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Success and Safety of Isolated Cup Revision Arthroplasty: A Systematic Review

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Abstract

Background: Isolated acetabular revision arthroplasty is increasingly performed as the number of primary total hip arthroplasties rises and implant longevity is challenged. Although this procedure avoids the morbidity associated with full-component revision, concerns remain regarding instability, osteolysis, and long-term implant survival. Previous reviews have not specifically synthesized clinical, radiological, and functional results of isolated acetabular revision based on implant type, surgical approach, and patient-related factors. The current review intends to summarize the clinical, radiological, and functional results of isolated acetabular revision surgeries while focusing on the effectiveness of different surgical approaches, implant types, and patient factors used to improve postoperative results.

Methods: A comprehensive search of PubMed, Scopus, Web of Science, Embase, and Cochrane Library was conducted from inception to January 2025. The entire review process adhered to PRISMA 2020 guidelines. Two independent reviewers conducted screening, critical appraisal, and data extraction. Eligibility criteria included adult patients undergoing isolated acetabular revision with a well-fixed femoral stem. Risk of bias was evaluated using RoB-2 for randomized trials and ROBINS-I for observational studies. Narrative synthesis was performed to integrate clinical, radiological, and survival outcomes.

Results: The initial search yielded 1154 records. Twelve studies met the inclusion criteria. Functional outcomes improved significantly (HHS increased from 48–50 to 86–88 across studies). Dislocation rates ranged from 0–7%, with lower rates in dual-mobility cups. Implant survival was 95–98% at 10–15 years.

Radiological evaluation demonstrated high rates of osteointegration and low rates of cup loosening among contemporary cementless implants. Long-term survival ranged from 95% to 98% at 10–15 years. Heterogeneity in study design, surgical approach, and implant type was observed, and the overall risk of bias was moderate.

Conclusion: Isolated acetabular revision arthroplasty provides significant functional improvement, reliable radiographic outcomes, and high implant survival when the femoral stem is stable. Modern cementless and dual-mobility components appear to reduce instability and enhance osteointegration. Further well-designed prospective studies with standardized outcome reporting are needed to refine indications and optimize long-term results.

Keywords: Hip Replacement, Reoperation, Treatment Outcome, Isolated Cup Revision Arthroplasty, Systematic Review

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Introduction

Isolated acetabular revision arthroplasty is commonly performed when failure of the acetabular component occurs while the femoral stem remains well fixed. As the number of primary total hip arthroplasties continues to rise and implant longevity is challenged by the aging population, the clinical demand for isolated acetabular revi-

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Key messages:

↑What is "already known" in this topic:

Isolated acetabular revision is performed when the cup fails, but the femoral stem remains stable. It is technically demanding and associated with complications such as instability, aseptic loosening, and osteolysis. Modern implants, including dual-mobility and porous-coated cups, have been introduced to improve stability and fixation.

→What this article adds:

This systematic review shows that isolated cup revision provides reliable functional improvement and high implant survival, with dislocation rates notably lower when dual-mobility cups are used. Radiologic outcomes and osteointegration were favorable with contemporary cementless designs. These findings support isolated cup revision as an effective and durable option.

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sions is increasing. Epidemiological studies report that revision surgery is required in approximately 10–15% of patients within 15 years after primary THA, highlighting the clinical burden of acetabular failure. This procedure addresses major complications such as aseptic loosening, polyethylene wear, osteolysis, malpositioning, and catastrophic failure of the acetabular component while preserving a stable femoral stem, thereby reducing surgical morbidity compared with full revision arthroplasty (1).

This procedure reduces morbidity compared with full revision arthroplasty because the femoral stem is preserved. However, it is technically demanding. Retention of the stem restricts surgical exposure and complicates cup positioning, bone defect management, and implant fixation. These limitations contribute to complications such as dislocation, wear, and progressive bone loss. Several studies have shown that instability may occur more frequently after isolated cup revision than after combined acetabular–femoral revision (2-4).

To mitigate these challenges, modern implant innovations such as dual-mobility cups and ceramic-on-ceramic bearings have been introduced, alongside advancements in surgical approaches. Evidence suggests that the anterolateral approach may reduce dislocation risk compared with posterior-based approaches (5-8).

Although numerous clinical studies have reported favorable functional and radiological outcomes after isolated acetabular revision, the available evidence remains heterogeneous. Prior reviews often combined isolated acetabular revisions with full-component revisions, limiting the ability to interpret outcomes specific to isolated procedures. Variations in implant type, bearing surfaces, surgical techniques, follow-up duration, and patient selection contribute to inconsistent findings across the literature. Consequently, a focused synthesis evaluating functional results, complication patterns, radiographic outcomes, and implant survival specifically in isolated acetabular revision—while also considering surgical approach and implant selection—has remained lacking. The present systematic review, therefore, aims to provide a comprehensive and structured evaluation of current evidence to better define expected outcomes and identify factors contributing to surgical success in isolated acetabular revision arthroplasty.

Methods

In this review, we specifically evaluated adults undergoing isolated acetabular revision (Population), receiving various acetabular implant types and surgical approaches (Intervention), with comparisons across approaches and implant designs (Comparison), focusing on functional outcomes, radiologic results, complications, and implant survival (Outcomes).

Data Sources and Search Strategy

A comprehensive search was conducted in bibliographic databases including PubMed, Scopus, Web of Science, Embase, and the Cochrane Library, supplemented by grey literature sources (OpenGrey, ProQuest Dissertations). Citation tracking, reference list scanning, journal handsearching, and expert consultation were also performed to minimize publication bias. Both controlled vocabulary (MeSH terms) and free-text keywords were used. Search terms were presented in continuous prose, for example: “isolated acetabular revision,” “acetabular cup revision,” “revision hip arthroplasty.” The search covered all years from database inception to January 2025. Full search strategies for PubMed and Embase are available from the first author. This systematic review was conducted in accordance with the PRISMA 2020 statement to ensure transparent and standardized reporting.

Study Selection

Preliminary screening was conducted based on titles and abstracts to identify potentially relevant studies. Full texts of eligible or unclear studies were subsequently retrieved. Two independent reviewers (A.Y. and J.K.M.) screened titles, abstracts, and full texts. Disagreements were resolved by consensus. Inter-rater agreement was calculated using Cohen’s kappa ($\kappa = 0.82$), indicating strong reliability.

The PRISMA 2020 workflow was followed, and a complete PRISMA flow diagram illustrating the study identification, screening, eligibility, and inclusion process is provided (Figure 1).

Inclusion/Exclusion Criteria

Eligible studies included adult patients undergoing isolated acetabular revision with retention of a well-fixed femoral stem. Interventions comprised cemented or cementless cups, hemispherical components, dual-mobility cups, or ceramic-on-ceramic bearings. Outcomes included Harris Hip Score (HHS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), radiographic findings (osteolysis, loosening, migration), complications, reoperation, and implant survival. Study designs included randomized controlled trials, cohort studies, and case series with ≥10 patients. Exclusion criteria were primary hip arthroplasty, combined acetabular–femoral revisions, incomplete outcome data, reviews, editorials, letters, and conference abstracts due to insufficient methodological detail.

Data Extraction

Data extraction was performed independently by two reviewers (A.Y. and J.K.M.) using customized Excel forms. Extracted variables included study characteristics (author, publication year, design, sample size, follow-up), patient demographics, Surgical approach (posterolateral, anterolateral, direct anterior), implant type (cementless vs. cemented cups, dual-mobility systems), use of grafts or cages, clinical outcomes (HHS, WOMAC, dislocation, infection, osteolysis, loosening), radiological outcomes (osteointegration, migration, cup stability), and reoperation data.

Risk of Bias Assessment

Risk of bias was assessed using RoB-2 for randomized controlled trials and ROBINS-I for observational studies. Each domain of bias (confounding, selection, intervention

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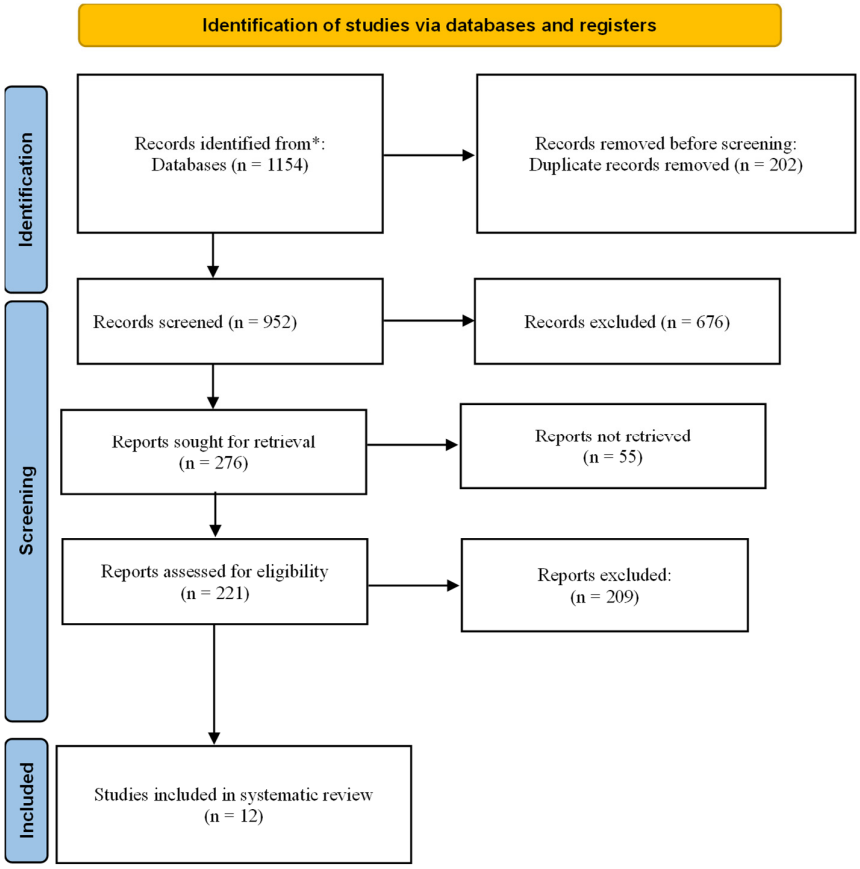

Figure 1. PRISMA flow diagram

classification, missing data, outcome measurement, reporting) was evaluated independently by two reviewers and described in continuous text.

Publication Bias

A narrative synthesis was performed to integrate clinical, radiological, and survival outcomes across heterogeneous study designs. Publication bias was assessed when ≥10 studies reported similar outcomes, using funnel plot analysis and qualitative evaluation of asymmetry. Limitations were discussed in the Discussion section rather than prematurely acknowledged in Methods.

Results

Search and Screening Process

A systematic search across PubMed, Scopus, Web of Science, Embase, and Cochrane Library initially identified 1154 articles. After removal of 202 duplicate records, a total of 952 unique studies were screened based on titles and abstracts. Following this phase, 276 studies were selected for full-text review. Of these, 55 articles could not be retrieved, and 221 full-text studies were assessed for eligibility. Ultimately, 12 studies satisfied all inclusion criteria and were incorporated into the final systematic review. These steps have been summarized according to PRISMA 2020 guidelines, with a detailed PRISMA flow diagram to reflect identification, screening, eligibility, and inclusion processes (Figure 1).

Patient Characteristics and Research Design

Across the included studies, patient demographics demonstrated considerable variability. Most patients undergoing isolated acetabular revision were between 60 and 80 years of age, consistent with typical revision arthroplasty cohorts. Mean age across studies ranged from 47.4 to 72.8 years. This reflects expected patterns of long-term implant wear, loosening, and failure that necessitate revision surgery.

The included studies consisted of 3 randomized controlled trials, 6 cohort studies, and 3 case series with ≥10 patients, mirroring the heterogeneity of available evidence in revision arthroplasty research. Follow-up duration varied markedly from 17 months to 15 years, affecting the comparability of long-term outcomes. For example, Hernigou et al. reported a 15-year follow-up, allowing meaningful assessment of long-term cup survival, whereas McLoughlin et al. reported a shorter 17-month follow-up, limiting interpretation of late complications and osteolysis progression (9, 2). A comprehensive table summarizing the design and characteristics of included studies is mentioned below (Table 1).

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Table 1. Summary of baseline characteristics, surgical details, and outcomes of included studies

First Author, Year	Mean Age	Mean Follow-Up	Common Reason for Revision	Loose Cup Replacement	Infection (Clinical)	Dislocation (Clinical and Radiological)	Osteolysis (Radiological)	Aseptic Loosening (Radiological)	Survival Rate of Acetabular Cup	Implant Failure (Radiological)	Re-Operation
(Hernigou, Dupuy et al. 2012) (9)	63 years (48–74)	15 years (10–25)	Polyethylene wear, acetabular osteolysis, aseptic loosening	Porous cup, cage & cemented cup, acetabular augmentation with graft	Not mentioned directly	3 dislocations (1–8 days), 1 recurrent	Less in ceramic head or liner, especially in younger patients (<50 years)	Not specifically mentioned, but re-revision noted due to osteolysis and loosening	98% at 15 years (alumina), 85% (metal)	Failure related to femoral stem loosening, periprosthetic fractures	Rerevision for femoral loosening in cases of osteolysis progression, more frequent with metal heads
(Civinini, Carulli et al. 2012) (1)	69 years (51.3–82.4)	3.3 years (2–5)	Aseptic loosening and malposition of the acetabular component	Cemented dual-mobility cup in an antiprotrusio cage or revision cup with screw fixations	1 revision for infection at 6 months, treated with reimplantation after a two-stage procedure	No dislocations	No radiographic osteolysis observed	No radiographic loosening or migration	97% at 5 years	No component failure, migration, or loosening observed	1 rerevision for infection at 6 months
(Castagnini, Mariotti et al. 2021) (10)	62.3 years (51–83)	5.7 ± 0.7 years (range 5–7 years)	Aseptic loosening, blood ions over threshold, pain, osteolysis	Highly porous titanium cups and Delta bearings	1 infection treated with antibiotics after positive cultures	1 dislocation (treated conservatively)	No post-revision osteolysis	No loosening or migration observed	100% survival rate at 5 years	No failure, osseointegration is good	No re-revision after 5 years
(Cogan, Klouche et al. 2011) (5)	65.8 years (27–86)	2.4 years ± 1.7 (1–7 years)	Aseptic loosening, prior instability, impingement	Cemented or cementless cup, graft, or cage	No septic or thromboembolic complications	4 dislocations (6.6% rate)	No significant radiolucency observed	No loosening or migration observed	6.6% dislocation rate, low risk of complications	No significant failure or complications observed	4 dislocations treated conservatively
(Kim, Kim et al. 2009) (20)	53 years (26–75)	76 months (range 37–131 months)	Transtrochanteric, posterolateral	No infections or thromboembolic complications	No dislocations	No significant osteolysis or subsidence	1 rerevision due to loosening (5 cases in total)	94% survival rate	Pre-op HHS: 57, Post-op HHS: 87	No significant failure observed	5 rerevisions for loosening
(Kim, Kim et al. 2014) (3)	49.9 years (range 24–65)	5.7 years (range 3–10 years)	Lateral approach with trochanteric osteotomy	No ceramic fractures, transient peroneal nerve palsy	No dislocations	4 osteolytic lesions around the stem, no new osteolysis	94.3% survival rate at mid-term follow-up	Pre-op HHS: 47.5, Post-op HHS: 84.7	Not specified	No ceramic fractures or osteolysis	3 re-revisions for loosening
(Kim, Park et al. 2015) (4)	47.4 years (range: 28–49)	15.6 years (11–19 years)	polyethylene wear and acetabular osteolysis (123 hips; 66%) aseptic loosening (49; 26%), recurrent dislocation (13; 7%), infection (2; 1%)	cementless, fully porous-coated acetabular component	post-operative pyogenic infection within three months (7 hips; 4%).	3 (1.5%) developed recurrent dislocation	No significant osteolysis or femoral osteolysis	13 hips (7%) re-revised for loosening	93%	implant failure (13 patients, 8%)	7 re-revisions (3 for loosening, 3 for recurrent dislocation)

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Table 1. Cont

First Author, Year	Mean Age	Mean Follow-Up	Common Reason for Revision	Loose Cup Replacement	Infection (Clinical)	Dislocation (Clinical and Radiological)	Osteolysis (Radiological)	Aseptic Loosening (Radiological)	Survival Rate of Acetabular Cup	Implant Failure (Radiological)	Re-Operation
(McLoughlin, Leonard et al. 2013) (2)	72.8 years (range: 37–86)	17 months (range: 8–27)	Aseptic loosening, osteolysis, polyethylene wear	porous coated hemispheric cups with modular cross-linked polyethylene liners	No infection reported	No dislocations	No radiolucency observed	No loosening or migration observed	No loosening or failure observed	No failure observed	No re-operations after 15 months
(Moskal, Danisa et al. 1997) (21)	66 years (range: 29–87)	58 months (range: 36–114)	aseptic loosening and malposition of a previously cemented or uncemented acetabular component with a well-fixed femoral prosthesis.	porous-coated hemispheric cup with or without bone-graft	None	No dislocations	No osteolysis	No evidence of progression	Not reported	None	Not reported
First Author, Year	Mean Age	Mean Follow-Up	Common Reason for Revision	Loose Cup Replacement	Infection (Clinical)	Dislocation (Clinical and Radiological)	Osteolysis (Radiological)	Aseptic Loosening (Radiological)	Survival Rate of Acetabular Cup	Implant Failure (Radiological)	Re-Operation
(Park, Moon et al. 2011) (6)	Posterolateral group: 54.9 years (range: 28–88) Anterolateral group: 55.6 (30–72)	Posterolateral group: 5.7 years (range: 2–13.2) Anterolateral group: 4.0 (2–12.1)	Polyethylene wear and osteolysis (47) Aseptic loosening (22)	anti-protrusion cage or a reinforcement ring	No deep infection in the posterolateral, 1 infection in the anterolateral group	4 dislocations in the posterolateral group, 0 in the anterolateral group	Not reported	3 aseptic cups loosening in the posterolateral group, 1in the anterolateral group	Not reported	Not reported	4 re-revision surgeries in the posterolateral group, 2 in the anterolateral group
(Stevenson, Fryhofer et al. 2020) (8)	68 years (SD: 34)	55.8 months (range 12.1-159)	Aseptic loosenin: (72; 36%) Osteolysis (71; 35.5%) Instability (68; 34%) Metallosis (15; 7.5%) Cup malposition (12; 6%) Other (44; 21%)	Not specified	Not specified	hip joint dislocation (24 hips, 12.0%)	Not reported	Not reported	Not reported	No significant implant failure from the Acetabular revision	required subsequent reoperation (37 hips; 18.5%)
(Piolanti, Andreani et al. 2014) (7)	67 years (range 40–81)	36 months (range 13–60)	Aseptic loosening (26; 78,79%), Implant instability (3; 9,1%), metallosis (4; 12,11%).	porous hemispheric revision shell matched with a cemented all-poly cup and a large diameter femoral head	Superficial wound infection (2)	Postoperative early dislocation (1)	osteolysis around the screws, without any change of the cup orientation and without evident evolution (3)	No	Not specified	No failure	No

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Revision Surgery Indications

Aseptic loosening was the most frequently reported indication for isolated acetabular revision across nearly all included studies. Polyethylene wear and associated osteolysis were also common, with several studies documenting chronic inflammatory reactions caused by wear particles leading to progressive bone loss around the acetabular component. Malposition of the acetabular cup was reported as an additional important indication for revision in studies such as Civinini et al., where incorrect cup positioning led to eccentric loading, instability, and loosening. These findings highlight the importance of correct implant alignment, high-quality bearing surfaces, and early identification of osteolytic changes (1).

Clinical Results

Complications and Functional Recovery

All studies reporting functional outcomes demonstrated significant postoperative improvement following isolated acetabular revision. Functional recovery was primarily measured using the HHS and WOMAC. Civinini et al. reported HHS improvement from 48 to 86 and a significant reduction in WOMAC scores (1). Castagnini et al. observed an increase in HHS from 50.3 to 88.3, indicating substantial functional gains (10). McLoughlin et al. noted improvement in both Oxford Hip Score and WOMAC, reflecting enhanced quality of life and reduced pain (2). Dislocation remained a notable postoperative complication, though its incidence varied. Studies utilizing dual-mobility cups reported markedly reduced dislocation rates, consistent with their increased jump distance and enhanced stability. Some included studies (e.g., Civinini et al.) reported no cases of dislocation, whereas others (Hernigou et al., Kim et al.) reported low but persistent rates (3, 4, 9-11). Infection occurred infrequently (1%–7%) and was managed with standard surgical protocols, including two-stage reimplantation or targeted antibiotic therapy. These findings collectively emphasize that modern implant designs and optimized surgical approaches have significantly improved stability and functional outcomes in isolated acetabular revision.

Radiology Results

Osteointegration and Implant Survival

Radiographic outcomes across all included studies were generally favorable. Most modern cementless hemispherical cups demonstrated satisfactory osteointegration, often graded as excellent. In Kim et al.'s study, 8 of 9 cases exhibited excellent bone ingrowth, underscoring the effectiveness of porous-coated cup designs (12). Implant survival rates were also high: Hernigou et al. reported 98% survival at 15 years. Castagnini et al. observed 100% survival at 5 years (9, 10).

Femoral stem loosening was rare due to the inclusion criterion requiring a well-fixed femoral stem. However, re-revision procedures were primarily performed for recurrent osteolysis or aseptic loosening, observed most commonly in older individuals.

Generation implants

These radiographic findings highlight the role of newer implant technologies—particularly highly porous coatings and dual-mobility constructs—in enhancing long-term acetabular component stability.

Risk of Bias: A formal risk of bias analysis was conducted for all included studies. Randomized controlled trials demonstrated low to moderate risk of bias according to the RoB-2 tool, while observational studies were found to have moderate risk of bias using the ROBINS-I assessment. Common sources of bias included confounding, variability in follow-up duration, and inconsistent outcome reporting. The results of the risk-of-bias analysis have been incorporated into the interpretation of clinical and radiological outcomes.

Discussion

Complications following primary total hip arthroplasty—including aseptic loosening of the acetabular component, polyethylene wear, progressive acetabular osteolysis, and malposition of the cup—remain common indications for isolated acetabular revision arthroplasty (13). With the increasing life expectancy of the global population and the finite longevity of earlier-generation implant materials, the absolute number of revision procedures is steadily rising, emphasizing the need for durable functional recovery and long-term implant stability (14).

In this context, the present systematic review synthesizes available evidence on clinical, functional, and radiological outcomes following isolated acetabular revision arthroplasty, with particular attention to surgical techniques, implant selection, complication profiles, and survivorship.

Across the included studies, functional outcomes demonstrated consistent and clinically meaningful improvement following isolated acetabular revision. Quantitatively, postoperative HHS values typically increased from poor-to-fair preoperative levels (approximately 30–50 points) to good-to-excellent postoperative ranges (approximately 85–90 points). For example, Kim et al. reported an increase in mean HHS from 33 preoperatively to 88 postoperatively Kim, Park, and Kim 2015, representing an improvement of more than 50 points. Similarly, Piolanti et al. observed an increase from 50.3 to 88.3 (4, 7, 12). WOMAC scores, when reported, followed comparable trends, reflecting substantial reductions in pain and functional limitation. These quantitative gains suggest that isolated acetabular revision can restore function to a level approaching that of successful primary arthroplasty in appropriately selected patients. These findings are consistent with recent literature highlighting the efficacy of revision arthroplasty in restoring hip function and reducing disability (15)

Complication rates were generally low but clinically relevant, with instability remaining the most frequently reported adverse event. Dislocation rates varied across studies but were consistently lower in cohorts utilizing dual-mobility acetabular components. This reduction is mechanistically explained by the increased jump distance and additional articulation provided by dual-mobility designs (11). Infection rates were reported infrequently and

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typically remained below 2–3%, consistent with contemporary revision arthroplasty benchmarks. When infections occurred, they were managed successfully using established perioperative protocols, underscoring the importance of meticulous surgical technique, appropriate antibiotic prophylaxis, and structured postoperative surveillance (16).

Radiological outcomes across the included studies were similarly favorable. Implant survivorship was high, with reported survival rates commonly exceeding 90% at mid- to long-term follow-up. Notably, Hernigou et al. reported a 98% survivorship at 15 years following isolated acetabular revision, highlighting the long-term durability achievable with modern materials and fixation strategies (9).

Porous-coated hemispherical cups were frequently associated with reliable osteointegration and minimal radiographic migration, supporting stable long-term fixation (17). Emerging technologies, including 3D-printed acetabular components, demonstrated promising mid-term

radiological performance, potentially attributable to optimized porosity and enhanced bone–implant interaction (18).

Surgical technique and implant selection emerged as critical determinants of successful outcomes. Accurate restoration of acetabular component position is essential to minimize abnormal biomechanical loading, edge wear, and subsequent loosening (12).

In the presence of substantial acetabular bone loss, adjunctive reconstructive strategies—such as augments or cup-cage constructs—were reported to provide effective restoration of acetabular integrity and mechanical stability (19). These findings collectively reinforce the importance of individualized surgical planning based on bone stock, patient characteristics, and anticipated functional demand.

Despite the overall favorable outcomes, several limitations of the available evidence warrant consideration. The included studies demonstrated substantial heterogeneity in patient populations, implant designs, surgical approaches, and follow-up durations, limiting direct cross-study comparability. Most studies were retrospective with modest sample sizes, constraining statistical power and generalizability. Additionally, variability in outcome reporting—particularly the use of different functional scoring systems—complicates pooled interpretation. Late complications such as aseptic loosening or polyethylene wear may also be underreported in studies with shorter follow-up. These limitations highlight the need for larger, prospective studies with standardized outcome reporting and extended follow-up periods.

From a broader perspective, the findings of this review have practical implications for clinical decision-making, guideline development, and health policy. The consistently favorable functional outcomes and acceptable complication rates support isolated acetabular revision as a cost-effective and tissue-preserving alternative to full component revision in appropriately selected patients. For policymakers and expert consensus groups, these data may inform evidence-based recommendations regarding implant selection, surgical indications, and resource allocation in revision hip arthroplasty. Continued refinement of implant technology and surgical techniques is likely to further enhance outcomes and reduce the long-term burden of revision procedures.

Overall, this systematic review demonstrates that isolated acetabular revision arthroplasty is associated with substantial functional improvement, low complication rates, and reliable radiological outcomes. When combined with meticulous surgical technique, appropriate implant selection, and careful patient selection, isolated acetabular revision represents an effective and durable strategy for managing complications following primary total hip arthroplasty.

Conclusion

This systematic review demonstrates that isolated acetabular revision arthroplasty provides substantial functional improvement and reliable radiological outcomes in patients with a well-fixed femoral stem. Modern implant designs—particularly dual-mobility cups and porous-coated cementless acetabular components—appear to reduce postoperative instability and enhance long-term osteointegration, contributing to high mid- to long-term implant survival.

Despite these favorable results, variability in surgical approach, implant selection, and study methodology highlights the need for standardized reporting and well-designed prospective studies to better characterize predictors of success. Taken together, the current evidence supports isolated acetabular revision as an effective and durable treatment option when meticulous surgical technique, appropriate implant choice, and careful patient selection are applied.

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Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

All authors meet the authorship criteria and have made substantial contributions to the conception and design of the study, data collection, analysis, interpretation, and drafting or critical revision of the manuscript.

Ethical Considerations

As this study is a systematic review of previously published data, no ethical approval or informed consent was required. All included studies were conducted in accordance with relevant ethical standards.

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Data Availability

More Data and details will be made available on request from the corresponding author during submission or after publication.

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AI Use Statement

No artificial intelligence (AI) tools or technologies were used in the preparation, writing, editing, or analysis of this manuscript.

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