Predictors of Total Hip Arthroplasty After Surgically Managed Acetabulum Fractures: A Prognostic Factor Systematic Review and Meta-Analysis

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Introduction

Operative management of acetabular fractures can be complicated by the development of symptomatic post-traumatic arthritis which may necessitate conversion total hip arthroplasty (THA).[1] There is increased interest in treatment with THA for acute management, but optimal patient selection depends on identifying those at risk of later symptomatic post-traumatic arthritis requiring conversion THA. Our study aimed to systematically review prognostic factors for symptomatic post-operative arthritis requiring conversion THA, including patient and fracture characteristics.

Methods

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The protocol was registered on PROSPERO. Deviations were declared.

We reported associations between potential prognostic factors and THA. Embase and MEDLINE databases were systematically searched, using the Ovid interface, from inception to September 27, 2024. Title and abstract screening, full-text screening, and data extraction was completed independently and in duplicate by two reviewers using predefined criteria. Study quality and risk of bias was assessed by two reviewers in duplicate using the Quality in Prognostics Studies tool. Conflicts were resolved by discussion and consensus.

Univariable and multivariable effect sizes were pooled separately. In univariable analysis of binary outcomes, study-specific exposure and outcome data for each prognostic factor were used to calculate odds ratios with 95% confidence intervals (CI). In the case of zero cell frequencies, a continuity correction of 0.5 was applied. For continuous prognostic factors, study sample size, mean, and standard deviation were used to calculate mean differences between patients with conversion THA and those with native joint survival. Medians and interquartile ranges (IQR) were converted to means and standard deviations (SD) respectively, assuming a normal distribution.[2] Multivariable odds ratios and/or hazard ratios were pooled separately when sufficient studies were encountered. Subgroups analyses were conducted comparing studies restricting inclusion to patients >60 years old against studies including patients of all ages.

Data was pooled using a random effects model using inverse of variance weights. T^2 was calculated using the restricted maximum likelihood method. Confidence intervals were calculated using the Hartung-Knapp adjustment or Wald estimator as appropriate.[3] As a secondary outcome, the overall pooled proportion of patients who required conversion THA was calculated using a generalized linear mixed-effects model with study specific logit-transformed proportions.[4] Confidence intervals for each study were calculated using the Clopper-Pearson method.[5,6] Heterogeneity was assessed using the I^2 statistic, T^2, and prediction intervals. The certainty of evidence was interpreted using the GRADE framework.[7]

Table 1. Summary of prognostic factors from univariable and multivariable analyses

Prognostic Factor	Sample	Pooled Crude Estimates (95% CI)	Heterogeneity (95% CI)	Certainty of Evidence
Impaction	1798 fractures with 322 THA in 14 studies	OR 2.08 (1.60 to 2.70)	I^2: 0% (0 to 55) PI: 1.55 to 2.76	Moderate due to serious risk of bias
Dislocation	1932 fractures with 324 THA in 12 studies	OR 2.20 (1.51 to 3.19)	I^2: 10.2% (0 to 49.4) PI: 0.93 to 5.16	Moderate due to serious risk of bias
Non-Anatomic Reduction (X-ray)	652 fractures with 150 THA in 8 studies	OR 2.36 (1.58 to 3.51)	I^2: 47.9% (0 to 76.8) PI: 1.46 to 3.81	Moderate due to serious risk of bias
Non-Anatomic Reduction (CT)	711 fractures with 115 THA in 5 studies	OR 3.46 (1.25 to 9.57)	I^2: 11.8% (0 to 81.7) PI: 0.75 to 16.1	Moderate due to serious risk of bias
Sex (Female)	2276 fractures with 399 THA in 15 studies	OR 1.48 (1.15 to 1.88)	I^2: 5.2% (0 to 56) PI: 1.13 to 1.93	Moderate due to serious risk of bias
Age	2050 fractures with 376 THA in 13 studies	MD 8.90 (7.27 to 10.53)	I^2: 0% (0 to 56.6) PI: 7.06 to 10.74	Moderate due to serious risk of bias
Posterior Wall Comminution	966 fractures with 177 THA in 5 studies	OR 2.39 (0.97 to 5.91)	I^2: 44% (0 to 79.4) PI: 0.53 to 10.84	Low due to serious risk of bias and serious imprecision
Fracture Type (Associated)	2681 fractures, 465 THA in 20 studies	OR 1.76 (1.29 to 2.41)	I^2: 23% (0 to 55.5) PI: 0.80 to 3.88	Low due to serious risk of bias and inconsistency

Prognostic Factor	Sample	Pooled Adjusted Estimates (95% CI)	Heterogeneity (95% CI)	Certainty of Evidence
Age (per 1 year increase)	1313 fractures with 249 THA in 7 studies	aOR 1.04 (1.02 to 1.06)	I^2: 82.4% (64.9 to 91.2) PI: 0.98 to 1.10	High
Age (per 1 year increase)	2262 fractures with 335 THA in 4 studies	aHR 1.04 (1.03 to 1.05)	I^2: 27% (0 to 72.6) PI: 1.01 to 1.07	High
Posterior Wall Comminution	769 fractures with 132 THA in 2 studies	aOR 2.05 (0.78 to 5.41)	I^2: 0% PI: 0.78 to 5.41	Moderate due to serious imprecision
Impaction	1346 fractures with 226 THA in 4 studies	aHR 2.08 (0.86 to 5.02)	I^2: 63% (0 to 87.6) PI: 0.39 to 11.15	Moderate due to serious imprecision
Sex (Female)	2133 fractures, with 337 THA in 5 studies	aHR 1.31 (0.44 to 3.89)	I^2: 56% (0 to 83.7) PI: 0.26 to 6,56	Low due to serious imprecision and inconsistency
Dislocation	936 fractures with 161 THA in 4 studies	aOR 1.80 (0.28 to 11.81)	I^2: 61.9% (0 to 87.2) PI: 0.07 to 49.20	Very low due to very serious imprecision and serious inconsistency

Results

Our search identified 3054 citations of which 38 studies ultimately met our eligibility criteria. The median (IQR) of participant mean age across all studies was 48.5 years (41.8 to 64.9). The median (IQR) proportion of females was 27.5% (21.7 to 32.6). There was a total of 6931 acetabulum fractures with 1122 fractures requiring conversion THA. Overall risk of bias was low in 4 studies, moderate in 22 studies, and high in 12 studies.

There was no credible subgroup effect related to study population age for any of the included prognostic factors. Removing high risk of bias studies did not impact any of the pooled estimates

Publication bias was not detected for any prognostic factor.

The weighted proportion of patients requiring THA conversion was 17.6% (95% CI 15.2 to 20.4%, low certainty due to serious risk of bias and serious inconsistency). The median (IQR) of reported mean time to conversion (22 studies) was 26.6 months (15.5 to 36).

Discussion

Our study demonstrated a significant association between increasing age and odds of conversion THA in adult patients with operatively managed acetabulum fractures based on high certainty evidence from multivariable analyses. There was a lack of reproducibility of the influence of the remaining prognostic factors when comparing univariable and multivariable analyses.

Further research incorporating multivariable models to adjust for a consistent set of confounding factors is needed to further understand the prognostic effect of injury and patient level factors in this patient population. This future research will help to identify patients who are potentially at high risk of treatment failure with ORIF who may benefit from acute THA.

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