

Admission Handgrip Strength and Clinical Frailty Scale as Predictors of 90-Day Functional Recovery after Geriatric Hip Fracture Surgery: A Prospective Cohort Study

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Abstract

Introduction: Functional recovery after geriatric hip fracture is influenced by physiological reserve, frailty, and muscle strength. Although frailty has been increasingly evaluated in Indian patients, evidence regarding the incremental prognostic value of admission handgrip strength for short-term functional recovery remains limited.

Objective: To evaluate whether handgrip strength and frailty independently predict 90-day mobility following hip fracture surgery.

Methods: This prospective observational cohort included 140 patients aged ≥ 60 years undergoing surgery for low-energy femoral neck or intertrochanteric fractures. Admission handgrip strength was measured using a dynamometer and classified according to Asian Working Group for Sarcopenia criteria. Frailty was assessed using the Clinical Frailty Scale (CFS). The primary outcome was 90-day Parker Mobility Score (PMS). Secondary outcomes included Barthel Index, mobility recovery, postoperative complications, length of stay, readmission, and mortality. Hierarchical multivariable linear regression assessed independent predictors of 90-day PMS.

Results: Low handgrip strength was present in 77 (55.0%) patients and frailty in 47 (33.6%). Among 134 survivors, patients with low handgrip strength had lower 90-day PMS (6.1 ± 1.3 vs 7.1 ± 1.6 ; $p < 0.001$), lower Barthel Index (79.2 ± 10.9 vs 85.4 ± 14.1 ; $p = 0.006$), and less frequent recovery of $\geq 80\%$ of pre-fracture mobility (55.6% vs 80.6% ; $p = 0.002$). In adjusted analysis, higher handgrip strength independently predicted better PMS ($\beta = 0.319$ per 5 kg; $p = 0.008$), while increasing frailty predicted poorer recovery ($\beta = -0.192$; $p = 0.032$).

Conclusion: Admission handgrip strength and frailty provide complementary prognostic information for 90-day functional recovery after geriatric hip fracture surgery. Bedside grip-strength assessment may be a practical addition to routine orthopaedic risk stratification, although external validation is required.

Keywords: Hip Fractures; Hand Strength; Frailty; Sarcopenia; Activities of Daily Living; Prognosis.

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Introduction

Hip fracture in older adults is a major cause of loss of independence, prolonged rehabilitation, morbidity and mortality. In India, the clinical burden is particularly important because hip fractures frequently occur after low energy falls in patients with osteoporosis and multiple comorbidities, while access to coordinated orthogeriatric rehabilitation remains variable. Prospective Indian work has documented distinct injury mechanisms and substantial functional consequences after geriatric hip fracture surgery, reinforcing the need for simple early prognostic

markers that can identify patients at risk of incomplete recovery [1,2]. Sarcopenia and frailty describe overlapping but non identical dimensions of reduced physiological reserve. Asian Working Group for Sarcopenia guidance places low muscle strength at the centre of sarcopenia diagnosis and defines low handgrip strength as < 28 kg in men and < 18 kg in women [3]. The revised European consensus similarly emphasises muscle strength as a key characteristic of sarcopenia [4]. Handgrip strength is therefore attractive in an acute orthopaedic setting because it is inexpensive,

repeatable and can be measured at the bedside even when lower limb testing is impractical. Recent evidence suggests that admission handgrip strength adds clinically useful prognostic information after hip fracture. Prowse et al. found that low handgrip strength was associated with mortality, residential status and postoperative delirium and that adding grip assessment to the Nottingham Hip Fracture Score improved discrimination for several adverse outcomes [5]. A large prospective cohort also showed that reduced handgrip strength predicted greater long term walking disability and mortality [6], while newer work has linked grip-based measures with post discharge functional trajectories [7]. Nevertheless, functional prognosis after hip fracture is multifactorial; systematic review evidence has highlighted uncertainty and heterogeneity across proposed predictors of recovery [8].

The Indian literature has begun to address frailty in geriatric hip fracture, but the emphasis has largely been on mortality and perioperative complications. Vasu et al. examined a modified frailty index and 90-day outcome in an Indian tertiary care cohort [9], and a recent South Indian prospective study showed strong associations between mFI-5 and 30-day mortality and complications [10]. These studies leave an important clinical gap that whether a direct bedside measure of muscle strength provides incremental information for short term functional recovery beyond baseline mobility, age, nutrition and frailty in Indian patients. The present study was therefore designed to test the hypothesis that lower admission handgrip strength and greater frailty are independently associated with poorer 90-day mobility after geriatric hip fracture surgery, and that handgrip strength adds explanatory value to a conventional clinical model.

The primary objective was to determine the association of admission handgrip strength and Clinical Frailty Scale (CFS) with the 90-day Parker Mobility Score (PMS). Secondary objectives were to compare functional recovery, Barthel Index, length of stay, delirium, postoperative complications, readmission and short-term mortality according to handgrip and frailty status, and to quantify the incremental contribution of CFS and handgrip strength in multivariable prediction of 90-day PMS.

Materials and Methods

Study Design, Setting and Study Population:

This prospective observational cohort study conducted in the Department of Orthopedics of a tertiary care teaching hospital in South India over an 18-month period. Consecutive eligible patients were enrolled at admission and followed for 90 days after surgery. Patients aged 60 years or older with a low energy femoral neck or intertrochanteric

fracture planned for operative treatment were eligible. Exclusion criteria were pathological or high energy fracture, periprosthetic fracture, polytrauma, pre-existing major upper limb neurological or musculoskeletal disease preventing reliable grip assessment, inability to understand or perform the grip test despite assistance, terminal illness with palliative intent, and refusal of consent. Patients were treated with arthroplasty or internal fixation according to fracture pattern, physiological status and the treating unit's standard protocol.

Exposure Assessment: Handgrip strength was measured within 24 hours of admission using a calibrated hydraulic hand dynamometer. With the patient seated or semi-recumbent, shoulder adducted, elbow flexed approximately 90 degrees and wrist in neutral position, three maximal voluntary contractions were obtained from the dominant hand with adequate rest between attempts and the highest value was used for analysis. In accordance with AWGS 2019 criteria, low handgrip strength was defined as <28 kg in men and <18 kg in women [3]. Frailty was assessed using the 9-point Clinical Frailty Scale (CFS) based on the patient's pre-fracture status and CFS ≥ 5 was considered frail. The Nottingham Hip Fracture Score (NHFS) was calculated from routinely available preoperative variables.

Outcome Measures: Pre-fracture mobility was recorded using the Parker Mobility Score (PMS), a 0-9 scale covering indoor walking, outdoor walking and shopping ability. The primary outcome was PMS at 90 days among survivors. Secondary functional outcomes were change in PMS from pre-fracture level and the 90 day Barthel Index. For a prespecified categorical secondary analysis, satisfactory mobility recovery was operationally defined as regaining at least 80% of the pre-fracture PMS. Other outcomes included time from admission to surgery, length of hospital stay, postoperative delirium, any in-hospital postoperative complication, 30-day mortality, 90-day mortality and 90-day readmission.

Sample Size Calculation: The sample size was calculated from the functional recovery difference reported by Pérez-Rodríguez et al., in which major deterioration in walking ability occurred in 32.7% of patients with reduced handgrip strength and 10.9% of those with preserved strength [6]. For a two-sided comparison of two independent proportions with $\alpha=0.05$ and 80% power, these proportions require approximately 53 participants per group (106 total). Allowing 20% for mortality, loss to follow-up and adequate precision for multivariable modelling increased the requirement to 133 and the final target sample was rounded to 140 participants.

Statistical Analysis: Continuous variables were summarized as mean $\pm$ standard deviation and categorical variables as frequency and percentage. Welch's independent-samples t test was used for continuous group comparisons. Categorical data were analysed using Pearson's chi-square test or Fisher's exact test when expected cell counts were small. Spearman's rank correlation assessed associations of baseline predictors with 90-day PMS and Barthel Index. Hierarchical multiple linear regression was used for the primary multivariable analysis: Model 1 contained age, sex, pre-fracture PMS and albumin; CFS was added in Model 2; and handgrip strength (per 5-kg increment) was added in Model 3. Change in R^2 was tested using nested-model F tests. A two-sided p value <0.05 was considered statistically significant. P values are reported to three decimal places, except values <0.001 .

Results

At baseline, the mean age of the study population was 75.0 ± 7.5 years, and 86 (61.4%) participants were women. Patients with low HGS were significantly older than those with preserved HGS (77.2 ± 6.9 vs. 72.2 ± 7.3 years; $p<0.001$) and had significantly lower serum albumin levels (3.3 ± 0.4 vs. 3.6 ± 0.4 g/dL; $p<0.001$). The mean CFS score was also higher in the low-HGS group (4.4 ± 1.1 vs. 3.8 ± 1.0 ; $p<0.001$), and frailty defined as CFS ≥ 5 was more frequent among patients with low HGS than among those with preserved HGS (42.9% vs. 22.2%; $p=0.010$). In contrast, sex distribution, body mass index, hemoglobin concentration, Nottingham Hip Fracture Score, pre-fracture PMS, and fracture pattern did not differ significantly between the two groups (Table 1). With respect to perioperative and short-term clinical outcomes, patients with low HGS had a significantly longer mean hospital stay than those with preserved HGS (9.4 ± 2.0 vs. 7.8 ± 1.8 days; $p<0.001$). Postoperative delirium occurred more frequently in the low-HGS group (20.8% vs. 3.2%; $p=0.002$), as did any postoperative complication (33.8% vs. 11.1%; $p=0.002$). Although 90-day mortality was numerically higher among patients with low HGS (6.5% vs. 1.6%), the difference was not statistically significant ($p=0.223$). Similarly, no significant between-group differences were observed in time to surgery, 30-day mortality, or 90-day readmission (Table 2). Among the 134 participants who survived to 90 days, functional recovery was significantly poorer in those with low HGS. The mean 90-day PMS was lower in the low-

HGS group than in the preserved-HGS group (6.1 ± 1.3 vs. 7.1 ± 1.6 ; $p<0.001$), while the decline from pre-fracture PMS was greater (1.4 ± 1.0 vs. 0.7 ± 1.1 points; $p<0.001$). The 90-day Barthel Index was also significantly lower among patients with low HGS (79.2 ± 10.9 vs. 85.4 ± 14.1 ; $p=0.006$). Furthermore, satisfactory mobility recovery, defined as regaining at least 80% of the pre-fracture PMS, was achieved by 55.6% of patients with low handgrip strength compared with 80.6% of those with preserved handgrip strength ($p=0.002$).

Frail participants had significantly poorer 90-day functional outcomes than non-frail participants, with a lower mean PMS (5.7 ± 1.5 vs. 7.0 ± 1.4 ; $p<0.001$) and Barthel Index (75.0 ± 13.3 vs. 85.3 ± 11.2 ; $p<0.001$). Frailty was also associated with a longer hospital stay (9.3 ± 2.1 vs. 8.4 ± 2.0 days; $p=0.022$), higher 90-day mortality (10.6% vs. 1.1%; $p=0.016$), and greater 90-day readmission (21.3% vs. 5.4%; $p=0.004$). Pre-fracture PMS showed the strongest positive correlation with both 90-day PMS ($\rho=0.722$; $p<0.001$) and Barthel Index ($\rho=0.717$; $p<0.001$). Handgrip strength was moderately and positively correlated with 90-day PMS ($\rho=0.486$; $p<0.001$) and Barthel Index ($\rho=0.341$; $p<0.001$), whereas the Clinical Frailty Scale showed inverse correlations with both outcomes ($\rho=-0.454$ and $\rho=-0.456$, respectively; both $p<0.001$). Increasing age was similarly associated with poorer functional outcomes, while higher serum albumin was associated with better recovery.

The hierarchical multivariable linear regression analysis for 90-day PMS is summarized in Table 6. The base model incorporating age, sex, pre-fracture PMS and serum albumin explained 63.7% of the variance in 90-day PMS ($R^2=0.637$; adjusted $R^2=0.626$). Addition of the CFS significantly improved model performance by 1.9% ($\Delta R^2=0.019$; $p=0.008$), and subsequent addition of handgrip strength produced a further 1.9% increase in explained variance ($\Delta R^2=0.019$; $p=0.008$), yielding a final R^2 of 0.675 and adjusted R^2 of 0.660. In the fully adjusted model, higher pre-fracture PMS independently predicted better 90-day mobility ($\beta=0.796$; 95% CI 0.624 to 0.968; $p<0.001$), while higher CFS was independently associated with poorer mobility ($\beta=-0.192$; 95% CI -0.367 to -0.017; $p=0.032$). Handgrip strength remained an independent positive predictor, with each 5-kg increase associated with a 0.319-point higher 90-day PMS (95% CI 0.086 to 0.551; $p=0.008$).

Table 1: Baseline demographic and clinical characteristics according to handgrip status

Variable	Overall (n=140)	Preserved HGS (n=63)	Low HGS (n=77)	p value
Age (years)	75.0 ± 7.5	72.2 ± 7.3	77.2 ± 6.9	<0.001
Female sex	86 (61.4%)	36 (57.1%)	50 (64.9%)	0.346
Handgrip strength (kg)	21.2 ± 6.3	24.8 ± 5.6	18.2 ± 5.2	<0.001
BMI (kg/m ²)	22.9 ± 3.0	23.2 ± 3.0	22.8 ± 3.1	0.454
Serum albumin (g/dL)	3.4 ± 0.4	3.6 ± 0.4	3.3 ± 0.4	<0.001
Hemoglobin (g/dL)	11.2 ± 1.4	11.2 ± 1.5	11.3 ± 1.3	0.722
Clinical Frailty Scale	4.1 ± 1.1	3.8 ± 1.0	4.4 ± 1.1	<0.001
NHFS	3.7 ± 1.1	3.6 ± 1.1	3.8 ± 1.2	0.193
Pre-fracture PMS	7.6 ± 1.0	7.8 ± 1.1	7.5 ± 1.0	0.080
Frailty (CFS ≥5)	47 (33.6%)	14 (22.2%)	33 (42.9%)	0.010
Intertrochanteric fracture	69 (49.3%)	36 (57.1%)	33 (42.9%)	0.093

Values are mean ± SD or n (%). Low HGS: <28 kg in men and <18 kg in women. CFS, Clinical Frailty Scale; NHFS, Nottingham Hip Fracture Score; PMS, Parker Mobility Score

Table 2: Perioperative and short-term clinical outcomes according to handgrip status

Outcome	Overall	Preserved HGS	Low HGS	p value
Time to surgery (hours)	40.7 ± 17.6	38.4 ± 16.2	42.7 ± 18.5	0.143
Length of stay (days)	8.7 ± 2.1	7.8 ± 1.8	9.4 ± 2.0	<0.001
Postoperative delirium	18 (12.9%)	2 (3.2%)	16 (20.8%)	0.002
Any postoperative complication	33 (23.6%)	7 (11.1%)	26 (33.8%)	0.002
30-day mortality	3 (2.1%)	0 (0.0%)	3 (3.9%)	0.252
90-day mortality	6 (4.3%)	1 (1.6%)	5 (6.5%)	0.223
90-day readmission	15 (10.7%)	4 (6.3%)	11 (14.3%)	0.173

Values are mean ± SD or n (%). Mortality analyses include all 140 participants

Table 3: Ninety-day functional outcomes among survivors according to handgrip status

Outcome	Overall (n=134)	Preserved HGS (n=62)	Low HGS (n=72)	p value
90-day Parker Mobility Score	6.6 ± 1.5	7.1 ± 1.6	6.1 ± 1.3	<0.001
Decline in PMS from pre-fracture	1.1 ± 1.1	0.7 ± 1.1	1.4 ± 1.0	<0.001
90-day Barthel Index	82.1 ± 12.8	85.4 ± 14.1	79.2 ± 10.9	0.006
Regained ≥80% of pre-fracture PMS	90 (67.2%)	50 (80.6%)	40 (55.6%)	0.002

Values are mean ± SD or n (%). Six deaths before 90 days were excluded from functional-score analyses

Table 4: Clinical and functional outcomes according to frailty status

Outcome	Overall	Non-frail (CFS <5)	Frail (CFS ≥5)	p value
90-day Parker Mobility Score	6.6 ± 1.5	7.0 ± 1.4	5.7 ± 1.5	<0.001
90-day Barthel Index	82.1 ± 12.8	85.3 ± 11.2	75.0 ± 13.3	<0.001
Length of stay (days)	8.7 ± 2.1	8.4 ± 2.0	9.3 ± 2.1	0.022
Postoperative delirium	18 (12.9%)	10 (10.8%)	8 (17.0%)	0.295
Any postoperative complication	33 (23.6%)	21 (22.6%)	12 (25.5%)	0.698
90-day mortality	6 (4.3%)	1 (1.1%)	5 (10.6%)	0.016
90-day readmission	15 (10.7%)	5 (5.4%)	10 (21.3%)	0.004
Regained ≥80% of pre-fracture PMS	90 (67.2%)	66 (71.7%)	24 (57.1%)	0.095

Functional-score rows include 134 survivors; mortality and hospital outcomes include all 140 participants

Table 5: Spearman correlations of baseline predictors with 90-day functional outcomes

Predictor	ρ with 90-day PMS	p value	ρ with Barthel Index	p value
Handgrip strength	0.486	<0.001	0.341	<0.001
Clinical Frailty Scale	-0.454	<0.001	-0.456	<0.001
Nottingham Hip Fracture Score	-0.294	<0.001	-0.277	0.001
Age	-0.457	<0.001	-0.377	<0.001
Serum albumin	0.316	<0.001	0.334	<0.001
Pre-fracture Parker Mobility Score	0.722	<0.001	0.717	<0.001

Analysis includes 134 survivors. Positive ρ indicates better function with increasing predictor value

Table 6: Hierarchical multivariable linear regression for 90-day Parker Mobility Score

Model/predictor	R ² or β	Adjusted R ² /95% CI	ΔR^2	p value
Panel A: Model performance				
Model 1: age + sex + pre-fracture PMS + albumin	0.637	0.626	Reference	—
Model 2: Model 1 + CFS	0.656	0.643	+0.019	0.008
Model 3: Model 2 + HGS (per 5 kg)	0.675	0.660	+0.019	0.008
Panel B: Final model coefficients	β	95% CI		p value
Age (per year)	-0.023	-0.047 to 0.001		0.060
Male sex	0.242	-0.334 to 0.817		0.408
Pre-fracture PMS (per point)	0.796	0.624 to 0.968		<0.001
Serum albumin (per g/dL)	0.222	-0.203 to 0.647		0.304
Clinical Frailty Scale (per point)	-0.192	-0.367 to -0.017		0.032
Handgrip strength (per 5 kg)	0.319	0.086 to 0.551		0.008
Dependent variable: 90-day PMS; n=134. ΔR^2 p values are from nested-model F tests. HGS, handgrip strength; CFS, Clinical Frailty Scale				

Discussion

This prospective cohort study supports the central hypothesis that admission muscle strength and frailty capture clinically relevant dimensions of recovery after geriatric hip fracture. Patients with low handgrip strength had poorer 90-day mobility, greater loss of pre-fracture mobility, lower Barthel scores, longer hospitalization and more early complications. Frailty showed a similar adverse gradient. Most importantly, grip strength remained independently associated with 90-day PMS after adjustment for pre-fracture function and CFS, and its addition significantly improved the hierarchical regression model. The implication is not that grip replaces established clinical assessment, but that a rapid muscle strength measure may add information about functional reserve that is not fully represented by age, comorbidity or frailty alone.

The observed association between handgrip strength and recovery is consistent with rehabilitation. HersHKovitz et al. found that higher handgrip strength was independently related to better motor Functional Independence Measure outcomes after post-acute hip fracture rehabilitation [11]. Chang et al. similarly reported that handgrip strength predicted early postoperative ambulation capacity [12]. Gleich et al. demonstrated positive correlations between grip strength, postoperative PMS and Barthel Index and proposed grip testing as a simple method for identifying patients likely to experience mobilisation difficulty [13]. A 2025 systematic review and meta-analysis further concluded that sarcopenia was associated with poor prognosis after fracture, including a higher risk of poor functional recovery in hip-fracture populations [14]. Together, these findings support the biological plausibility of using handgrip strength as a bedside surrogate for global neuromuscular reserve.

Frailty contributed independently to functional outcome in the final model. Inoue et al. reported that greater frailty predicted lower short-term motor-FIM efficiency, complications and failure to return home after hip fracture [15]. Meta-analysis by Song et al. showed that frailty was associated with complications, mortality and prolonged hospital stay [16], while a more recent meta-analysis and trial sequential analysis confirmed robust associations with inpatient, 30-day and one-year mortality and selected postoperative complications [17]. Kennedy et al., analysing more than 8,000 patients in the Scottish Hip Fracture Audit, found CFS to be an independent predictor of survival and early residential outcome [18]. The current pattern therefore fits a broader literature in which frailty marks multisystem vulnerability, whereas handgrip adds a more direct measure of muscle performance.

Pre-fracture mobility was the strongest individual correlate of 90-day function and remained a dominant predictor in multivariable analysis. This finding is clinically intuitive and is supported by prospective work showing that pre-fracture functional status and early postoperative recovery are major determinants of subsequent instrumental activities of daily living [19]. This finding is similar to study by Belangero et al. in which they demonstrated persistent mobility loss at 90 days after surgically treated intertrochanteric fracture and identified preinjury health and nutritional markers as important prognostic factors [20]. These observations explain why a prognostic model should adjust for baseline mobility rather than treating postoperative score alone as an isolated outcome.

The association between low handgrip strength, hypoalbuminaemia and worse recovery also deserves attention. Comorbidity burden has been associated with poorer PMS and quality-of-life outcomes after hip fracture and with increased 90-

day readmission [21]. A recent systematic review found that malnutrition substantially increases mortality, mobility decline and need for more supported living arrangements after hip fracture [22]. Because grip strength is influenced by both chronic sarcopenia and acute physiological reserve, it may integrate several adverse domains in a single low-cost measurement.

However, it should not be interpreted as a substitute for nutritional assessment or formal sarcopenia diagnosis, which additionally requires evaluation of muscle quantity or physical performance depending on the diagnostic framework. Use of PMS as the primary functional endpoint is appropriate for a hip-fracture cohort because it directly captures indoor mobility and outdoor mobility. Voeten SC et al. has shown strong agreement between PMS and simplified fracture-mobility classifications [23]. More broadly, frailty meta-analysis by Ma y et al. has demonstrated that adverse outcomes are not confined to mortality; postoperative complications and abnormal discharge are also enriched among frail patients [24]. This supports the decision to focus the present study on function rather than use mortality as the sole clinically meaningful endpoint. Recent work by Nag DS et al. has demonstrated the usefulness of frailty indices and physiological scores for predicting short-term mortality and complications, including comparison of NHFS with APACHE-II in geriatric hip-fracture surgery [25]. Such tools are valuable for perioperative risk stratification, but they do not directly quantify muscle strength or explain the large variation in recovery among survivors.

The present study had several limitations. Its single-center design may limit the generalizability of the findings to other populations and healthcare settings. As an observational cohort study, residual confounding could not be completely excluded despite multivariable adjustment, and causal relationships between handgrip strength, frailty and subsequent functional recovery cannot be established. Handgrip strength was assessed only at admission and therefore did not capture perioperative or postoperative changes in muscle strength. Functional outcomes at 90 days were assessed only among survivors, introducing the possibility of survivor bias, while the 90-day follow-up period may have been insufficient to characterize longer-term recovery, institutionalization or mortality. In addition, potentially relevant factors such as detailed nutritional status, sarcopenia measures, cognitive function, rehabilitation, social support and postoperative adherence were not comprehensively incorporated into the predictive models.

Conclusion

Admission handgrip strength and frailty appear to provide complementary prognostic information for 90-day functional recovery after geriatric hip fracture surgery. In our study, lower grip strength was associated with poorer mobility, lower Barthel Index, longer hospitalization and more postoperative morbidity, and adding handgrip strength to a model containing conventional clinical variables and CFS significantly improved prediction of 90-day PMS. A simple grip measurement could therefore be evaluated as a practical adjunct to routine geriatric hip-fracture assessment in orthopedic units.

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