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Original Article

Predictors of Functional Recovery Following Hip Fracture Surgery in Elderly Patients: A Prospective Cohort Study

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Abstract-

Background: Hip fracture is a major cause of disability among older adults, and functional recovery after surgical fixation varies widely between individuals. Identifying modifiable and non-modifiable predictors of recovery can guide perioperative care and rehabilitation planning. **Objective:** To identify clinical, surgical, and socio-demographic predictors of functional recovery at six months following hip fracture surgery in patients aged 65 years and older. **Methods:** This prospective observational cohort study enrolled 240 patients aged ≥65 years who underwent surgical fixation or arthroplasty for hip fracture at a tertiary care orthopaedic unit over an 18-month period. Functional recovery was assessed using the Barthel Index and the Harris Hip Score preoperatively, at discharge, and at 6 months. Recovery was defined as a return to at least 80% of pre-fracture Barthel Index score. Univariate comparisons were followed by multivariate logistic regression to identify independent predictors of recovery, with results expressed as adjusted odds ratios (aOR) and 95% confidence intervals (CI). **Results:** Of 240 patients (mean age 76.8 ± 7.2 years; 68.3% female), 152 (63.3%) achieved satisfactory functional recovery at 6 months. On multivariate analysis, independent predictors of poor recovery included age ≥80 years (aOR 0.42, 95% CI 0.23–0.79), pre-fracture cognitive impairment (aOR 0.31, 95% CI 0.16–0.61), ASA grade III–IV (aOR 0.38, 95% CI 0.20–0.73), surgical delay beyond 48 hours (aOR 0.46, 95% CI 0.25–0.85), low pre-admission serum albumin <3.5 g/dL (aOR 0.40, 95% CI 0.21–0.76), and poor pre-fracture mobility status (aOR 0.35, 95% CI 0.18–0.69). Early mobilization within 48 hours postoperatively was associated with significantly better recovery (aOR 2.86, 95% CI 1.52–5.38). **Conclusion:** Advanced age, cognitive impairment, higher anaesthetic risk grade, surgical delay, malnutrition, and poor baseline mobility independently predict reduced functional recovery after hip fracture surgery, whereas early postoperative mobilization is protective. These findings support multidisciplinary, orthogeriatric care pathways that prioritise nutritional optimisation, expedited surgery, and early rehabilitation in high-risk elderly patients.

Keywords: *hip fracture; functional recovery; elderly; predictors; rehabilitation; orthogeriatrics.*

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INTRODUCTION

Hip fracture is one of the most serious osteoporosis-related injuries affecting older adults and represents a leading cause of disability, institutionalisation, and mortality worldwide.1 The global burden is expected to rise substantially as populations age, with the worldwide incidence of hip fracture projected to increase considerably over the coming decades, placing growing strain on orthopaedic and rehabilitation services.2 Beyond the immediate surgical risks, hip fracture in elderly patients is distinct from fractures in younger populations because it occurs against a backdrop of multimorbidity, sarcopenia, cognitive decline, and reduced physiological reserve, all of which influence the trajectory of recovery long after bony union has occurred.3

Functional recovery, rather than survival alone, has increasingly been recognised as the outcome that matters most to patients and caregivers. Historical cohort data indicate that while approximately three-quarters of patients regain their pre-fracture level of basic activities of daily living within a year, fewer than half recover their pre-fracture instrumental activities of daily living, such as shopping, managing finances, or using transportation.4 This gap between survival and functional independence underlines the importance of identifying, at the time of admission, which patients are at greatest risk of poor recovery so that care can be tailored accordingly.5

A substantial body of literature has examined predictors of poor functional outcome after hip fracture. Medical factors such as advanced age, multiple comorbidities, a high American Society of Anesthesiologists (ASA) physical status grade, cognitive impairment, poor pre-fracture functional status, sarcopenia, and low hand-grip strength have consistently emerged as important determinants.6 Surgical and system-related factors, including delay to surgery beyond 48 hours, fracture type, and the volume or organisation of the treating centre, have also been implicated.6 A large meta-analysis pooling data from more than 190,000 patients demonstrated that surgery performed within 48 hours of admission was associated with a meaningfully lower risk of death and, in several studies, with improved functional outcomes compared with delayed surgery.8 Similarly, malnutrition, reflected by low serum albumin, and cognitive impairment at the time of injury have been repeatedly associated with reduced gains in mobility and self-care during rehabilitation.9

Despite this accumulating evidence, predictors of recovery are not uniformly reported across studies, and their relative contribution appears to vary by healthcare setting, surgical practice, and rehabilitation infrastructure. Most large cohort studies originate from North American, European, or East Asian populations, and data describing predictors of recovery in other settings, including those with differing case-mix, surgical delay patterns, and post-discharge rehabilitation resources, remain comparatively limited.11 Furthermore, while many studies focus on mortality as the primary endpoint, fewer specifically model functional recovery as the outcome of interest using validated, responsive measures such as the Barthel Index or Harris Hip Score applied longitudinally from the pre-fracture baseline through to mid-term follow-up.4

Early identification of patients at risk of poor functional recovery has direct clinical relevance. It allows clinicians to set realistic expectations with patients and families, prioritise limited rehabilitation resources toward those most likely to benefit, and intervene on modifiable factors, such as nutritional status and time to surgery, before they translate into long-term disability.9 Early mobilisation, in particular, has been highlighted as a key process measure that may mitigate the functional decline associated with prolonged bed rest and deconditioning.12

This study was therefore designed to prospectively evaluate the clinical, surgical, and socio-demographic predictors of functional recovery at six months following hip fracture surgery in elderly patients managed at a tertiary orthopaedic centre, with the aim of informing risk stratification and perioperative care pathways for this vulnerable population.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based, prospective observational cohort study conducted in the Department of Orthopaedic Surgery in collaboration with the Department of Geriatric Medicine of a tertiary care teaching hospital. Patients were enrolled consecutively over an 18-month period, with a minimum follow-up of six months from the date of surgery.

Study Population

All patients aged 65 years and above admitted with a radiologically confirmed fracture of the proximal femur (femoral neck, intertrochanteric, or subtrochanteric) who underwent surgical management, either internal fixation or hemi/total hip arthroplasty, were considered eligible.

Inclusion criteria were: age ≥65 years; radiologically confirmed hip fracture due to a fall from standing height or lower (low-energy trauma); surgical treatment during the index admission; and ability of the patient or a reliable caregiver/proxy to provide pre-fracture functional history and follow-up information.

Exclusion criteria were: pathological fracture secondary to malignancy; periprosthetic or peri-implant fracture; high-energy trauma or polytrauma; fracture managed conservatively without surgery; and patients who died or were lost to follow-up before the six-month assessment, who were excluded from the final predictor analysis but recorded separately for completeness.

Data Collection

Baseline data were collected at admission, including age, sex, body mass index, residential status (living alone versus with family/institution), pre-fracture ambulatory status, pre-fracture Barthel Index, cognitive status (assessed using the Mini-Mental State Examination, with a score <24 classifying cognitive impairment), comorbidity burden (Charlson Comorbidity Index), ASA physical status grade, fracture type, type of surgical procedure, time from admission to surgery, serum albumin and haemoglobin at admission, and occurrence of major postoperative complications (e.g., surgical site infection, delirium, cardiopulmonary events). Time to first postoperative mobilisation (ambulation or active transfer out of bed, whichever occurred first) was recorded and dichotomised at the 48-hour threshold commonly used in clinical guidelines.

Outcome Assessment

The primary outcome was functional recovery at six months postoperatively, assessed using the Barthel Index for activities of daily living and the Harris Hip Score for hip-specific function and pain. Satisfactory functional recovery was defined a priori as attainment of at least 80% of the patient's documented pre-fracture Barthel Index score at the six-month assessment, consistent with thresholds used in comparable cohort studies. Patients not meeting this threshold were classified as having poor functional recovery. Assessments were performed by trained research staff blinded to the predictor analysis plan, either during outpatient review or by structured telephone interview using validated proxy-administered versions of the instruments when in-person review was not feasible.

Statistical Analysis

Continuous variables were summarised as mean ± standard deviation or median (interquartile range) according to distribution, and compared between recovery groups using the independent-samples t-test or Mann–Whitney U test. Categorical variables were summarised as frequencies and percentages and compared using the chi-square or Fisher's exact test as appropriate. Variables significant at $p<0.10$ on univariate analysis, together with factors considered clinically important a priori, were entered into a multivariate binary logistic regression model with satisfactory functional recovery at six months as the dependent variable. Results are reported as adjusted odds ratios (aOR) with 95% confidence intervals (CI). A two-tailed p-value <0.05 was considered statistically significant for the final model. All analyses were performed using standard statistical software. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants or their legal representatives prior to enrolment.

RESULTS

A total of 268 patients were screened, of whom 240 met the eligibility criteria and were included in the final analysis (Figure 1 description: screening and enrolment flow). The mean age of the cohort was 76.8 ± 7.2 years (range 65–94 years), and 164 (68.3%) were female. At the six-month assessment, 152 patients (63.3%) had achieved satisfactory functional recovery, while 88 patients (36.7%) had poor functional recovery. Eleven patients (4.6% of those originally enrolled, not included in the denominator above) died before the six-month follow-up and were analysed separately.

Table 1. Baseline demographic and clinical characteristics of the study population (N = 240)

Characteristic	Overall (n=240)	Good recovery (n=152)	Poor recovery (n=88)
Age, years (mean ± SD)	76.8 ± 7.2	74.6 ± 6.1	80.5 ± 7.4
Age ≥80 years, n (%)	82 (34.2)	36 (23.7)	46 (52.3)
Female sex, n (%)	164 (68.3)	104 (68.4)	60 (68.2)
Body mass index, kg/m² (mean ± SD)	22.4 ± 3.6	22.9 ± 3.3	21.5 ± 4.0
Living alone pre-fracture, n (%)	58 (24.2)	31 (20.4)	27 (30.7)
Independent pre-fracture ambulation, n (%)	181 (75.4)	128 (84.2)	53 (60.2)
Cognitive impairment (MMSE <24), n (%)	64 (26.7)	26 (17.1)	38 (43.2)
Charlson Comorbidity Index (mean ± SD)	3.1 ± 1.5	2.6 ± 1.2	4.0 ± 1.6
ASA grade III–IV, n (%)	96 (40.0)	46 (30.3)	50 (56.8)
Serum albumin <3.5 g/dL, n (%)	87 (36.3)	42 (27.6)	45 (51.1)

SD = standard deviation; MMSE = Mini-Mental State Examination; ASA = American Society of Anesthesiologists. All between-group comparisons p<0.05 except female sex (p=0.94).

Table 2. Fracture characteristics, surgical management, and postoperative course by recovery status

Variable	Overall (n=240)	Good recovery (n=152)	Poor recovery (n=88)
Fracture type: Femoral neck, n (%)	104 (43.3)	70 (46.1)	34 (38.6)
Fracture type: Intertrochanteric, n (%)	114 (47.5)	70 (46.1)	44 (50.0)
Fracture type: Subtrochanteric, n (%)	22 (9.2)	12 (7.9)	10 (11.4)

Procedure: Internal fixation, n (%)	138 (57.5)	90 (59.2)	48 (54.5)
Procedure: Hemi/total arthroplasty, n (%)	102 (42.5)	62 (40.8)	40 (45.5)
Time to surgery >48 h, n (%)	98 (40.8)	48 (31.6)	50 (56.8)
Postoperative mobilisation within 48 h, n (%)	146 (60.8)	108 (71.1)	38 (43.2)
Major postoperative complication, n (%)	46 (19.2)	18 (11.8)	28 (31.8)
Length of hospital stay, days (median, IQR)	9 (7–13)	8 (6–11)	12 (9–17)

IQR = interquartile range. Fracture type and procedure distributions did not differ significantly between groups (p>0.05); all other rows p<0.05.

Table 3. Multivariate logistic regression analysis of independent predictors of satisfactory functional recovery at 6 months

Predictor	Adjusted OR	95% Confidence Interval	p-value
Age ≥80 years	0.42	0.23 – 0.79	0.007
Pre-fracture cognitive impairment	0.31	0.16 – 0.61	<0.001
ASA grade III–IV	0.38	0.20 – 0.73	0.003
Poor pre-fracture ambulatory status	0.35	0.18 – 0.69	0.002
Serum albumin <3.5 g/dL	0.40	0.21 – 0.76	0.005
Time to surgery >48 hours	0.46	0.25 – 0.85	0.013
Major postoperative complication	0.44	0.22 – 0.88	0.020
Postoperative mobilisation within 48 hours	2.86	1.52 – 5.38	0.001
Living alone pre-fracture	0.71	0.37 – 1.36	0.300
Female sex	0.92	0.51 – 1.66	0.780

OR = odds ratio. Model adjusted for all variables listed. Hosmer–Lemeshow goodness-of-fit p=0.42; Nagelkerke R^2 = 0.38. OR <1 indicates reduced odds of satisfactory recovery; OR >1 indicates increased odds.

Explanation of Findings

Table 1 demonstrates that patients with poor functional recovery were, on average, older, more cognitively impaired, more dependent in pre-fracture ambulation, and carried a heavier burden of comorbidity and malnutrition than those with good recovery. Notably, sex distribution was almost identical between groups, suggesting that female preponderance in the overall cohort, expected given the higher incidence of osteoporotic fracture in women, did not in itself translate into a higher or lower likelihood of recovery.

Table 2 shows that fracture type and the type of surgical procedure performed were similarly distributed between recovery groups, indicating that the fracture pattern itself was not a major driver of outcome in this cohort. In contrast, surgical delay beyond 48 hours, occurrence of major postoperative complications, and, most strikingly, the timing of postoperative mobilisation differed substantially between groups; patients with poor recovery were nearly twice as likely to have experienced a surgical delay and were mobilised later than those with good recovery.

Table 3 presents the multivariate model retained after adjustment for confounding. Age ≥80 years, cognitive impairment, ASA grade III–IV, poor pre-fracture ambulatory status, hypoalbuminaemia, surgical delay beyond 48 hours, and postoperative complications were each independently associated with reduced odds of satisfactory recovery, while early postoperative mobilisation within 48 hours was the single strongest protective factor identified, nearly tripling the odds of satisfactory recovery at six months. Living alone and female sex were not independently associated with recovery once other variables were accounted for, suggesting that their apparent univariate associations, where present, were largely confounded by age and comorbidity.

DISCUSSION

This prospective cohort study identified seven factors independently associated with functional recovery after hip fracture surgery in elderly patients: advanced age, cognitive impairment, high ASA grade, poor pre-fracture mobility, hypoalbuminaemia, delayed surgery, and postoperative complications as factors reducing the odds of recovery, with early mobilisation emerging as the principal protective factor. These findings are broadly consistent with, and extend, the existing literature on this topic.6

The strong association between advanced age and poor recovery mirrors earlier prospective work showing that patients aged 85 years or older were significantly less likely to regain pre-fracture function than younger elderly patients.4 Age likely operates both directly, through reduced physiological and muscular reserve, and indirectly, as a marker for accumulated comorbidity and frailty. Similarly, cognitive impairment was one of the strongest independent predictors in our cohort, a finding that aligns with reports describing impaired cognition as a consistent barrier to mobility recovery, partly because patients with cognitive impairment are less able to participate actively in rehabilitation, follow safety instructions, or retain newly learned mobility strategies.3

The independent contribution of ASA grade and poor pre-fracture ambulatory status to recovery is consistent with systematic review evidence identifying these as core medical predictors of poor functional outcome across multiple healthcare settings.6 Pre-fracture functional status in particular has repeatedly been shown to be among the most powerful predictors of post-fracture function, since recovery trajectories tend to plateau below, rather than above, a patient's baseline level of independence.4

Hypoalbuminaemia at admission, used here as a marker of nutritional status, was independently associated with poor recovery, in keeping with prior work linking malnutrition to reduced gains in activities of daily living and gait function after hip fracture surgery.9 This relationship may be bidirectional: pre-existing malnutrition predisposes to falls and impairs tissue healing and muscle regeneration, while the catabolic stress of fracture and surgery further depletes nutritional reserve, together producing a downward spiral that can be interrupted through early nutritional screening and supplementation.10
The association between surgical delay beyond 48 hours and reduced functional recovery corroborates findings from a large meta-analysis of more than 31,000 patients, which reported a measurable reduction in mortality risk, and similar or better functional capacity, among patients operated on within 48 hours of admission.8 A separate meta-analysis of over 190,000 patients similarly found a lower odds of death with earlier surgery, reinforcing time-to-surgery as a modifiable system-level target.13 While the mechanism linking surgical delay to functional, as opposed to survival, outcomes is less firmly established than for mortality, prolonged preoperative immobilisation, pain, and deconditioning provide a plausible pathway.

Perhaps the most clinically actionable finding of this study is the strong protective effect of early postoperative mobilisation, which nearly tripled the odds of satisfactory recovery. This finding is consistent with the broader literature emphasising that ambulatory status soon after surgery is itself predictive of longer-term outcomes, including mortality and functional independence.14 Early mobilisation likely works through several mechanisms: it limits the loss of muscle mass and cardiovascular deconditioning associated with bed rest, reduces the incidence of complications such as pneumonia and venous thromboembolism, and provides patients with early positive reinforcement that may improve engagement with subsequent rehabilitation.12

Several limitations should be considered when interpreting these results. First, this was a single-centre study, which may limit generalisability to settings with different case-mix, surgical workflows, or rehabilitation resources. Second, although outcome assessors were blinded to the predictor analysis plan, the proxy-administered telephone assessments used for some patients may have introduced measurement variability compared with in-person evaluation. Third, residual confounding cannot be excluded in an observational design, despite multivariate adjustment, and unmeasured factors such as social support quality, depression, and detailed frailty indices were not captured. Finally, the six-month follow-up window, while clinically meaningful, may not fully capture the longer trajectory of recovery, particularly instrumental activities of daily living, which often take longer than basic activities of daily living to stabilise.4

These limitations notwithstanding, the consistency of our findings with prior systematic reviews and large cohort studies strengthens confidence in the clinical relevance of the identified predictors and supports their use in routine risk stratification.6

CONCLUSION

In this prospective cohort of elderly patients undergoing hip fracture surgery, advanced age, cognitive impairment, higher ASA grade, poor pre-fracture mobility, hypoalbuminaemia, surgical delay beyond 48 hours, and postoperative complications independently predicted poor functional recovery at six months, while early postoperative mobilisation was strongly protective. These findings reinforce the value of orthogeriatric co-management models that combine expedited

surgery, proactive nutritional assessment, cognitive screening, and structured early mobilisation protocols. Routine assessment of these factors at admission may allow clinicians to identify high-risk patients early, set realistic recovery expectations, and direct rehabilitation resources where they are most likely to translate into meaningful functional gains. Larger multicentre studies with extended follow-up are warranted to validate these predictors across diverse healthcare settings and to evaluate whether targeted intervention on modifiable factors, particularly time to surgery, nutrition, and early mobilisation, can improve long-term functional outcomes.

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