SYSTEMATIC REVIEW

Open Reduction and Internal Fixation (ORIF) for Acetabular Fractures in the Elderly: A Systematic Review and Meta-Analysis

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Abstract

Objectives: To evaluate the outcomes of open reduction and internal fixation (ORIF) in older adults with acetabular fractures, with a focus on postoperative complications, mortality, and conversion to total hip arthroplasty (THA).

Methods: We systematically reviewed studies published between September 2013 and February 2025 in Web of Science, PubMed, Embase, Scopus, and the Cochrane Library. Studies reporting postoperative outcomes of ORIF in elderly patients aged ≥65 years were included. Data extraction and quality assessment were performed independently by two reviewers. Statistical analyses were conducted using Comprehensive Meta-Analysis software, version 3.0.

Results: Twenty-one studies involving 2,410 patients were included in the analysis. Follow-up duration ranged from 12 to 96 months. The pooled mortality rate after ORIF was 11.0% (95% CI: 7.0%–16.7%). The pooled complication rate was 26.5% (95% CI: 21.3%–32.4%), and the pooled rate of conversion to THA was 20.0% (95% CI: 15.2%–26.0%). The pooled infection rate was 5.8% (95% CI: 4.2%–7.9%). Fixation failure occurred in 12.6% of patients (95% CI: 9.8%–15.9%) and was primarily attributed to secondary loss of reduction, implant loosening, or hardware breakage, often requiring revision surgery or conversion to THA.

Conclusion: ORIF in elderly patients with acetabular fractures is associated with substantial risks, including a high complication rate and a notable likelihood of conversion to THA. Alternative treatment strategies, such as primary THA or nonoperative management, should be considered in selected patients.

Level of evidence: I

Keywords: Acetabular fracture, Complication, Elderly, Mortality, ORIF, Total hip arthroplasty

Introduction

With advancing age, the incidence of acetabular fractures increases due to several factors, including a higher risk of osteoporosis, greater susceptibility to trauma-related fractures, and age-related metabolic bone disorders.[1,2] In younger patients, open reduction and internal fixation (ORIF) is considered the gold-standard treatment for acetabular fractures. However, there remains no consensus regarding the optimal treatment strategy associated with the most favorable outcomes in older adults.[3] Because elderly patients are more likely to have bone fragility and poor bone quality, they are often considered candidates for alternative surgical strategies, such as total hip arthroplasty (THA) combined with column fixation or percutaneous fixation.[4] Moreover, given the higher prevalence of underlying comorbidities in this age group, surgery may sometimes be delayed until these conditions are optimized.[5]

In addition, complex acetabular fractures resulting from trauma or severe osteoporosis can make the choice of surgical approach challenging, and some patients may

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require staged surgical procedures. The mechanism of injury in older adults may also differ substantially from that in younger patients. In this context, the presence of femoral head fracture, articular impaction, or comminution involving the weight-bearing dome may influence both the clinical course and the choice of surgical approach.[6] These factors are sometimes regarded as predictors of surgical failure. Some studies have shown that dome impaction, even after reduction of the dome fragment, may be associated with reduction and/or fixation failure in approximately 70% of elderly patients and may predict the need for conversion to THA.

Therefore, surgical outcomes are expected to differ substantially between younger and older patients, given the marked differences in baseline characteristics, comorbidity burden, bone quality, and the surgical strategies used for acetabular fractures in these two age groups. However, the reported outcomes of ORIF in older adults remain inconsistent across studies. Accordingly, the present study aimed to provide a clearer synthesis of the evidence by systematically reviewing studies that evaluated postoperative outcomes following ORIF for acetabular fractures in elderly patients.

Materials and Methods

Search strategy

This systematic review and meta-analysis included studies published between September 2013 and February 2025 that were indexed in Web of Science, PubMed, Embase, Scopus, and the Cochrane Library. The aim was to assess the outcomes of open reduction and internal fixation (ORIF) in older patients aged ≥65 years with acetabular fractures. The full search strategy for each database is presented in [Table 1]. All studies included in this systematic review and meta-analysis were observational studies, predominantly retrospective cohort or cross-sectional studies. No randomized controlled trials meeting the predefined inclusion criteria were identified. According to commonly used evidence hierarchies, such as the Oxford Centre for Evidence-Based Medicine framework, the included studies would generally be classified as Level II–III evidence rather than Level I evidence. Studies were excluded if the full text was unavailable, if they were published in a language other than English, or if they provided incomplete data relevant to the objectives of this review.

Table 1. Full Search Strategy for Each Database

Database	Platform	Full Search Strategy (Verbatim)	Filters / Limits	Records Retrieved (n)
PubMed/MEDLINE	NCBI	("Acetabulum"[Mesh] OR acetabular fracture* OR acetabulum fracture*) AND ("Open Reduction Internal Fixation"[Mesh] OR ORIF OR internal fixation) AND (aged OR elderly OR geriatric* OR older adult*)	Humans; English	41
Embase	Elsevier	('acetabulum fracture'/exp OR acetabular fracture*:ti,ab) AND ('open reduction internal fixation'/exp OR ORIF:ti,ab) AND (aged:ti,ab OR elderly:ti,ab OR geriatric*:ti,ab)	Human; English	9
Scopus	Elsevier	TITLE-ABS-KEY (acetabular AND fracture*) AND TITLE-ABS-KEY (ORIF OR "internal fixation") AND TITLE-ABS-KEY (elderly OR aged OR geriatric*)	English	5
Web of Science Core Collection	Clarivate	TS=(acetabular fracture*) AND TS=(ORIF OR "open reduction internal fixation") AND TS=(elderly OR aged OR geriatric*)	English	2
Cochrane Library (CENTRAL)	Wiley	(acetabular fracture*):ti,ab,kw AND (ORIF OR "open reduction internal fixation"):ti,ab,kw AND (elderly OR aged OR geriatric*):ti,ab,kw	English	4

Eligibility criteria

The present systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was registered in the PROSPERO database (CRD42011270093). The research questions were initially formulated based on the study objectives. A comprehensive search was then conducted in Web of Science, PubMed, Embase, Scopus, and the Cochrane Library by two independent reviewers to identify eligible studies. The search strategy included the following keywords: "acetabular fracture," "outcome," "elderly," "procedure," "complication," "mortality," and "open reduction and internal fixation." The inclusion criteria were as follows: (1) studies that evaluated surgical outcomes after acetabular fracture surgery in elderly patients and reported relevant baseline determinants, and (2) studies published in English. Studies with unclear or irreproducible results, case reports, and review articles were excluded. Data extraction was performed independently by two reviewers (MYS and PT), and disagreements were resolved through consultation with a third reviewer (SJ). Study quality and methodological rigor were assessed using predefined criteria, including the clarity of the research question, appropriateness of the eligibility criteria, comprehensiveness of the database search, duplicate full-text screening, independent assessment of study quality, completeness of reported study characteristics and findings, assessment of publication bias and risk of bias,

and evaluation of heterogeneity.

Quality assessment

Risk of bias in the included studies was assessed using criteria recommended in the Cochrane Handbook for Systematic Reviews of Interventions, together with the Newcastle–Ottawa Scale (NOS) for non-randomized studies. The NOS evaluates methodological quality across three domains: selection, comparability, and outcome/exposure. Studies can receive up to nine stars, with higher scores indicating better methodological quality. Scores were categorized as high quality (7–9 stars), moderate quality (4–6 stars), or low quality (≤3 stars).[7]

Statistical analysis

Data analysis was performed by BS and HA. For pooling prevalence estimates, proportions were stabilized using the Freeman–Tukey double-arcsine transformation before meta-analysis, and pooled estimates were back-transformed for presentation. Given the expected clinical and methodological heterogeneity among the included studies, a random-effects model was applied using the DerSimonian–Laird estimator to estimate between-study variance (τ^2). Studies reporting zero events were retained in the meta-analysis. Where required, a continuity correction of 0.5 was applied to zero-event cells to allow variance estimation. Statistical heterogeneity was assessed using Cochran's Q test and quantified using the I^2 statistic. Prespecified subgroup analyses were conducted according to study design, geographic region, and sample size. Univariable meta-regression analyses were also performed to explore potential sources of heterogeneity when at least ten studies were available per covariate. All analyses were conducted using Comprehensive Meta-Analysis (CMA), version 3.0 (Biostat, Englewood, NJ, USA). The following CMA settings were used: random-effects model, Freeman–Tukey double-arcsine transformation for proportions, DerSimonian–Laird τ^2 estimator, and inverse-variance weighting.

Results

Study selection

As shown in the study selection flow diagram, 61 articles were initially identified through database searches [Figure 1]. After the removal of 3 duplicate records, 58 records underwent preliminary screening. Based on title and abstract screening, 27 records were excluded, and the remaining 31 full-text articles were assessed for eligibility. Of these, 8 articles were excluded because of incomplete data or insufficiently relevant content. Finally, 23 articles were included in the qualitative assessment, and 21 were included in the quantitative analysis.[8-28] The included studies were qualitatively assessed using the Newcastle–Ottawa Scale (NOS). All studies included in the quantitative analysis were rated as good quality, and none was judged to have a high risk of bias. The summary of the NOS quality assessment is presented in [Table 2].

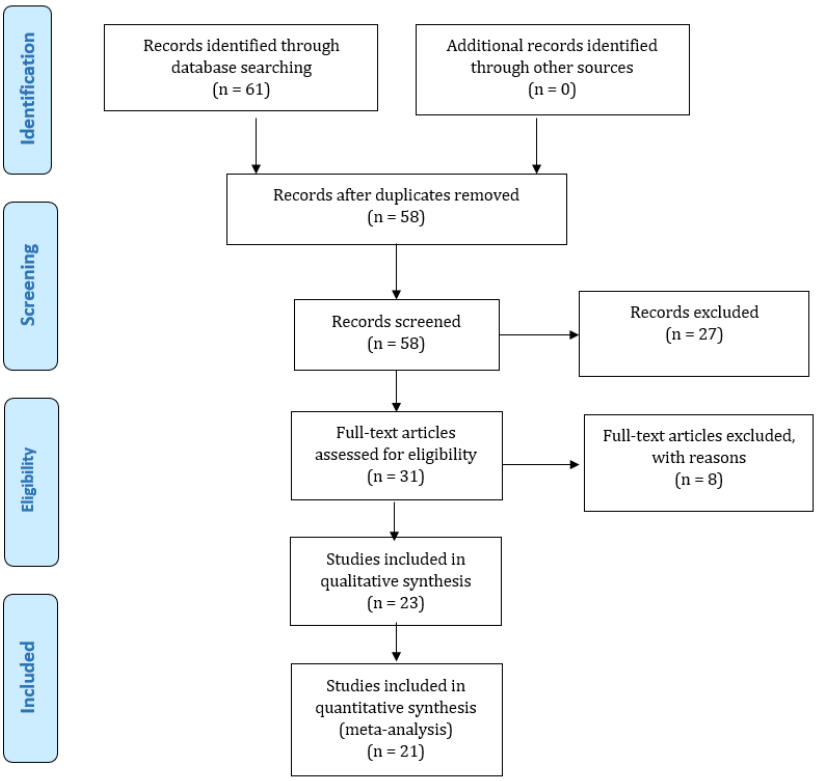

Figure 1. Eligibility assessment flowchart for the studies being evaluated

Table 2. The quality assessment of the studies according to the nine-star Newcastle-Ottawa Scale (NOS) scoring system

ID	Author, year	Selection				Comparability		Outcome			Total
		❶	❷	❸	❹	❺	❻	❼	❽	❾	
1	Nilssen, 2024 [8]	★	★	★		★	★	★	★	★	8
2	Gao, 2024 [9]	★	★	★	★	★	★	★	★		8
3	Lim, 2023 [10]	★	★	★	★	★	★	★	★		8
4	Llano, 2023 [11]	★	★	★	★	★	★	★	★	★	9
5	Panteli, 2023 [12]	★	★	★		★	★	★	★	★	9
6	Smakaj, 2022 [13]	★	★	★	★	★	★	★	★		8
7	Heimke, 2022 [14]	★	★	★	★		★	★	★		7
8	Sanders, 2022 [15]	★	★	★	★	★	★	★	★		8
9	Navarre, 2020 [16]	★	★	★	★	★	★	★	★		8
10	Nicol, 2021 [17]	★	★	★		★	★	★	★	★	8
11	Rommens, 2020 [18]	★	★	★	★	★	★	★	★		8
12	Khoshbin, 2020 [19]	★	★	★		★	★	★	★	★	8
13	Borg, 2019 [20]	★	★	★		★	★	★	★	★	8
14	Gibbons, 2019 [21]	★	★	★	★	★	★	★	★		8
15	Weaver, 2018 [22]	★	★	★	★	★	★	★	★		8
16	Zha, 2017 [23]	★	★	★	★		★	★	★		7
17	Walley, 2017 [24]	★	★	★	★	★	★	★	★		8
18	Li, 2014 [25]	★	★	★	★	★	★	★	★		8
19	Schnaser, 2014 [26]	★	★	★		★	★	★	★	★	8
20	Zha, 2013 [27]	★	★	★	★	★	★	★	★		8
21	Gary, 2011 [28]	★	★	★		★	★	★	★	★	8

Study population

In total, 2,410 patients, including 1,423 men and 987 women, who underwent ORIF for acetabular fractures were included in the study. The mean age of participants ranged from 66.0 to 78.0 years, and the follow-up duration ranged from 12 to 96 months. Baseline study characteristics are summarized in [Table 3].

Table 3. Baseline characteristics of studies assessed

Author, year	Country	No. population	Mean age, y	Male/Female	Follow-up time, m
Nilssen, 2024 [8]	USA	962	71.3±6.5	450/512	96.0
Gao, 2024 [9]	China	118	66.9±6.2	82/36	77.4
Lim, 2023 [10]	Korea	54	68.9±5.8	39/15	45.0
Llano, 2023 [11]	Argentina	50	78.0±8.8	35/15	72.0
Panteli, 2023 [12]	UK	62	71.5±8.0	48/14	54.2

Table 3. Continued

Smakaj, 2022 [13]	Italy	24	69.5±1.1	16/8	32.0
Heimke, 2022 [14]	USA	40	66.0±5.0	30/10	60.0
Sanders, 2022 [15]	Canada	78	70.1±7.4	57/21	51.6
Navarre, 2020 [16]	Australia	80	69.7±5.6	61/19	18.0
Nicol, 2021 [17]	Canada	26	78.5±7.5	14/12	60.0
Rommens, 2020 [18]	Germany	46	77.0±5.0	31/15	60.0
Khoshbin, 2020 [19]	Canada	303	78.2±9.2	123/180	60.0
Borg, 2019 [20]	Sweden	14	68.2±5.8	9/5	36.0
Gibbons, 2019 [21]	Ireland	42	73.4±6.6	26/16	60.0
Weaver, 2018 [22]	USA	33	73.0±4.5	19/14	22.0
Zha, 2017 [23]	China	53	73.1±4.1	44/9	52.0
Walley, 2017 [24]	USA	37	78.0±4.4	19/18	14.0
Li, 2014 [25]	China	52	69.9±6.2	73/9	18.0
Schnaser, 2014 [26]	USA	171	69.0±6.9	124/47	12.0
Zha, 2013 [27]	China	86	67.7±5.3	71/15	39
Gary, 2011 [28]	USA	79	73.0±1.0	52/27	46.8

Procedural outcome

During the follow-up period, the pooled mortality rate after ORIF in elderly patients was 11.0% (95% CI: 7.0%–16.7%) [Figure 2]. The pooled rate of postoperative complications was 26.5% (95% CI: 21.3%–32.4%) [Figure 3]. The pooled rate of conversion to THA was 20.0% (95% CI: 15.2%–26.0%) [Figure 4]. The pooled infection rate was 5.8% (95% CI: 4.2%–7.9%), with moderate heterogeneity across studies (I^2 = 46%). Most reported infections were deep surgical site infections requiring prolonged antibiotic therapy or surgical debridement. The pooled rate of fixation failure was 12.6% (95% CI: 9.8%–15.9%), with substantial heterogeneity (I^2 = 63%). Fixation failure was primarily attributed to secondary loss of reduction, implant loosening, or hardware breakage, often necessitating revision surgery or conversion to THA.

Heterogeneity and publication bias

Statistical heterogeneity was significant across all analyses, with I^2 values ranging from 77.4% to 82.6% ($P < 0.001$). This heterogeneity was likely attributable to differences in follow-up duration, sample size, and baseline patient comorbidities across the included studies. However, no significant publication bias was detected, as indicated by visual inspection of the funnel plots [Figure 5] and Egger's test across all analyses.

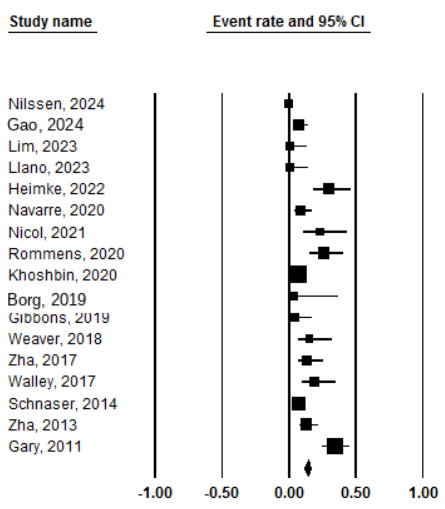

Figure 2. The pooled prevalence of postoperative death (11.0%, 95%CI: 7.0% to 16.7%)

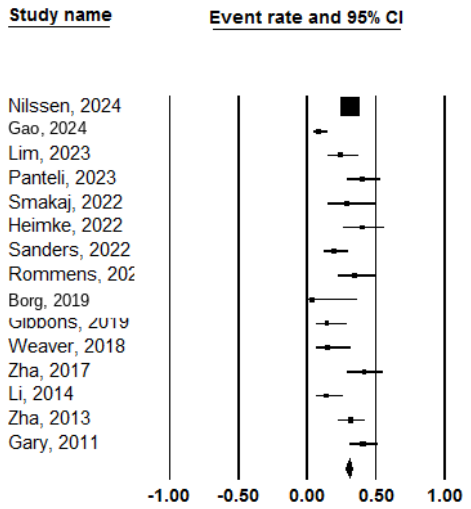

Figure 3. The pooled prevalence of postoperative complications (26.5%, 95%CI: 21.3% to 32.4%)

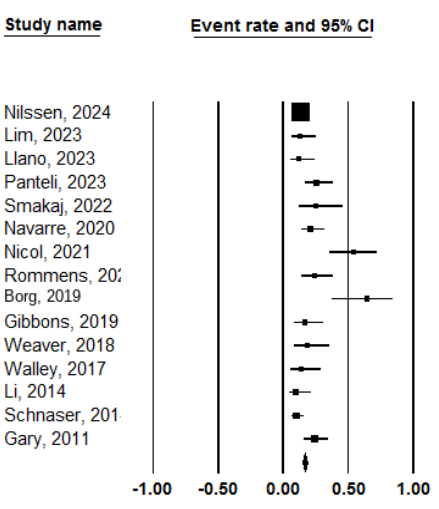

Figure 4. The pooled prevalence of conversion to THA (20.0%, 95%CI: 15.2% to 26.0%)

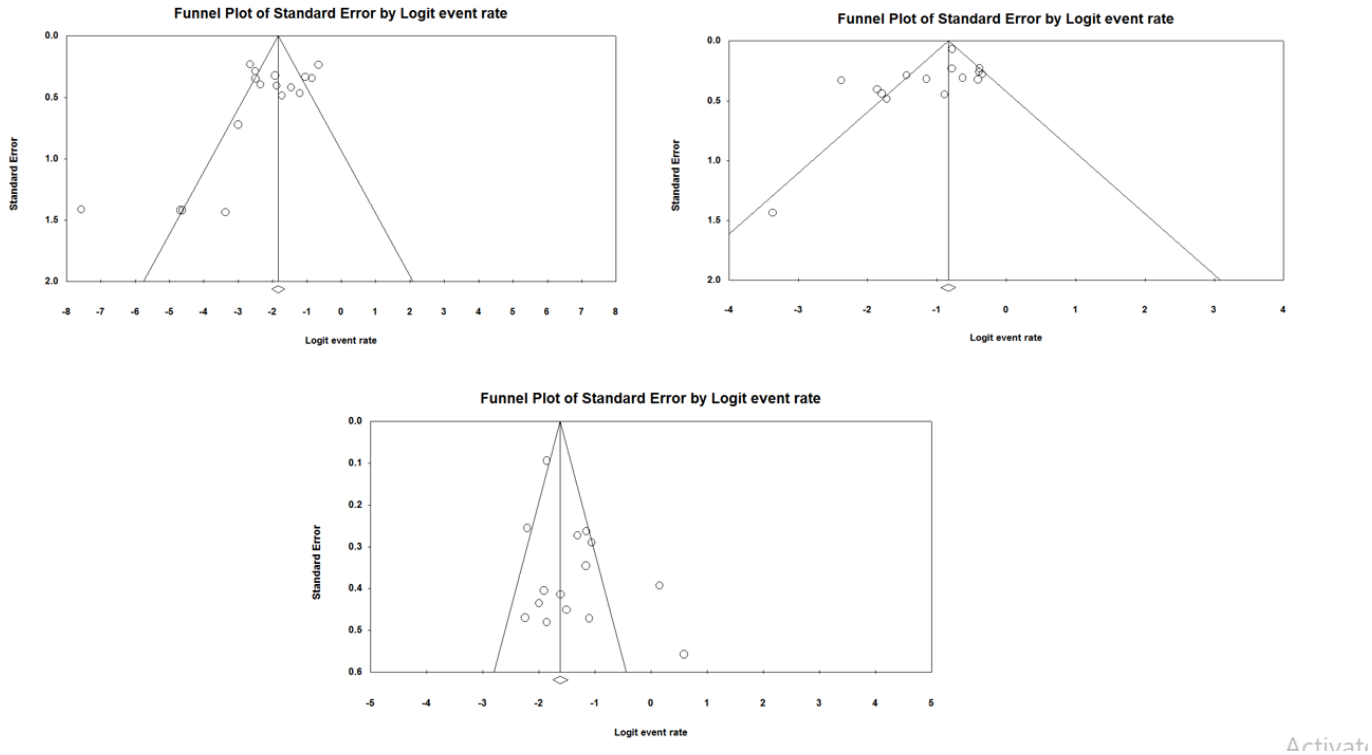

Figure 5. The funnel plot for assessing the publication bias to assess death (A), complication (B), and conversion to THA (C)

Discussion

In elderly patients, acetabular fractures without significant displacement are generally managed conservatively. Avoiding prolonged hospitalization, anesthesia—particularly in patients with underlying hemodynamic instability—and typical postoperative complications, especially those affecting vital organs, are among the main advantages of nonoperative management in this population.[29,30] Given that older patients often present with multiple comorbidities, including osteoporosis, nonoperative approaches may be acceptable to both patients and physicians in carefully selected cases.[31] However, complex acetabular fractures or those with substantial displacement are often poorly tolerated in older adults, making conservative management impractical in many cases. Under such circumstances, surgical intervention may be required to improve clinical status, maintain hemodynamic stability, achieve adequate pain control, and restore physical function.[32] Some studies have reported that nonoperative management fails in approximately one-third of these patients.[33,34] In this context, ORIF is widely considered a standard treatment option for displaced acetabular fractures across age groups and remains the preferred surgical approach in younger patients. However, whether ORIF should continue to be regarded as the optimal surgical strategy in elderly patients remains uncertain. Regardless of age, ORIF may be indicated in patients at high risk of joint destruction, provided that an acceptable reduction can be achieved. The quality of reduction is a key determinant of ORIF success and may be influenced by baseline factors such as fracture type, fracture impaction, time to surgery, and surgeon experience.[35,36] Overall, the literature suggests that clinical outcomes after ORIF are generally more favorable in younger patients than in elderly patients. In particular, conversion to THA and the need for revision surgery have been reported less frequently among younger patients undergoing ORIF.[2,37]

The findings of the present systematic review indicate relatively high rates of postoperative complications and conversion to THA after ORIF in elderly patients. The pooled rates of post-ORIF complications and conversion to THA were 26.5% and 20.0%, respectively. Although these complications and subsequent changes in surgical management may develop over an extended follow-up period, their occurrence can adversely affect patients' daily functioning and quality of life. Therefore, in carefully selected elderly patients, conservative management may be considered initially. When surgery is required, alternative surgical strategies should also be considered where appropriate, and some patients may be better suited for primary THA. Careful identification of risk factors is essential for selecting the most appropriate surgical approach in elderly patients with acetabular fractures. Several patient-related, fracture-related, and surgery-related factors have been associated with an increased risk of complications and failure after ORIF in this population. Advanced age,

particularly ≥70–75 years, is an important risk factor because of reduced physiological reserve and impaired bone healing capacity. Osteoporosis or poor bone quality increases the risk of fixation failure and subsequent loss of reduction. Complex fracture patterns, including both-column fractures, comminuted posterior wall fractures, dome impaction, and marginal impaction of the acetabular roof, are associated with lower fixation stability and higher revision rates. Pre-existing hip osteoarthritis and femoral head cartilage damage may further worsen postoperative outcomes and increase the likelihood of conversion to THA. Comorbidities such as diabetes mellitus, chronic renal failure, cardiovascular disease, and immunosuppression may contribute to postoperative infections, impaired healing, and medical complications. Additional patient-related factors, including high body mass index, smoking, and poor nutritional status, may also adversely affect outcomes. Surgery-related factors, such as delayed fixation, prolonged operative time, substantial intraoperative blood loss, and the use of extensile surgical approaches, may increase the risk of infection and fixation failure. Furthermore, limited surgical expertise in reconstructive acetabular surgery in elderly patients may negatively affect outcomes.[16]

In the present study, substantial heterogeneity was observed across the included studies. This heterogeneity was primarily attributable to differences in follow-up duration, which ranged from 1 year to, in some studies, up to 10 years, as well as variations in surgical expertise and treatment settings. Although heterogeneity may limit the precision and generalizability of the pooled estimates, the direction of effect was generally consistent across studies, and sensitivity analyses showed that no individual study disproportionately influenced the pooled results. Therefore, the pooled estimates should be interpreted as reflecting average effects across diverse real-world clinical settings rather than precise estimates applicable to a single standardized clinical context. Several factors may have contributed to the observed heterogeneity. Over the past decade, advances in surgical techniques, perioperative care, implant selection, and postoperative management may have influenced outcomes after ORIF for acetabular fractures. In addition, outcomes may differ across centers according to institutional experience, surgeon expertise, case volume, and access to specialized acetabular fracture services. These factors may partly explain the between-study variability observed in the present meta-analysis.

Conclusion

In conclusion, in elderly patients with acetabular fractures, ORIF as the initial surgical treatment is associated with a considerable risk of postoperative complications and a notable likelihood of subsequent conversion to THA. Therefore, the decision to perform ORIF in this population, particularly in advanced age groups, should be made with careful consideration of patient-related factors, comorbidities, bone quality, and fracture characteristics. In selected patients with minimally displaced fractures, nonoperative management may be an appropriate initial option, whereas primary THA may be considered in patients with displaced fractures, poor bone quality, pre-existing hip osteoarthritis, or fracture patterns associated with a high risk of fixation failure.

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Declaration of Ethical Approval for Study: Ethical approval was not required for this study because it is a systematic review and meta-analysis based exclusively on previously published data.

Declaration of Informed Consent: No identifiable patient information is included in the manuscript. Written informed consent was obtained from all participants.

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