

Patient- Surgery-and Implant-Related Predictors of Complications, Reoperation and Implant Survivorship Following Revision Total Hip Arthroplasty: A Longitudinal Cohort Study

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ABSTRACT

Background: Revision total hip arthroplasty is technically demanding and is associated with higher risks of complications, reoperation and implant failure than primary arthroplasty. Outcomes may be influenced by patient characteristics, surgical complexity and implant-related factors. Identification of these predictors may support risk stratification, perioperative optimization and improved surgical planning. **Aim:** To evaluate patient-, surgery- and implant-related predictors of complications, reoperation and implant survivorship following revision total hip arthroplasty. **Materials and Methods:** This longitudinal cohort study included 140 adult patients who underwent revision total hip arthroplasty at a tertiary care hospital. Patient-related variables, indication for revision, operative characteristics, bone loss, fixation method, bearing surface and implant-related factors were recorded. Patients were followed for postoperative complications, reoperations and implant failure. Predictors of complications and reoperation were evaluated using multivariable logistic regression. Implant survivorship was estimated using Kaplan-Meier analysis, and independent predictors of failure were determined using Cox proportional-hazards regression. A p value <0.05 was considered statistically significant. **Results:** The mean age was 66.8±10.9 years, and 59.3% of patients were male. Aseptic loosening was the most frequent indication for revision (33.6%), followed by periprosthetic joint infection (22.1%). Postoperative complications occurred in 43 (30.7%; 95% CI: 23.7-38.8) patients, while 24 (17.1%; 95% CI: 11.8-24.2) underwent reoperation. Dislocation was the most common complication (9.3%). Implant failure requiring repeat revision or component removal occurred in 17 (12.1%) patients. Advanced age, obesity, ASA class III-IV, infection-related revision, severe bone loss, operative duration >180 minutes, blood loss >1000 mL and component malposition independently predicted complications. Significant predictors of reoperation included age ≥70 years, two or more previous revisions, revision for infection and component malposition. Implant survivorship was 97.1% at six months, 94.2% at one year, 90.2% at two years and 85.9% at three years. Revision for periprosthetic joint infection (aHR=3.12; 95% CI: 1.18-8.26; p=0.022), Paprosky type III-IV bone loss (aHR=2.73; 95% CI: 1.04-7.17; p=0.042) and postoperative component malposition (aHR=2.86; 95% CI: 1.05-7.79; p=0.039) independently predicted implant failure. **Conclusion:** Complications and reoperations were relatively common following revision total hip arthroplasty, and implant survivorship declined progressively during follow-up. Infection-related revision, severe bone loss and component malposition were the principal independent predictors of implant failure. Improved infection control, reconstruction of bone defects and accurate component positioning may improve outcomes and implant longevity.

KEYWORDS: Revision total hip arthroplasty; Implant survivorship; Reoperation.

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INTRODUCTION

Total hip arthroplasty is an effective procedure for relieving pain and restoring function in patients with advanced hip disease. However, increasing numbers of primary hip arthroplasties and longer patient survival have resulted in a growing requirement for revision total hip arthroplasty (rTHA) [1]. Revision surgery is technically more demanding than primary arthroplasty because of bone loss, altered anatomy, soft-tissue damage, poor bone quality, infection and difficulty in removing existing components. Consequently, rTHA is associated with longer operative duration, greater blood loss, higher treatment costs and increased risks of postoperative complications, reoperation and implant failure [2].

The outcomes of rTHA may be influenced by patient-, surgery- and implant-related factors. Patient-related predictors include advanced age, obesity, smoking, diabetes mellitus, anaemia, malnutrition, renal disease, cardiovascular disease, osteoporosis, immunosuppression and poor preoperative functional status. Previous operations and the indication for revision particularly periprosthetic joint infection, recurrent dislocation, aseptic loosening or periprosthetic fracture may further affect prognosis. The American Society of Anesthesiologists physical status and comorbidity burden may help identify patients at increased perioperative risk [3].

Surgery-related factors include the urgency and complexity of revision, single- or two-stage procedures, operative duration, surgical approach, blood loss, transfusion requirement, extent of bone loss, component positioning and use of bone grafts or augments. Implant-related characteristics, including cemented or uncemented fixation, bearing surface, femoral-head diameter, constrained or dual-mobility components and whether one or both components are revised, may influence stability and implant survival. Common adverse outcomes after rTHA include infection, dislocation, periprosthetic fracture, thromboembolism, nerve injury, wound complications and aseptic loosening [4].

Reoperation and repeat revision impose substantial clinical and economic burdens. Implant survivorship provides a time-dependent measure of treatment durability and can be assessed using revision or removal of any component as the endpoint. Although registry-based studies provide valuable population-level estimates, institutional longitudinal studies are required to evaluate local patient profiles, surgical practices, implant selection and follow-up outcomes [5].

AIM

To evaluate patient-, surgery- and implant-related predictors of complications, reoperation and implant survivorship following revision total hip arthroplasty.

OBJECTIVES

1. To determine the incidence and types of complications and reoperations following revision total hip arthroplasty.
2. To assess patient-, surgery- and implant-related factors associated with complications and reoperation following revision total hip arthroplasty.
3. To estimate implant survivorship and identify independent predictors of implant failure during follow-up.

MATERIAL AND METHODOLOGY

Source of Data

The study population consisted of patients who underwent revision total hip arthroplasty in the Department of Orthopaedics at the selected tertiary care teaching hospital. Data were obtained from patients' clinical examinations, inpatient and outpatient records, operative notes, anaesthesia records, laboratory and microbiological reports, radiographs, implant records and structured follow-up assessments.

Study Design

This was a hospital-based prospective longitudinal cohort study. Eligible patients were enrolled consecutively at the time of revision total hip arthroplasty and were followed after surgery to document complications, reoperations and implant survivorship.

Study Location

The study was conducted in the Department of Orthopaedics. Relevant investigations were performed in the Departments of Radiodiagnosis, Pathology and Microbiology of the same institution.

Study Duration

The study was conducted over three years. Patients were recruited during the first two years and followed for a minimum of 12 months after revision surgery. Patients were assessed before surgery, during hospitalization and at 6 weeks, 3 months, 6 months, 12 months and annually thereafter.

Sample Size

The sample size was calculated using the formula:

$$n = \frac{Z_{\alpha/2}^2 \times p(1-p)}{d^2}$$

where $Z_{\alpha/2} = 1.96$ at the 95% confidence level, $p = 0.20$ was the anticipated proportion of postoperative complications, and $d = 0.07$ was the absolute precision.

$$n = \frac{(1.96)^2 \times 0.20 \times 0.80}{(0.07)^2} \approx 126$$

After allowing approximately 10% for loss to follow-up or incomplete data, the required sample size was approximately 139. Therefore, 140 patients undergoing revision total hip arthroplasty were included using consecutive sampling.

Inclusion Criteria

1. Patients aged 18 years or older.
2. Patients undergoing revision of one or more components of a previous total hip arthroplasty.
3. Patients undergoing revision for aseptic loosening, instability, implant wear, periprosthetic fracture, implant breakage, adverse local tissue reaction or periprosthetic joint infection.
4. Patients undergoing either single-stage or two-stage revision total hip arthroplasty.
5. Patients who provided written informed consent and agreed to participate in follow-up.

Exclusion Criteria

1. Patients undergoing primary total hip arthroplasty.
2. Patients undergoing isolated superficial wound procedures without intervention involving the prosthetic joint.
3. Patients undergoing conversion of hemiarthroplasty or previous internal fixation to primary total hip arthroplasty.
4. Patients with incomplete baseline clinical, operative or implant information.
5. Patients who were medically unfit for the planned revision procedure.
6. Patients who declined consent or were unavailable for postoperative follow-up.

Procedure and Methodology

After approval from the Institutional Ethics Committee, eligible patients were enrolled after written informed consent had been obtained. Each patient underwent a detailed clinical assessment. Information regarding age, sex, body mass index, smoking, alcohol use, diabetes, hypertension, anaemia, renal disease, cardiovascular disease, osteoporosis, previous hip procedures and duration from primary arthroplasty to revision was documented. Comorbidity burden and ASA physical status were recorded.

The indication for revision was classified as aseptic loosening, periprosthetic joint infection, recurrent dislocation, polyethylene wear or osteolysis, periprosthetic fracture, component malposition, implant breakage or other causes. Preoperative anteroposterior pelvic and lateral hip radiographs were evaluated for component position, fixation, migration, osteolysis and bone loss. Acetabular and femoral bone loss was classified using the Paprosky classification.

Computed tomography was performed when additional assessment of bone loss or component orientation was required.

Preoperative investigations included complete blood count, renal and liver function tests, serum glucose, coagulation profile, C-reactive protein and erythrocyte sedimentation rate. Joint aspiration and synovial fluid examination were performed when infection was suspected.

The surgical approach, type of revision, number of components revised, fixation method, bearing surface, femoral-head diameter, use of dual-mobility or constrained liners, bone grafts, augments and revision stems were recorded. Operative duration, estimated blood loss, transfusion requirement, intraoperative cultures, complications and length of hospital stay were documented. Antibiotic and venous thromboembolism prophylaxis were administered according to the institutional protocol.

Postoperative complications were categorized as medical or surgical and as early (within 90 days) or late (after 90 days). They included wound complications, periprosthetic joint infection, dislocation, periprosthetic fracture, thromboembolism, nerve injury, aseptic loosening and component migration.

Reoperation was defined as any subsequent surgical procedure involving the operated hip. Repeat revision was defined as removal, exchange or addition of one or more prosthetic components. Implant failure was defined as repeat revision, removal of any component or permanent implant removal. Implant survivorship was calculated from the date of rTHA to implant failure. Patients without failure were censored at death, loss to follow-up or their last clinical assessment.

Pain and hip function were assessed using the Harris Hip Score before surgery and during follow-up. Follow-up radiographs were examined for component migration, radiolucent lines, osteolysis, loosening, fracture, dislocation and implant failure.

Sample Processing

No separate biological samples were stored solely for this study. When periprosthetic joint infection was suspected, preoperative synovial fluid was collected under aseptic precautions and submitted for total leukocyte count, differential count, Gram staining and aerobic and anaerobic cultures.

During revision surgery, at least three to five separate periprosthetic tissue samples were obtained from suspicious areas using separate sterile instruments. Samples were immediately transported to the microbiology laboratory in sterile containers for aerobic, anaerobic and, when clinically indicated, fungal or mycobacterial culture. Tissue specimens were also sent for histopathological examination.

Isolated organisms were identified, and antimicrobial susceptibility testing was performed according to the prevailing laboratory standards.

Data Collection

Data were collected using a predesigned and pretested case-record form. The form included:

- Patient-related variables: demographic characteristics, BMI, comorbidities, smoking, ASA class, preoperative haemoglobin and functional score.
- Surgery-related variables: indication, revision strategy, surgical approach, bone loss, operative duration, blood loss, transfusion, components revised and intraoperative complications.
- Implant-related variables: fixation, bearing surface, head diameter, stem type, liner type, bone grafts and augments.
- Outcome variables: postoperative complications, reoperation, repeat revision, mortality, functional outcome and implant survivorship.

Each participant was assigned a unique study identification number. Data were checked for completeness and entered into a password-protected electronic database. Patient identity was kept confidential.

Statistical Methods

Data were analysed using IBM SPSS Statistics or an equivalent statistical package. Continuous variables were presented as mean and standard deviation or median and interquartile range, depending on their distribution. Categorical variables were summarized as frequencies and percentages. All estimates were reported with 95% confidence intervals.

The independent-samples t-test or Mann-Whitney U test was used to compare continuous variables. The chi-square test or Fisher's exact test was used for categorical variables. Changes in functional scores over time were assessed using the paired t-test, repeated-measures ANOVA or suitable non-parametric alternatives.

Univariable logistic regression was used to evaluate patient-, surgery- and implant-related predictors of complications and reoperation. Variables with clinical relevance or a univariable $p < 0.20$ were entered into multivariable logistic regression models. Adjusted odds ratios with 95% confidence intervals were reported. Multicollinearity and model calibration were assessed.

Implant survivorship was estimated using the Kaplan-Meier method, with repeat revision or removal of any component as the endpoint. Survivorship curves were compared using the log-rank test. Cox proportional-hazards regression was used to identify independent predictors of implant failure. Adjusted hazard ratios

with 95% confidence intervals were reported, and the proportional-hazards assumption was examined. A two-sided $p < 0.05$ was considered statistically significant.

OBSERVATION AND RESULTS

Table 1: Patient-, surgery- and implant-related profile of patients undergoing revision total hip arthroplasty (N=140)

Study parameter	n (%) or Mean (SD)	95 % CI	Test statistic	P value
Patient-related characteristics				
Age, years	66.8 (10.9)	65.0 - 68.6		
Age ≥ 70 years	52 (37.1)	29.6 - 45.4		
Age <70 years	88 (62.9)	54.6 - 70.4	$\chi^2=9.26$	0.002
Male	83 (59.3)	51.0 - 67.1		
Female	57 (40.7)	32.9 - 49.0	$\chi^2=4.83$	0.028
BMI, kg/m ²	27.6 (4.6)	26.8 - 28.4		
BMI ≥ 30 kg/m ²	39 (27.9)	21.1 - 35.8		
Diabetes mellitus	34 (24.3)	17.9 - 32.0		
Hypertension	52 (37.1)	29.6 - 45.4		
Current smoker	27 (19.3)	13.6 - 26.6		
Preoperative anaemia	43 (30.7)	23.7 - 38.8		
ASA physical status III-IV	49 (35.0)	27.6 - 43.2		

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Previous revision surgery ≥ 2	22 (15.7)	10.6 - 22.6		
Preoperative Harris Hip Score	42.8 (12.6)	40.7 - 44.9		
Indication for revision			$\chi^2=41.7$ 7†	<0.0 01
Aseptic loosening	47 (33.6)	26.3 - 41.7		
Periprosthetic joint infection	31 (22.1)	16.1 - 29.7		
Recurrent dislocation	23 (16.4)	11.2 - 23.4		
Periprosthetic fracture	18 (12.9)	8.3- 19.4		
Polyethylene wear/osteolysis	12 (8.6)	5.0- 14.4		
Component malposition/im plant failure	9 (6.4)	3.4- 11.8		
Surgery-related characteristics				
Operative duration, minutes	176.4 (48.7)	168. 3- 184. 5		
Operative duration >180 minutes	47 (33.6)	26.3 - 41.7		
Estimated blood loss, mL	842.0 (356.0)	782. 5- 901. 5		
Blood loss >1000 mL	39 (27.9)	21.1 - 35.8		
Blood transfusion required	61 (43.6)	35.6 - 51.8		
Severe bone loss: Paprosky III-IV	34 (24.3)	17.9 - 32.0		
Acetabular component revision alone	46 (32.9)	25.6 - 41.0		
Femoral component revision alone	33 (23.6)	17.3 - 31.2		

Both components revised	61 (43.6)	35.6 - 51.8	$\chi^2=8.87$ †	0.01 2
Length of hospital stay, days	9.6 (4.1)	8.9- 10.3		
Implant-related characteristics				
Uncemented fixation	79 (56.4)	48.2 - 64.4		
Hybrid fixation	43 (30.7)	23.7 - 38.8		
Cemented fixation	18 (12.9)	8.3- 19.4	$\chi^2=41.8$ 6†	<0.0 01
Ceramic-on-polyethylene bearing	88 (62.9)	54.6 - 70.4		
Metal-on-polyethylene bearing	31 (22.1)	16.1 - 29.7		
Ceramic-on-ceramic bearing	21 (15.0)	10.0 - 21.8	$\chi^2=53.5$ 6†	<0.0 01
Dual-mobility component used	31 (22.1)	16.1 - 29.7	$\chi^2=43.4$ 6‡	<0.0 01
Constrained liner used	9 (6.4)	3.4- 11.8	$\chi^2=106.$ 31‡	<0.0 01
Bone graft/metal augment used	43 (30.7)	23.7 - 38.8	$\chi^2=20.8$ 3‡	<0.0 01

†Chi-square goodness-of-fit test across mutually exclusive categories.

‡One-sample chi-square test comparing the presence and absence of the characteristic. Continuous variables were descriptive; therefore, significance testing was not applicable.

Table 1 presents the patient-, surgery- and implant-related characteristics of 140 patients who underwent revision total hip arthroplasty. The mean age was 66.8±10.9 years (95% CI: 65.0-68.6), and 52 (37.1%) patients were aged ≥ 70 years. Most patients were male (59.3%), with a statistically significant difference in sex distribution ($\chi^2=4.83$, $p=0.028$). The mean BMI was 27.6±4.6 kg/m², while 27.9% were obese. Hypertension was present in 37.1%, preoperative anaemia in 30.7%, diabetes mellitus in 24.3%, and ASA class III-IV in 35.0%. Aseptic loosening was the most common indication for revision (33.6%), followed by periprosthetic joint infection (22.1%), recurrent dislocation (16.4%) and periprosthetic

fracture (12.9%); the distribution of indications was statistically significant ($\chi^2=41.77$, $p<0.001$). The mean operative duration was 176.4 ± 48.7 minutes, mean blood loss was 842.0 ± 356.0 mL, and 43.6% required a blood transfusion. Both acetabular and femoral components were revised in 43.6% of patients, compared with isolated acetabular revision in 32.9% and isolated femoral revision in 23.6% ($\chi^2=8.87$, $p=0.012$). Uncemented fixation was used most frequently (56.4%), and ceramic-on-polyethylene was the predominant bearing surface (62.9%). Dual-mobility components, constrained liners and bone grafts or metal augments were used in 22.1%, 6.4% and 30.7% of patients, respectively.

Table 2: Incidence and types of complications and reoperations following revision total hip arthroplasty (N=140)

Outcome	n (%)	95 % CI	Test statistic	P value
Any postoperative complication	43 (30.7)	23.7-38.8	$\chi^2=20.83$	<0.001
No postoperative complication	97 (69.3)	61.2-76.3		
Early complication, ≤ 90 days	31 (22.1)	16.1-29.7		
Late complication, >90 days	12 (8.6)	5.0-14.4	$\chi^2=8.85$	0.003
Types of complications§			Q=24.67	<0.001
Dislocation	13 (9.3)	5.5-15.3		
Periprosthetic joint infection	9 (6.4)	3.4-11.8		
Aseptic loosening/component migration	8 (5.7)	2.9-10.9		
Wound-related complication	7 (5.0)	2.4-10.0		
Periprosthetic fracture	6 (4.3)	2.0-9.0		
Venous thromboembolism	4 (2.9)	1.1-7.1		
Neurological injury	3 (2.1)	0.7-6.1		

Other medical complications	11 (7.9)	4.4-13.5		
Ninety-day mortality	3 (2.1)	0.7-6.1		
Any reoperation	24 (17.1)	11.8-24.2	$\chi^2=60.46$	<0.001
No reoperation	116 (82.9)	75.8-88.2		
Reoperation within 90 days	11 (7.9)	4.4-13.5		
Reoperation after 90 days	13 (9.3)	5.5-15.3	$\chi^2=0.17$	0.683
Primary type of reoperation¶			$\chi^2=13.83$	0.008
Repeat revision of component(s)	11 (7.9)	4.4-13.5		
Debridement, antibiotics and implant retention	7 (5.0)	2.4-10.0		
Open reduction/internal fixation of fracture	3 (2.1)	0.7-6.1		
Evacuation of haematoma/wound debridement	2 (1.4)	0.4-5.1		
Nerve exploration/other procedure	1 (0.7)	0.1-3.9		
Implant failure requiring repeat revision/removal	17 (12.1)	7.7-18.6	$\chi^2=80.23$	<0.001
Implant retained at last follow-up	123 (87.9)	81.4-92.3		

§Patients could experience more than one complication; therefore, complication types did not sum to 43. Cochran's Q test compared the frequencies of different complication types. ¶Reoperation categories represented the first major reoperation and were mutually exclusive. Binary chi-square tests compared patients with and without the specified outcome.

Table 2 shows that 43 (30.7%; 95% CI: 23.7-38.8) patients experienced at least one postoperative complication, whereas 97 (69.3%) remained free of

complications ($\chi^2=20.83$, $p<0.001$). Early complications occurring within 90 days were more frequent than late complications (22.1% versus 8.6%; $\chi^2=8.85$, $p=0.003$). Dislocation was the most frequent individual complication (9.3%), followed by other medical complications (7.9%), periprosthetic joint infection (6.4%), aseptic loosening or component migration (5.7%), wound complications (5.0%) and periprosthetic fracture (4.3%). The frequencies of different complication types varied significantly (Cochran's $Q=24.67$, $p<0.001$). Ninety-day mortality was 2.1%. Overall, 24 (17.1%; 95% CI: 11.8-24.2) patients underwent reoperation, while 116 (82.9%) did not ($\chi^2=60.46$, $p<0.001$). Reoperation occurred within 90 days in 7.9% and after 90 days in 9.3%, with no significant difference between the two periods ($p=0.683$). Repeat component revision was the most frequent reoperation (7.9%), followed by debridement, antibiotics and implant retention (5.0%). Implant failure requiring repeat revision or removal occurred in 17 (12.1%; 95% CI: 7.7-18.6) patients, whereas the implant was retained in 123 (87.9%) patients ($p<0.001$).

Table 3: Patient-, surgery- and implant-related factors associated with complications and reoperation following revision total hip arthroplasty (N=140)

Predictor	Total exposed, n (%)	Complication, n/N (%)	Adjusted OR (95% CI)	P value*	Reoperation, n/N (%)	Adjusted OR (95% CI)	P value*
Patient-related factors							
Age ≥ 70 years	52 (37.1)	24/52 (46.2)	2.41 (1.12-5.18)	0.025	14/52 (26.9)	2.36 (1.01-5.53)	0.048
BMI ≥ 30 kg/m ²	39 (27.9)	18/39 (46.2)	2.17 (1.01-4.66)	0.047	11/39 (28.2)	2.24 (0.94-5.34)	0.068

Diabetes mellitus	34 (24.3)	16/34 (47.1)	1.96 (0.88-4.38)	0.100	9/34 (26.5)	1.71 (0.68-4.29)	0.254
Preoperative anaemia	43 (30.7)	19/43 (44.2)	1.82 (0.85-3.90)	0.123	11/43 (25.6)	1.68 (0.70-4.04)	0.246
ASA class III-IV	49 (35.0)	23/49 (46.9)	2.53 (1.17-5.47)	0.018	13/49 (26.5)	2.27 (0.96-5.38)	0.062
Previous revision surgery ≥ 2	22 (15.7)	12/22 (54.5)	2.46 (0.96-6.31)	0.061	8/22 (36.4)	2.78 (1.01-7.67)	0.048
Surgery-related factors							
Revision for infection	31 (22.1)	16/31 (51.6)	3.08 (1.30-7.30)	0.011	10/31 (32.3)	3.17 (1.22-8.25)	0.018
Paprosky type III-IV bone loss	34 (24.3)	17/34 (50.0)	2.69 (1.18-6.13)	0.019	10/34 (29.4)	2.51 (0.99-6.38)	0.053
Operative duration >180 minutes	47 (33.6)	22/47 (46.8)	2.36 (1.10-5.08)	0.028	12/47 (25.5)	2.09 (0.88-4.98)	0.096
Blood loss >100	39 (27.9)	19/39 (48.7)	2.47 (1.11-	0.027	11/39 (28.2)	2.21 (0.91-	0.079

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0 mL			5.4 (8)			5.3 (6)	
Both components revised	61 (43.6)	25/61 (41.0)	1.63 (0.77-3.45)	0.204	14/61 (23.0)	1.68 (0.71-3.97)	0.236
Implant-related factors							
Post operative component malposition	27 (19.3)	14/27 (51.9)	3.21 (1.29-7.99)	0.012	9/27 (33.3)	2.84 (1.06-7.60)	0.038
Cemented fixation	18 (12.9)	8/18 (44.4)	1.42 (0.51-3.94)	0.502	4/18 (22.2)	1.31 (0.37-4.61)	0.674
Dual-mobility component	31 (22.1)	5/31 (16.1)	0.38 (0.13-1.08)	0.069	3/31 (9.7)	0.47 (0.13-1.73)	0.257
Constrained liner	9 (6.4)	4/9 (44.4)	1.38 (0.32-5.91)	0.667	2/9 (22.2)	1.21 (0.22-6.80)	0.825

*Wald test from multivariable binary logistic regression. OR: odds ratio; ASA: American Society of Anesthesiologists. The complication and reoperation models were adjusted for clinically relevant patient-, surgery- and implant-related variables. Table 3 demonstrates that several patient-, surgery- and implant-related factors independently predicted postoperative complications. Age ≥ 70 years (aOR=2.41; 95% CI: 1.12-5.18; p=0.025), obesity (aOR=2.17; 95% CI: 1.01-4.66; p=0.047) and ASA class III-IV (aOR=2.53; 95% CI: 1.17-5.47; p=0.018) were significant patient-related predictors. Among the surgery-related factors, revision for infection increased the odds of complications approximately

threefold (aOR=3.08; 95% CI: 1.30-7.30; p=0.011). Severe Paprosky type III-IV bone loss (aOR=2.69; p=0.019), operative duration >180 minutes (aOR=2.36; p=0.028) and blood loss >1000 mL (aOR=2.47; p=0.027) were also independently associated with complications. Postoperative component malposition was the strongest implant-related predictor of complications (aOR=3.21; 95% CI: 1.29-7.99; p=0.012). Significant independent predictors of reoperation included age ≥ 70 years (aOR=2.36; p=0.048), two or more previous revision operations (aOR=2.78; p=0.048), revision for infection (aOR=3.17; p=0.018) and postoperative component malposition (aOR=2.84; p=0.038). Diabetes, anaemia, cemented fixation, constrained liners and revision of both components were not significantly associated with either outcome. Dual-mobility components showed a potentially protective association, but this did not reach statistical significance for complications (p=0.069) or reoperation (p=0.257).

Table 4: Implant survivorship and predictors of implant failure following revision total hip arthroplasty (N=140)

A. Kaplan-Meier implant survivorship

Follow-up period	Patients at risk, n	Cumulative implant failure s, n	Implant survivorship, % (95% CI)	Test statistic	P value
6 months	136	4	97.1 (92.8-98.9)		
1 year	128	8	94.2 (88.7-97.1)		
2 years	94	13	90.2 (83.4-94.4)		
3 years	57	17	85.9 (77.5-91.4)		
Overall comparison according to indication for revision				Log-rank $\chi^2=1$ 2.46	0.06

B. Cox proportional-hazards analysis of predictors of implant failure

Predictor	Implant failures, n/N (%)	Unadjusted HR (95% CI)	P value	Adjusted HR (95% CI)	Wald statistic	P value
Age ≥ 70 years	9/52 (17.3)	2.09 (0.81-5.39)	0.127			
BMI ≥ 30 kg/m ²	7/39 (17.9)	1.87 (0.70-4.97)	0.211			
ASA class III-IV	9/49 (18.4)	2.27 (0.87-5.91)	0.094			
Previous revision surgery ≥ 2	6/22 (27.3)	2.84 (1.05-7.70)	0.040			
Revision for periprosthetic joint infection	8/31 (25.8)	3.38 (1.30-8.79)	0.013	3.12 (1.18-8.26)	5.24	0.022
Paprosky type III-IV bone loss	8/34 (23.5)	2.91 (1.12-7.55)	0.028	2.73 (1.04-7.17)	4.15	0.042
Operative duration >180 minutes	9/47 (19.1)	2.31 (0.89-6.00)	0.086			
Both components revised	10/61 (16.4)	1.72 (0.65-4.57)	0.277			
Postoperative component malposition	7/27 (25.9)	3.17 (1.18-8.49)	0.022	2.86 (1.05-7.79)	4.24	0.039
Dual-mobility component	2/31 (6.5)	0.43 (0.10-1.88)	0.263			

Table 4 shows a progressive decline in Kaplan-Meier implant survivorship during follow-up. Survivorship was 97.1% (95% CI: 92.8-98.9) at six months, 94.2% (95% CI: 88.7-97.1) at one year, 90.2% (95% CI: 83.4-94.4) at two years and 85.9% (95% CI: 77.5-91.4) at three years. Implant survivorship differed significantly according to the indication for revision (log-rank $\chi^2=12.46$, $p=0.006$). On unadjusted Cox regression, two or more previous revision surgeries (HR=2.84; $p=0.040$), revision for periprosthetic joint infection (HR=3.38; $p=0.013$), Paprosky type III-IV bone loss (HR=2.91; $p=0.028$) and postoperative component malposition (HR=3.17; $p=0.022$) significantly increased the hazard of implant failure. After multivariable adjustment, revision for periprosthetic joint infection remained the strongest independent predictor (aHR=3.12; 95% CI: 1.18-8.26; $p=0.022$), followed by postoperative component malposition (aHR=2.86; 95% CI: 1.05-7.79; $p=0.039$) and severe bone loss (aHR=2.73; 95% CI: 1.04-7.17; $p=0.042$). Age, obesity, higher ASA class, prolonged operative duration and revision of both components were not significant predictors of implant failure. Dual-mobility components showed a lower hazard of failure (HR=0.43), although the association was not statistically significant ($p=0.263$).

DISCUSSION

Patient-, surgery- and implant-related profile

The present study included 140 patients undergoing revision total hip arthroplasty (rTHA), with a mean age of 66.8 ± 10.9 years; 37.1% were aged ≥ 70 years and 59.3% were male. The age profile reflected the increasing burden of revision procedures among older adults who frequently have multiple comorbidities and reduced physiological reserve. Gwam et al. (2017)^[1] similarly observed that most patients undergoing rTHA were older adults and that the number of revision procedures was increasing with the expanding population of primary arthroplasty recipients. Schwartz et al. (2020)^[2] also projected a substantial rise in revision hip arthroplasty procedures, emphasizing the clinical and economic importance of identifying modifiable risk factors.

Obesity was present in 27.9%, diabetes mellitus in 24.3%, hypertension in 37.1%, preoperative anaemia in 30.7% and ASA class III-IV in 35.0% of the patients. These findings demonstrated that patients undergoing revision surgery commonly had a considerable preoperative medical burden. Kunutsor et al. (2016)^[3] identified obesity, diabetes, smoking and higher comorbidity burden as important risk factors for periprosthetic joint infection following arthroplasty. The relatively high frequency of anaemia in the present study was also clinically important because anaemic patients have lower physiological

tolerance for the substantial blood loss associated with revision procedures.

Aseptic loosening was the most frequent indication for revision in the present study, accounting for 33.6% of cases, followed by periprosthetic joint infection (22.1%), recurrent dislocation (16.4%) and periprosthetic fracture (12.9%). Kelmer et al. (2021)^[4] similarly reported aseptic loosening, infection, instability and periprosthetic fracture as the principal mechanisms leading to revision THA. Kenney et al. (2019)^[5], in a systematic review of failed revision hip arthroplasties, found that aseptic loosening, instability and infection were the three leading mechanisms of failure. The relatively high proportion of infection-related revisions in the present study could reflect the tertiary referral setting, where complex infected arthroplasties were more likely to be managed.

The mean operative duration was 176.4±48.7 minutes, and one-third of the procedures lasted longer than 180 minutes. Mean estimated blood loss was 842.0±356.0 mL, 27.9% lost more than 1000 mL, and 43.6% required transfusion. Both acetabular and femoral components were revised in 43.6% of patients. These findings indicated the technical complexity of rTHA. Surace et al. (2019)^[6] found that prolonged operative duration in hip arthroplasty was associated with higher rates of surgical and medical complications. Extended surgery increases tissue exposure, blood loss, transfusion requirement and the opportunity for bacterial contamination. Revision of both components and severe Paprosky type III-IV bone loss, found in 24.3% of patients, would further increase surgical difficulty and operative duration.

Uncemented fixation was used in 56.4% of cases, and ceramic-on-polyethylene was the predominant bearing surface. Dual-mobility components were used in 22.1%, while constrained liners were used in 6.4%. The use of dual-mobility components was consistent with the increasing preference for these implants in revision procedures with an elevated risk of instability. Reina et al. (2019)^[7] found lower dislocation rates with dual-mobility constructs than with conventional bearings in revision THA. Bone grafts or metal augments were required in 30.7% of patients, reflecting the proportion of cases with substantial acetabular or femoral bone deficiency.

Postoperative complications and reoperations

The overall postoperative complication rate was 30.7% (95% CI: 23.7-38.8). Early complications within 90 days occurred in 22.1%, whereas late complications occurred in 8.6% ($p=0.003$). The predominance of early complications was expected because wound problems, infection, dislocation, venous thromboembolism and perioperative medical events frequently occur during the initial postoperative period. Revision arthroplasty has a higher

complication burden than primary arthroplasty because patients are generally older, medically more complex and subjected to longer and technically demanding surgical procedures.

Dislocation was the most frequent individual complication, affecting 9.3% of patients. This incidence was higher than the 3.2% reported by Shin et al. (2023)^[8], but remained within the broad range reported following revision THA. The difference could be explained by variations in revision indication, abductor function, implant selection, component positioning and the number of previous operations. Hartzler et al. (2018)^[9] demonstrated that dual-mobility constructs reduced dislocation, re-revision and reoperation compared with large femoral heads in revision THA. Nevertheless, Scholz et al. (2024)^[10] emphasized that dual-mobility bearings did not completely eliminate instability, particularly when abductor deficiency or other major mechanical abnormalities were present.

Periprosthetic joint infection occurred in 6.4% of patients, while aseptic loosening or component migration occurred in 5.7%. Infection after rTHA remains particularly challenging because revision procedures involve extensive tissue dissection, longer operative duration, devitalized tissue, bone defects and repeated implant exposure. The infection rate in this study was clinically relevant, especially because 22.1% of the cohort had already undergone revision for periprosthetic joint infection. De Martino et al. (2017)^[11] noted that although modern implant designs may reduce instability, infection and aseptic loosening continue to influence the long-term success of revision arthroplasty.

Periprosthetic fracture occurred in 4.3%, wound complications in 5.0%, venous thromboembolism in 2.9% and neurological injury in 2.1%. Ninety-day mortality was 2.1%. These findings highlighted that rTHA was associated with both local surgical and systemic medical complications. The mortality rate may have been related to advanced age, comorbidity burden, infection, blood loss and prolonged hospitalization rather than the implant alone.

Overall, 17.1% of patients underwent reoperation. Reoperations occurring within and after 90 days were comparable at 7.9% and 9.3%, respectively ($p=0.683$), demonstrating that clinically important failures continued beyond the immediate postoperative period. Repeat component revision was the most frequent reoperation, followed by debridement, antibiotics and implant retention. Implant failure requiring repeat revision or removal occurred in 12.1% of patients. Khatod et al. (2015)^[12] reported five-year implant survival of approximately 86.8% following rTHA, demonstrating that repeat failure remains an important concern after revision surgery.

Predictors of complications and reoperation

Advanced age was an independent predictor of complications (aOR=2.41; p=0.025) and reoperation (aOR=2.36; p=0.048). Older patients may have frailty, osteoporosis, reduced immune function and diminished capacity to tolerate prolonged surgery and postoperative rehabilitation. Higher ASA class was also associated with complications (aOR=2.53; p=0.018), supporting the importance of preoperative medical optimization. However, ASA class did not independently predict reoperation, suggesting that reoperation was more strongly determined by local mechanical and infective factors.

Obesity independently increased the odds of complications (aOR=2.17; p=0.047), although its association with reoperation did not reach statistical significance. Obesity can make surgical exposure more difficult, prolong operative duration and increase wound-related and infectious complications. Kunutsor et al. (2016)^[3] similarly identified elevated BMI as a risk factor for infection after total joint arthroplasty. Diabetes and anaemia showed increased odds of adverse outcomes, but their adjusted associations were not statistically significant. This absence of significance may have been due to the modest sample size, effective perioperative optimization or correlation with other comorbid factors.

Patients with two or more previous revisions had a significantly increased likelihood of reoperation (aOR=2.78; p=0.048). Khatod et al. (2015)^[12] similarly found that the indication for revision and the history of previous revision operations affected the risk of subsequent re-revision. Repeated surgery causes progressive bone loss, scar formation, soft-tissue damage, abductor insufficiency and increased microbial exposure, creating an increasingly difficult reconstructive environment.

Revision for infection was one of the strongest predictors of complications (aOR=3.08; p=0.011) and reoperation (aOR=3.17; p=0.018). Persistent or recurrent infection can result from biofilm-producing organisms, poor host immunity, resistant microorganisms or inadequate soft-tissue coverage. Kenney et al. (2019)^[5] identified infection as one of the leading causes of failure after revision arthroplasty. These results indicated that patients undergoing septic revision required careful organism identification, adequate debridement, appropriate antimicrobial therapy and close postoperative monitoring.

Severe Paprosky type III-IV bone loss independently increased the odds of complications (aOR=2.69; p=0.019) and showed a borderline association with reoperation (aOR=2.51; p=0.053). Severe bone deficiency reduces the available host bone for implant fixation and may require structural grafts, porous metal augments or complex revision components. The

wide confidence interval and borderline p value for reoperation indicated limited statistical precision rather than absence of a clinically meaningful relationship.

An operative duration exceeding 180 minutes and blood loss exceeding 1000 mL were independently associated with complications. Surace et al. (2019)^[6] similarly showed that prolonged operative time increased short-term complications after hip arthroplasty. Prolonged surgery and excessive blood loss may indicate greater surgical complexity and may also directly contribute to infection, transfusion-associated events and delayed recovery. However, neither variable independently predicted reoperation, suggesting that their principal effects were concentrated in the perioperative period.

Postoperative component malposition was the strongest implant-related predictor of complications (aOR=3.21; p=0.012) and also independently predicted reoperation (aOR=2.84; p=0.038). Improper cup inclination, anteversion, femoral version or offset restoration can cause impingement, instability, abnormal wear and recurrent dislocation. Shin et al. (2023)^[8] identified component position, head size and prior hip operations as clinically relevant factors affecting instability after revision THA. The present findings reinforced the need for meticulous preoperative planning and accurate component orientation.

Dual-mobility components demonstrated a potentially protective effect against complications and reoperation, although the associations did not reach statistical significance. Reina et al. (2019)^[7] reported that dual-mobility constructs reduced dislocation following revision THA. Hartzler et al. (2018)^[9] also observed lower dislocation and re-revision rates than with large femoral heads. In the present study, the absence of statistical significance could be related to the relatively small number of patients receiving dual-mobility implants and their preferential use in individuals already considered at high risk of instability. Scholz et al. (2024)^[10] similarly cautioned that dual-mobility implants improve stability but cannot compensate completely for severe abductor deficiency or unresolved mechanical abnormalities.

Implant survivorship and predictors of implant failure

Kaplan-Meier implant survivorship declined from 97.1% at six months to 94.2% at one year, 90.2% at two years and 85.9% at three years. Survivorship differed significantly according to the indication for revision (log-rank $\chi^2=12.46$, p=0.006). The three-year survivorship observed in the present study was comparable to the five-year implant survival of 86.8% reported by Khatod et al. (2015)^[12], although differences in follow-up, case complexity and failure

definitions should be considered. Shin et al. (2023)^[8] reported 91.7% survivorship with dislocation as the endpoint at 125 months; their more restricted endpoint explains the apparently higher survival estimate.

On unadjusted analysis, previous revision surgery, revision for infection, severe bone loss and component malposition significantly increased the hazard of implant failure. After multivariable adjustment, revision for infection remained the strongest independent predictor (aHR=3.12; p=0.022), followed by component malposition (aHR=2.86; p=0.039) and Paprosky type III-IV bone loss (aHR=2.73; p=0.042). These findings were consistent with the systematic review by Kenney et al. (2019)^[5], which identified infection, instability and aseptic loosening as the major causes of failure after rTHA.

Age, obesity, ASA class, prolonged operative duration and revision of both components did not independently predict implant failure. These variables appeared to influence short-term complications more strongly than mechanical implant survival. Dual-mobility components showed a lower hazard of failure (HR=0.43), but the association was not statistically significant. The direction of this association agreed with the findings of Hartzler et al. (2018)^[9], Reina et al. (2019)^[7] and Scholz et al. (2024)^[10], who reported fewer instability-related failures with dual-mobility bearings.

CONCLUSION

Revision total hip arthroplasty was associated with a considerable burden of postoperative complications, reoperations and implant failure. Nearly one-third of patients developed complications, 17.1% underwent reoperation and 12.1% experienced implant failure. Advanced age, obesity, higher ASA class, revision for infection, severe bone loss, prolonged operative duration, excessive blood loss and postoperative component malposition independently increased the risk of complications. Advanced age, multiple previous revisions, infection-related revision and component malposition were significant predictors of reoperation. Implant survivorship progressively declined from 97.1% at six months to 85.9% at three years. Periprosthetic joint infection, Paprosky type III-IV bone loss and postoperative component malposition independently predicted implant failure. Careful patient selection, preoperative optimization, effective infection control, appropriate reconstruction of bone defects and accurate component positioning may reduce adverse outcomes and improve implant survivorship following revision total hip arthroplasty.

Limitations

1. The study was conducted at a single tertiary care centre; therefore, the findings may not be generalizable to hospitals with different

patient profiles, surgical expertise or implant practices.

2. The sample size of 140 patients was relatively small, particularly for subgroup and survival analyses.
3. Only 17 implant failures occurred. Consequently, the number of predictors that could be reliably included in the multivariable Cox regression model was limited.
4. The follow-up duration was relatively short for evaluating late complications, polyethylene wear, aseptic loosening and long-term implant survivorship.
5. Loss to follow-up and censoring may have introduced attrition bias, particularly in the later survivorship estimates.
6. Revision procedures were heterogeneous with respect to their indications, bone loss severity, surgical approach, fixation method and implant design.
7. Surgeon experience, hospital volume, abductor integrity, exact component orientation and adherence to rehabilitation were not evaluated comprehensively.
8. Some relatively uncommon complications may have been underestimated because of their small numbers.
9. The observational design could demonstrate associations but could not establish a direct causal relationship between the identified predictors and adverse outcomes.
10. Residual confounding from unmeasured factors, including nutritional status, frailty, socioeconomic status and organism-related characteristics, could not be excluded.

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