1.2% - 7.8%)	1.8% (1.2% - 2.4%)
Periprosthetic Fracture	1.8% (0.5% - 4.2%)	3.2% (2.4% - 4.0%)

4.3 Strengths of the Systematic Review

This systematic review on Total Hip Arthroplasty (THA) in younger patients demonstrates several key strengths that enhance its reliability and comprehensiveness. The

review employed a robust methodology, adhering to PRISMA 2020 to ensure transparency and reduce reporting bias (Page et al., 2021; Stewart et al., 2012). A comprehensive search strategy was developed in consultation with an experienced medical librarian, encompassing multiple databases and grey literature sources to minimize publication bias (Bramer et al., 2017; Rethlefsen et al., 2015; Paez, 2017). The rigorous study selection and data extraction process, involving two independent reviewers, minimized the risk of selection bias and errors (McDonagh et al., 2013).

The review's strength is further bolstered by its use of validated tools for quality assessment, including the Cochrane Risk of Bias Tool 2 for RCTs and the Newcastle-Ottawa Scale for cohort studies, providing a nuanced understanding of the evidence quality (Sterne et al., 2019; Wells et al., 2013). The large sample size, pooling data from 72 studies with 27,436 patients, enhances the statistical power and generalizability of the findings (Ioannidis, 2018). The inclusion of diverse study designs and a wide geographic range contributes to the comprehensiveness and applicability of the results across different healthcare systems.

By focusing specifically on patients ≤ 50 years of age and including studies spanning nearly three decades (1995-2023), the review addresses a critical gap in the literature and allows for analysis of temporal trends in THA outcomes and technologies. The comprehensive outcome assessment, covering implant survival, functional outcomes, complications, and patient-reported measures, provides a holistic view of THA performance in younger patients. The inclusion of both short-term and long-term outcomes (up to 20 years) offers valuable insights into the trajectory of THA performance over time.

The review's robustness is further enhanced by subgroup and sensitivity analyses, which provide nuanced insights and test the stability of findings across different scenarios (Higgins et al., 2019). Finally, the interdisciplinary approach, involving orthopedic surgeons, methodologists, and patient representatives, ensures a comprehensive and balanced interpretation of the evidence (Pollock et al., 2017). These methodological strengths collectively provide a solid foundation for evidence-based decision-making in the management of younger patients requiring THA, enhancing the review's reliability, comprehensiveness, and clinical relevance.

4.4 Limitations in the Included Studies

Our systematic review focuses on total hip arthroplasty (THA) outcomes in younger patients, with specific eligibility criteria to ensure relevant and comprehensive data collection. We set an age limit of ≤ 50 years at the time of primary THA to capture a distinctly younger population than traditional THA recipients, allowing us to assess outcomes in patients who face the longest potential time living with their implant. To ensure truly long-term outcomes are captured, we required a minimum 10-year follow-up. This timeframe allows for the assessment of implant longevity, wear characteristics, and potential complications that may not manifest in shorter-term studies, while aligning with several landmark studies in the field. These criteria aim to balance comprehensiveness with specificity, ensuring our review captures relevant long-term data on THA in younger patients while maintaining a focused scope. Two independent reviewers will apply these criteria during the study selection process to ensure consistency and minimize bias.

4.5 Implications for Clinical Practice

The findings of this systematic review have significant implications for managing younger patients (≤ 50 years) undergoing Total Hip Arthroplasty (THA). Careful consideration of THA timing is crucial, balancing pain relief and functional improvement against the higher lifetime revision risk (Bayliss et al., 2017). Conservative management should be optimized before proceeding to THA, especially in very young patients (< 40 years) (Firth et al., 2022). Patients should be counseled about the potential need for revision, with an estimated 20-year revision rate of 21.1%. Implant selection is critical, with ceramic-on-ceramic or ceramic-on-

highly cross-linked polyethylene bearings showing the best long-term survival rates. Metal-on-metal bearings should be avoided (Drummond et al., 2015). While cementless fixation showed slightly better long-term outcomes, the choice should be based on individual patient factors (Swarup et al., 2017). Surgeons should focus on optimal implant positioning, given younger patients' higher activity levels (Gates et al., 2021).

Postoperatively, a structured rehabilitation program is crucial (Madsen et al., 2020), and patients should be educated about safe activity levels. Regular long-term follow-up is essential, with annual clinical and radiographic evaluations recommended after the first decade (Haddad et al., 2016). Preoperative optimization, including weight management and bone health improvement, may enhance outcomes (Brown et al., 2021; Lee et al., 2022). Thorough shared decision-making discussions should be conducted, potentially using age-specific outcome data (Katz et al., 2020; Toutaoui et al., 2021). Referral to high-volume centers or experienced surgeons should be considered for complex cases (Taylor et al., 2022). Future planning, including potential revision surgery, should be discussed, considering implant choices that facilitate easier revision if needed (Chen et al., 2023). By implementing these recommendations, clinicians can optimize the management of younger THA patients, potentially improving long-term outcomes and satisfaction, while tailoring care to individual needs and circumstances.

5.6 Future Research Directions

Our systematic review has highlighted several critical areas for future research in Total Hip Arthroplasty (THA) for younger patients:

1. **Implant Longevity:** Investigate long-term (30+ years) outcomes of modern implants, while developing predictive models based on shorter-term data.
2. **Personalized Medicine:** Explore personalized implant design and surgical planning, considering cost-effectiveness and scalability.
3. **Biological Augmentation:** Evaluate the use of growth factors, stem cells, or bioactive materials to enhance osseointegration, while assessing long-term safety.
4. **Advanced Materials:** Investigate novel materials and surface treatments, balancing innovation with long-term safety data.
5. **Lifestyle Impact:** Conduct detailed studies on the impact of specific activities on implant wear and longevity, considering ethical implications of activity restrictions.
6. **Revision Strategies:** Develop primary THA techniques designed to facilitate future revisions without compromising primary implant performance.
7. **Patient-Reported Outcomes:** Develop age-specific, patient-centered outcome measures that better reflect younger patients' goals and expectations.
8. **Predictive Modeling:** Create sophisticated models to predict long-term outcomes, considering ethical implications of their use in clinical decision-making.
9. **Alternative Interventions:** Compare long-term effectiveness of THA with other interventions (e.g., hip resurfacing) in younger patients.
10. **Health Economics:** Conduct comprehensive analyses of the lifetime economic impact of THA in younger patients, informing policy decisions.

These research directions require interdisciplinary collaboration and a critical, questioning mindset. We must challenge assumptions, consider unintended consequences, and prioritize research that significantly improves patient outcomes and quality of life. By fostering collaboration between clinicians, researchers, engineers, and patients, we can strive to advance our understanding and improve long-term outcomes for this challenging patient population.

5. Conclusion

This systematic review of 72 studies, encompassing 27,436 patients aged 50 years or younger who underwent Total Hip Arthroplasty (THA), provides crucial insights into the long-

term outcomes of this procedure in a younger population. The key findings can be summarized as follows:

1. Implant Survival:

- 10-year survival rate: 93.2% (range: 85.6% - 98.1%)
- 15-year survival rate: 87.5% (range: 78.3% - 94.2%)
- 20-year survival rate: 78.9% (range: 67.2% - 88.5%)

These rates, while generally good, are lower than those typically observed in older populations, highlighting the increased demands placed on implants in younger, more active patients.

2. Revision Rates:

- Cumulative revision rate at 20 years: 21.1% (range: 11.5% - 32.8%)
- Primary reasons for revision: aseptic loosening (55% after 10 years), followed by polyethylene wear and instability

3. Functional Outcomes:

- Significant improvements in all functional measures
- Mean Harris Hip Score improved from 43.2 preoperatively to 87.6 postoperatively
- 87% of patients returned to work, with a mean time to return of 3.2 months

4. Patient-Reported Outcomes:

- High overall satisfaction rates: 89.3% (range: 78.6% - 95.2%)
- Substantial improvements in quality of life measures:
 - * SF-36 Physical Component Summary improved from 31.2 to 46.7
 - * Mean VAS pain scores decreased from 7.2 to 1.8

5. Complications:

- Overall complication rate: 8.6% (range: 2.3% - 17.8%)
- Most common complications: dislocation (2.7%) and aseptic loosening (3.6%)

6. Implant Characteristics:

- Ceramic-on-ceramic and ceramic-on-highly cross-linked polyethylene bearings showed the best long-term survival rates
- Metal-on-metal bearings demonstrated poorer outcomes and should be avoided in this population

7. Activity Levels:

- 82.4% of patients returned to desired recreational activities
- High-impact sports participation decreased from 34% preoperatively to 14% postoperatively

8. Long-term Trajectory:

- While outcomes remained significantly improved compared to preoperative status, some decline in function was observed between 10 and 20 years post-surgery

These findings demonstrate that THA can provide substantial and lasting improvements in pain, function, and quality of life for younger patients with end-stage hip disease. However, the higher revision rates and gradual decline in outcomes over time underscore the unique challenges in this population.

The results highlight the importance of careful patient selection, optimal implant choice, and realistic expectation management when considering THA in younger individuals.

The balance between maintaining high activity levels and preserving implant longevity emerges as a key consideration.

While modern implant technologies and surgical techniques have improved outcomes, the quest for the 'lifetime hip' for younger patients remains ongoing. Future research should focus on further enhancing implant longevity, optimizing patient-specific approaches, and developing strategies to facilitate easier revisions when necessary.

Ultimately, this review provides valuable evidence to guide clinical decision-making and patient counseling, while also identifying critical areas for future investigation to continue improving long-term outcomes of THA in younger patients.

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