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Role of Sarcopenia in Predicting Functional Recovery Following Surgical Management of Intertrochanteric Fractures in Elderly Patients: A Prospective Observational Study

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Abstract

Background: Intertrochanteric fractures are common among elderly individuals and are associated with substantial morbidity, prolonged hospitalization and loss of functional independence. Sarcopenia, characterized by reduced skeletal muscle mass, muscle strength and physical performance, may adversely influence postoperative recovery.

Aim: The present study was undertaken to evaluate the role of preoperative Sarcopenia in predicting functional recovery following surgical management of Intertrochanteric fractures in elderly patients.

Methods: A prospective observational study was conducted among 100 elderly patients undergoing surgical treatment for Intertrochanteric femoral fractures. Patients were evaluated preoperatively for Sarcopenia using muscle strength, physical performance and muscle-mass parameters. Demographic characteristics, co morbidities, fracture characteristics, hemoglobin, serum albumin, vitamin D and other relevant laboratory parameters were recorded. Postoperative outcomes

included time to first mobilization, duration of hospital stay, postoperative complications and mortality. Functional recovery was assessed using the Harris Hip Score (HHS), Barthel Index and Timed Up and Go (TUG) test at 6 weeks, 3 months, 6 months and 12 months. Poor functional recovery at 12 months was defined as HHS <80.

Results: Among the 100 patients, 26 (26.0%) were classified as having Sarcopenia and 74 (74.0%) as non-sarcopenic. Sarcopenic patients were older and had a lower mean BMI than non-sarcopenic patients. Mean handgrip strength, gait speed, calf circumference and skeletal muscle index were lower in the sarcopenic group. Serum albumin was also lower among sarcopenic patients (3.1 ± 0.4 vs. 3.5 ± 0.4 g/dL). Sarcopenic patients had delayed postoperative mobilization (4.2 ± 1.3 vs. 2.9 ± 0.9 days) and longer hospital stay (10.6 ± 3.1 vs. 7.4 ± 2.2 days). Postoperative complications occurred in 34.6% of sarcopenic patients compared with 16.2% of non-sarcopenic patients. Functional recovery was consistently poorer in the sarcopenic group. At 12 months, mean HHS was 68.9 ± 12.0 compared with 82.1 ± 8.7 in the non-sarcopenic group. Poor functional recovery was observed in 73.1% of sarcopenic patients compared with 45.9% of non-sarcopenic patients (p=0.014). Independent walking at 12 months was achieved by 42.3% and 70.3% of patients, respectively.

Conclusion: Preoperative Sarcopenia was associated with delayed mobilization, prolonged hospitalization, increased postoperative complications and poorer functional recovery following surgery for Intertrochanteric fractures in elderly patients. Assessment of Sarcopenia before surgery may therefore help identify patients at increased risk of delayed functional recovery and may facilitate individualized perioperative rehabilitation and nutritional interventions.

Keywords: Sarcopenia, Intertrochanteric Fracture, Elderly, Hip Fracture, Functional Recovery, Harris Hip Score, Handgrip Strength; Rehabilitation.

Introduction

Intertrochanteric fractures of the femur are among the most common fractures encountered in elderly individuals and represent a major cause of morbidity, functional dependence and reduced quality of life. With increasing life expectancy and population ageing, the incidence and overall burden of hip fractures among older adults continue to increase. These fractures frequently occur following low-energy falls in individuals with osteoporosis, impaired balance, reduced muscle strength and multiple age-related co morbidities. Despite advances in surgical fixation, perioperative management and rehabilitation, a considerable proportion of elderly patients fail to regain their pre-fracture level of mobility and independence [1,2].

Intertrochanteric fractures are generally managed surgically to restore alignment, provide stable fixation and facilitate early mobilization. Early mobilization is particularly important in elderly patients because prolonged immobilization can contribute to chest infections, venous thromboembolism, pressure injuries, muscle wasting and further functional decline. Functional recovery following hip fracture is influenced by several factors, including advanced age, pre-existing co morbidities, nutritional status, fracture pattern, surgical factors, pre-fracture functional status and the patient's physiological reserve [5,10].

One important but frequently under-recognized determinant of postoperative recovery is Sarcopenia. Sarcopenia is a progressive skeletal muscle disorder

characterized by a reduction in skeletal muscle strength, muscle quantity or quality and physical performance. The revised European Working Group on Sarcopenia in Older People (EWGSOP2) emphasizes low muscle strength as the principal characteristic**,** while reduced muscle quantity or quality is used to confirm the diagnosis and impaired physical performance indicates severe Sarcopenia[1]. Sarcopenia has also been recognized as an important geriatric syndrome associated with disability, falls, fractures and adverse clinical outcomes [2].

Age-related Sarcopenia develops through multiple interacting mechanisms, including reduced physical activity, hormonal alterations, chronic inflammation, inadequate nutritional intake, impaired muscle protein synthesis and neuromuscular changes. The resulting decline in muscle strength and physical performance can impair balance, gait and the ability to perform activities of daily living. Consequently, Sarcopenia is closely associated with falls and fractures in older adults [2,4]. The relationship between Sarcopenia and hip fracture is potentially bidirectional. Pre-existing loss of muscle mass and strength may increase the risk of falls and subsequent fracture, while acute trauma, surgical stress, immobilization and postoperative inflammatory responses may further accelerate muscle loss. This may create a cycle of reduced mobility, progressive muscle deterioration and delayed functional recovery [3,4]

Assessment of Sarcopenia can be performed using several complementary parameters. Handgrip strength is a commonly used measure of muscle strength, while physical performance can be evaluated using gait speed or the Timed Up and Go (TUG) test. Muscle quantity or quality may be assessed using bioelectrical impedance analysis, dual-energy X-ray absorptiometry, computed tomography or other validated techniques. The EWGSOP2 consensus provides a standardized framework for case finding, diagnosis and severity assessment of Sarcopenia [1].

The presence of Sarcopenia may be particularly important in patients undergoing surgery for hip fractures because these patients already have limited physiological reserve. A systematic review evaluating older adults with hip fractures reported that Sarcopenia was common and was associated with poorer postoperative functional recovery in several included studies [3]. Similarly, a systematic review examining the effect of Sarcopenia on orthopaedic surgical outcomes found associations between Sarcopenia and adverse postoperative outcomes, including poorer functional performance[6]. Sarcopenia may also influence postoperative independence and activities of daily living. Studies involving orthopaedic surgery have demonstrated poorer functional outcomes among patients with sarcopenia, suggesting that reduced muscle reserve can adversely affect the ability to participate in rehabilitation and regain independent mobility [6,7]. In elderly patients recovering from hip fracture surgery, structured exercise-based rehabilitation can improve physical function and mobility, emphasizing the importance of identifying patients who may require more intensive rehabilitation strategies [8,9]. Nutritional status represents another important factor associated with sarcopenia and postoperative recovery. Elderly patients with hip fractures frequently have reduced nutritional reserves, and parameters such as body mass index, serum albumin and vitamin status may provide additional information regarding physiological reserve. Sarcopenia and malnutrition may coexist and potentially contribute to delayed wound healing, infection,

prolonged hospitalization and reduced rehabilitation potential [3,7].

Functional outcome following Intertrochanteric fracture surgery can be evaluated using standardized instruments such as the Harris Hip Score (HHS), Barthel Index and Timed Up and Go (TUG) test**.** The Harris Hip Score evaluates pain, function, mobility and activities of daily living, whereas the Barthel Index assesses independence in basic activities of daily living. The TUG test provides an objective assessment of functional mobility and can help identify persistent gait and mobility limitations.

Several factors have been identified as potential predictors of poor outcome after hip fracture, including advanced age, co morbidities, frailty, low handgrip strength, Sarcopenia and impaired pre-fracture functional status [5]. Thus, assessment of muscle health may provide prognostic information beyond chronological age alone. Identifying Sarcopenia before surgery could potentially allow clinicians to recognize patients at increased risk of delayed recovery and provide individualized rehabilitation and nutritional support.

Recent evidence has further emphasized the prognostic relevance of Sarcopenia in patients with hip fractures. A recent systematic review and meta-analysis reported an association between Sarcopenia and poor functional recovery and other adverse outcomes following hip fracture [11]. Similarly, broader systematic reviews have demonstrated associations between Sarcopenia and adverse outcomes among surgical and orthopaedic populations [6,12]. Emerging research has also explored computed tomography-based assessment of muscle characteristics as a potential predictor of postoperative complications, mortality and functional outcomes following geriatric hip fracture surgery [13].

Although existing evidence supports an association between Sarcopenia and poorer outcomes, considerable variation remains regarding the diagnostic criteria used, methods of assessing muscle mass and strength, functional outcome measures and duration of follow-up [3,6,11]. Therefore, prospective studies using standardized assessments of Sarcopenia and repeated postoperative functional measurements are important for determining its clinical relevance.

The present study was therefore designed to evaluate the role of Sarcopenia in predicting functional recovery following Intertrochanteric fracture surgery in elderly patients**.** The study assesses preoperative muscle strength, muscle mass and physical performance and evaluates their relationship with postoperative mobilization, duration of hospitalization, postoperative complications and functional recovery using the Harris Hip Score, Barthel Index and Timed Up and Go test during follow-up. Identification of sarcopenic patients at admission may help clinicians recognize individuals at increased risk of delayed functional recovery and facilitate appropriate nutritional, physiotherapy and rehabilitation interventions [1,3,8,11].

Materials and Methods

Study Design

The present study was designed as a prospective observational study to evaluate the role of preoperative Sarcopenia in predicting functional recovery following surgical treatment of Intertrochanteric femoral fractures in elderly patients.

Study Setting

The study was conducted in the Department of Orthopaedics at KKBM Subharti Hospital, Gautam Buddha Chikitsa Mahavidyalaya, Dehradun**.** Elderly patients presenting with Intertrochanteric femoral

fractures and fulfilling the predefined eligibility criteria were enrolled and followed prospectively.

Study Duration

The study was conducted over a period of approximately 18 months**,** including patient recruitment, surgical treatment and postoperative follow-up.

Study Population

The study population consisted of elderly patients aged ≥60 years presenting with acute Intertrochanteric fractures of the femur and undergoing operative fixation. A total of 100 patients were included in the study. Based on the study data, 26 patients (26%) were classified as sarcopenic and 74 patients (74%) as non-sarcopenic**.**

Study Objectives

Primary objective

To determine whether preoperative sarcopenia is associated with poor functional recovery 12 months after surgical treatment of Intertrochanteric femoral fractures**.**

Secondary objectives

1. To determine the prevalence of Sarcopenia among elderly patients with Intertrochanteric fractures.
2. To compare postoperative functional recovery between sarcopenic and non-sarcopenic patients.
3. To compare time to first mobilization and duration of hospital stay between the two groups.
4. To compare postoperative complications between sarcopenic and non-sarcopenic patients.
5. To assess the relationship of handgrip strength, gait speed and skeletal muscle mass with postoperative functional recovery.
6. To evaluate the relationship between nutritional and biochemical parameters and Sarcopenia.
7. To assess mortality and readmission during the 12-month follow-up period.

Inclusion Criteria

Patients fulfilling all of the following criteria were included:

- Age ≥ 60 years**.**
- Radio logically confirmed Intertrochanteric fracture of the femur.
- Patients undergoing operative fixation.
- Presentation within the study recruitment period.
- Patients medically fit for surgical intervention.
- Patients willing to participate in the study.
- Patients providing written informed consent.
- Patients willing and able to attend scheduled postoperative follow-ups.

Exclusion Criteria

Patients were excluded if they had:

- Pathological fractures due to primary or metastatic bone tumors.
- Previous fracture or major surgery involving the same hip.
- Bilateral hip fractures.
- Associated major lower-limb fractures affecting mobility assessment.
- Pre-existing neurological disorders severely affecting gait or muscle strength.
- Severe cognitive impairment preventing reliable functional assessment.
- Terminal illness with expected survival of less than 12 months.
- Patients managed conservatively.
- Patients unwilling to participate or unable to provide consent.
- Incomplete baseline or follow-up assessment.

Ethical Considerations

This study was conducted in accordance with the ethical standards of the institution. Written informed consent

was obtained from every participant or an appropriate legally authorized representative where applicable. Patient confidentiality was maintained throughout the study. Each participant was assigned a study identification number, and personal identifying information was not used in the analysis or presentation of results.

Data Collection

At enrollment, demographic, clinical, radiological and laboratory information were recorded using a structured study proforma.

The following variables were documented

Demographic parameters

- Age
- Sex
- Height
- Weight
- Body mass index

Clinical parameters

- History of fall
- Pre-fracture ambulatory status
- Living arrangement
- Smoking/alcohol history where applicable
- Co morbidities
- Number of co morbidities
- Charlson Co morbidity Index, if used

Fracture-related parameters

- Side of fracture
- Stable/unstable fracture
- AO/OTA fracture classification
- Radiographic fracture characteristics

Laboratory parameters

- Hemoglobin
- Serum albumin
- Serum calcium
- Serum creatinine
- Vitamin D

Assessment of Sarcopenia

Sarcopenia was assessed preoperatively using a combination of muscle strength, muscle mass and physical performance**,** consistent with contemporary consensus recommendations [1].

A. Muscle strength

Handgrip strength was assessed using a calibrated hand dynamometer.

The patient was seated comfortably with the shoulder adducted and elbow flexed at approximately 90°. The dynamometer was held in the dominant hand, and the patient was instructed to squeeze maximally.

At least two measurements were obtained, with an appropriate rest interval, and the highest reliable value was recorded.

Low handgrip strength was interpreted according to the predefined sex-specific criteria of the selected sarcopenia guideline.

B. Assessment of muscle mass

Skeletal muscle mass was assessed using bio electrical impedance analysis (BIA) where available.

Skeletal Muscle Index (SMI) was calculated as:

SMI = Appendicular skeletal muscle mass (kg) / height^2 (m^2)

Low muscle mass was defined according to the selected consensus criteria and the reference values used by the study institution.

If BIA is unavailable, an alternative validated method such as DEXA was used, provided the same method is applied consistently throughout the study.

C. Physical performance

Physical performance was assessed using:

- Gait speed, measured over a predefined walking distance.
- Timed Up and Go (TUG) test**,** where clinically feasible.

The TUG test measures the time required for a participant to rise from a chair, walk a specified distance, turn, return and sit down.

Patients unable to perform the test safely were documented as having impaired physical performance rather than being forced to complete the test.

Classification of Sarcopenia

Patients were categorized according to the predefined diagnostic algorithm.

- **No Sarcopenia:** normal muscle strength and no evidence of reduced muscle mass.
- **Probable Sarcopenia:** reduced muscle strength.
- **Confirmed Sarcopenia:** reduced muscle strength plus reduced muscle quantity/quality.
- **Severe Sarcopenia:** confirmed Sarcopenia associated with impaired physical performance.

Nutritional Assessment

Nutritional status was assessed using anthropometric and biochemical parameters.

The following were recorded:

- BMI
- Serum albumin
- Hemoglobin
- Vitamin D
- Calorie/protein intake where feasible

A validated nutritional screening instrument such as the Mini Nutritional Assessment (MNA) was additionally used.

Surgical Management

All patients underwent operative treatment according to the fracture pattern, bone quality, general medical condition and treating surgeon's decision.

The principal fixation methods included:

- Proximal femoral/intramedullary nail fixation**,** or
- Dynamic hip screw fixation where appropriate.

The following operative parameters were recorded

- Type of implant
- Duration of surgery
- Estimated blood loss
- Requirement for blood transfusion
- Intraoperative complications
- Quality of fracture reduction
- Time from admission to surgery

Postoperative management, including analgesia, Thromboprophylaxis, antibiotic prophylaxis and physiotherapy, followed the hospital's standard protocol.

Postoperative Rehabilitation

Patients received standardized postoperative rehabilitation as clinically appropriate.

Rehabilitation included

1. Bedside limb and ankle exercises.
2. Quadriceps and gluteal strengthening.
3. Sitting and standing exercises.
4. Assisted ambulation with a walker.
5. Progressive weight-bearing according to fracture stability and surgeon's recommendation.
6. Progressive gait training.
7. Home-based or supervised physiotherapy after discharge.

The date of first mobilization and achievement of independent ambulation were recorded.

Outcome Measures

Primary outcome

The primary outcome was functional recovery at 12 **months**, assessed using the Harris Hip Score (HHS)**.**

For the planned analysis:

- **HHS ≥80:** satisfactory functional recovery.
- **HHS <80:** poor/incomplete functional recovery.

Secondary outcomes

Secondary outcomes include:

- Harris Hip Score at 6 weeks, 3 months, 6 months and 12 months.
- Barthel Index.
- Timed Up and Go test.
- Independent walking status.
- Requirement for walking aid.
- Time to first mobilization.
- Duration of hospital stay.
- Postoperative complications.
- Readmission.
- Mortality.

Follow-up Schedule

Patients were assessed at predetermined intervals

Follow-up	Assessments
Preoperative	Sarcopenia, demographics, co morbidities, laboratory parameters
6 weeks	HHS, Barthel Index, TUG, walking status, complications
3 months	HHS, Barthel Index, TUG, mobility
6 months	HHS, Barthel Index, TUG, complications
12 months	HHS, Barthel Index, TUG, independent walking, readmission and mortality

Patients who cannot attend in person were contacted telephonically for appropriate outcome information, while objective functional tests were preferably performed during in-person assessment.

Postoperative Complications

The following complications were specifically documented

- Surgical-site/wound infection
- Delayed wound healing
- Chest infection
- Urinary tract infection
- Deep-vein thrombosis
- Pulmonary embolism
- Pressure sores
- Implant-related complications
- Loss of reduction
- Non-union
- Reoperation
- Readmission
- Mortality

The timing and severity of each complication was recorded.

Statistical Analysis

Data was entered into a computerized database and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation or median with interquartile range depending on distribution. Categorical variables were expressed as frequency and percentage**.** A two-sided p-value <0.05 was considered statistically significant. Appropriate

effect estimates, including odds ratios with 95% confidence intervals**,** were reported where applicable.

Results

Table 1: Baseline demographic characteristics

Parameter	Sarcopenia (n=26)	No Sarcopenia (n=74)	Total (n=100)
Age, years, mean ± SD	76.8 ± 6.1	71.9 ± 5.4	73.2 ± 5.9
Age ≥75 years	17 (65.4%)	25 (33.8%)	42 (42.0%)
Male	9 (34.6%)	31 (41.9%)	40 (40.0%)
Female	17 (65.4%)	43 (58.1%)	60 (60.0%)
BMI, kg/m²	21.1 ± 2.3	23.4 ± 2.6	22.8 ± 2.6
BMI <22 kg/m²	16 (61.5%)	24 (32.4%)	40 (40.0%)

Table 1 shows the demographic characteristics of the study population. Among the 100 elderly patients, 26 (26%) were identified as having Sarcopenia, whereas 74 (74%) did not have Sarcopenia. The mean age of patients with Sarcopenia was 76.8 ± 6.1 years, compared with 71.9 ± 5.4 years among those without Sarcopenia. Patients aged ≥75 years constituted a larger proportion of the sarcopenic group (65.4%) than the non-sarcopenic group (33.8%). Females predominated in both groups, accounting for 65.4% of the sarcopenic group and 58.1% of the non-sarcopenic group. The mean BMI was lower among sarcopenic patients (21.1 ± 2.3 kg/m²) compared with non-sarcopenic patients (23.4 ± 2.6 kg/m²). Overall, the findings indicate that Sarcopenia was more frequently observed among older and relatively leaner patients.

Table 2: Distribution according to co morbidities

Co morbidity	Sarcopenia (n=26)	No Sarcopenia (n=74)	Total
Hypertension	15 (57.7%)	37 (50.0%)	52 (52.0%)
Diabetes mellitus	11 (42.3%)	25 (33.8%)	36 (36.0%)
Ischemic heart disease	5 (19.2%)	8 (10.8%)	13 (13.0%)
COPD	6 (23.1%)	8 (10.8%)	14 (14.0%)
Chronic kidney disease	3 (11.5%)	4 (5.4%)	7 (7.0%)
≥2 co morbidities	12 (46.2%)	19 (25.7%)	31 (31.0%)

Table 2 describes the associated comorbid conditions. Hypertension was the most frequently observed co morbidity, affecting 57.7% of sarcopenic and 50.0% of non-sarcopenic patients. Diabetes mellitus was present in 42.3% of patients with Sarcopenia compared with 33.8% without Sarcopenia. COPD was observed in 23.1% of sarcopenic patients and 10.8% of non-sarcopenic patients. Nearly half (46.2%) of the sarcopenic patients had two or more co morbidities, compared with 25.7% in the non-sarcopenic group. Thus, the sarcopenic group demonstrated a greater burden of multiple comorbid conditions.

Graph 1: Distribution according to co morbidities

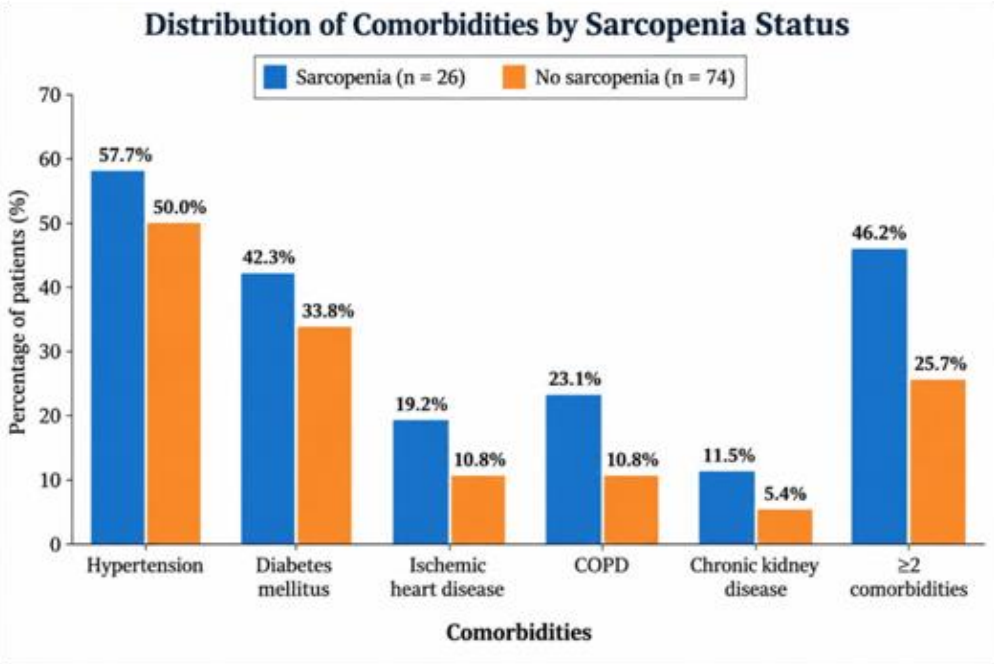

Table 3: Fracture characteristics

Parameter	Sarcopenia (n=26)	No sarcopenia (n=74)	Total
Right-sided fracture	14 (53.8%)	39 (52.7%)	53 (53.0%)
Left-sided fracture	12 (46.2%)	35 (47.3%)	47 (47.0%)
Stable fracture	8 (30.8%)	31 (41.9%)	39 (39.0%)
Unstable fracture	18 (69.2%)	43 (58.1%)	61 (61.0%)
AO/OTA 31-A1	6 (23.1%)	24 (32.4%)	30 (30.0%)
AO/OTA 31-A2	14 (53.8%)	36 (48.6%)	50 (50.0%)
AO/OTA 31-A3	6 (23.1%)	14 (18.9%)	20 (20.0%)

Table 3 presents the characteristics of the intertrochanteric fractures. Right-sided fractures accounted for 53.8% of cases with sarcopenia and 52.7% of cases without sarcopenia, while the remaining fractures involved the left side. Unstable fractures were more common than stable fractures in both groups. Among sarcopenic patients, 69.2% had unstable fractures compared with 58.1% among non-sarcopenic patients. AO/OTA type A2 fractures were the most frequently observed fracture pattern, accounting for 53.8% of sarcopenic and 48.6% of non-sarcopenic patients. The distribution suggests a predominance of unstable and A2 fracture patterns in the study population.

Table 4: Sarcopenia-related parameters

Parameter	Sarcopenia (n=26)	No Sarcopenia (n=74)
Handgrip strength, kg	16.8 ± 3.2	24.7 ± 4.1

Gait speed, m/s	0.48 ± 0.12	0.72 ± 0.15
Calf circumference, cm	29.1 ± 2.1	33.2 ± 2.4
Skeletal muscle index, kg/m²	6.4 ± 0.7	7.8 ± 0.8
Low muscle strength	26 (100%)	15 (20.3%)
Low physical performance	22 (84.6%)	17 (23.0%)
Low muscle mass	26 (100%)	10 (13.5%)

Table 4 demonstrates the differences in muscle-related parameters between the two groups. Sarcopenic patients had substantially lower mean handgrip strength (16.8 ± 3.2 kg vs. 24.7 ± 4.1 kg) and slower gait speed (0.48 ± 0.12 m/s vs. 0.72 ± 0.15 m/s) compared with non-sarcopenic patients. Mean calf circumference and skeletal muscle index were also lower in the sarcopenic group. All 26 sarcopenic patients had low muscle mass and low muscle strength according to the study classification. These findings demonstrate the expected reduction in muscle quantity, strength and physical performance among patients classified as sarcopenic.

Table 5: Preoperative laboratory parameters

Parameter	Sarcopenia (n=26)	No Sarcopenia (n=74)
Hemoglobin, g/dL	10.2 ± 1.3	10.8 ± 1.2
Serum albumin, g/dL	3.1 ± 0.4	3.5 ± 0.4
Vitamin D, ng/mL	18.7 ± 6.2	22.9 ± 7.1
Serum calcium, mg/dL	8.5 ± 0.5	8.7 ± 0.5
Serum creatinine, mg/dL	1.08 ± 0.32	0.98 ± 0.27

Table 5 compares selected preoperative laboratory parameters. The mean hemoglobin concentration was lower in the sarcopenic group (10.2 ± 1.3 g/dL) than in the non-sarcopenic group (10.8 ± 1.2 g/dL). Serum albumin was also lower among sarcopenic patients (3.1 ± 0.4 g/dL vs. 3.5 ± 0.4 g/dL), suggesting a greater prevalence of poor nutritional status in this group. Mean vitamin D levels were lower in sarcopenic patients, while calcium and creatinine values showed relatively smaller differences. Overall, the laboratory findings indicate that sarcopenia was associated with poorer nutritional and biochemical status.

Table 6: Surgical and early postoperative outcomes

Outcome	Sarcopenia (n=26)	No Sarcopenia (n=74)	Total
Intramedullary nail fixation	18 (69.2%)	53 (71.6%)	71 (71.0%)
DHS fixation	8 (30.8%)	21 (28.4%)	29 (29.0%)
Operative time, min	78.4 ± 14.6	72.1 ± 12.8	73.7 ± 13.4
Time to first mobilization, days	4.2 ± 1.3	2.9 ± 0.9	3.2 ± 1.1
Hospital stay, days	10.6 ± 3.1	7.4 ± 2.2	8.2 ± 2.7

Postoperative complication	9 (34.6%)	12 (16.2%)	21 (21.0%)
Delayed wound healing	3 (11.5%)	3 (4.1%)	6 (6.0%)
Chest infection	4 (15.4%)	4 (5.4%)	8 (8.0%)
Urinary infection	2 (7.7%)	3 (4.1%)	5 (5.0%)
DVT	1 (3.8%)	2 (2.7%)	3 (3.0%)

Table 6 summarizes operative characteristics and early postoperative outcomes. Intramedullary nail fixation was the most frequently used surgical procedure in both groups. The mean operative time was somewhat longer among sarcopenic patients (78.4 ± 14.6 minutes) compared with non-sarcopenic patients (72.1 ± 12.8 minutes). Sarcopenic patients required more time for first mobilization, averaging 4.2 ± 1.3 days, compared with 2.9 ± 0.9 days in the non-sarcopenic group. Their mean hospital stay was also longer (10.6 ± 3.1 vs. 7.4 ± 2.2 days). Postoperative complications occurred in 34.6% of sarcopenic patients compared with 16.2% of non-sarcopenic patients. These findings demonstrate poorer early postoperative recovery among sarcopenic patients.

Table 7: Functional outcome according to Harris Hip Score

Follow-up	Sarcopenia (n=26)	No Sarcopenia (n=74)
Preoperative HHS	34.8 ± 7.2	36.1 ± 6.8
6 weeks	43.7 ± 8.9	55.6 ± 9.4
3 months	55.2 ± 10.1	68.8 ± 9.7
6 months	63.4 ± 11.2	76.5 ± 9.3
12 months	68.9 ± 12.0	82.1 ± 8.7

Table 7 demonstrates the progression of functional recovery using the Harris Hip Score (HHS). Although both groups showed improvement following surgery, the increase in HHS was consistently lower in patients with Sarcopenia. At 6 weeks, the mean HHS was 43.7 ± 8.9 in the sarcopenic group compared with 55.6 ± 9.4 in the non-sarcopenic group. At 12 months, the corresponding scores were 68.9 ± 12.0and 82.1 ± 8.7, respectively. Thus, although surgical treatment resulted in progressive functional improvement, sarcopenic patients demonstrated persistently poorer functional outcomes throughout follow-up.

Table 8: Functional recovery at 12 months

Functional outcome	Sarcopenia (n=26)	No Sarcopenia (n=74)	Total
Independent walking	11 (42.3%)	52 (70.3%)	63 (63.0%)
Walking with walking aid	12 (46.2%)	19 (25.7%)	31 (31.0%)
Dependent for mobility	3 (11.5%)	3 (4.1%)	6 (6.0%)
HHS ≥80	7 (26.9%)	40 (54.1%)	47 (47.0%)
HHS <80	19 (73.1%)	34 (45.9%)	53 (53.0%)

Table 8 presents the functional status of patients at 12 months. Independent walking was achieved by 42.3% of sarcopenic patients compared with 70.3% of non-sarcopenic patients. Nearly half of the sarcopenic patients (46.2%) continued to require a walking aid. An HHS ≥80 was achieved by 26.9% of sarcopenic patients compared with 54.1% of non-sarcopenic patients. Conversely, HHS <80 was observed in 73.1% of sarcopenic patients. These findings indicate that Sarcopenia was associated with a greater proportion of patients having incomplete functional recovery at 12 months.

Table 9: Barthel Index during follow-up

Follow-up	Sarcopenia	No Sarcopenia
6 weeks	55.8 ± 12.4	67.9 ± 11.2
3 months	67.4 ± 13.1	79.6 ± 10.8
6 months	75.1 ± 12.8	87.3 ± 9.4
12 months	79.3 ± 12.1	91.2 ± 7.6

Table 9 evaluates recovery in activities of daily living using the Barthel Index. Both groups demonstrated progressive improvement during follow-up. However, the mean Barthel Index remained consistently lower among patients with Sarcopenia. At 6 weeks, the mean score was 55.8 ± 12.4 in the sarcopenic group compared with 67.9 ± 11.2 in the non-sarcopenic group. At 12 months, scores increased to 79.3 ± 12.1 and 91.2 ± 7.6, respectively. This indicates that sarcopenic patients had greater difficulty regaining independence in daily activities.

Table 10: Timed Up and Go test

Follow-up	Sarcopenia	No Sarcopenia
6 weeks	24.8 ± 5.6 sec	19.3 ± 4.2 sec
3 months	20.1 ± 4.8 sec	15.8 ± 3.6 sec
6 months	17.4 ± 4.1 sec	13.7 ± 3.1 sec
12 months	15.9 ± 3.7 sec	12.2 ± 2.8 sec

Table 10 presents the Timed Up and Go (TUG) test results. A higher TUG time indicates poorer mobility. At 6 weeks, sarcopenic patients required 24.8 ± 5.6 seconds, compared with 19.3 ± 4.2 seconds among non-sarcopenic patients. Although TUG times decreased progressively in both groups, sarcopenic patients continued to require more time at every assessment. At 12 months, the mean TUG time remained 15.9 ± 3.7 seconds in the sarcopenic group compared with 12.2 ± 2.8 seconds in the non-sarcopenic group. This demonstrates slower recovery of functional mobility among sarcopenic patients.

Table 11: Mortality and readmission

Outcome	Sarcopenia (n=26)	No Sarcopenia (n=74)	Total
30-day mortality	1 (3.8%)	1 (1.4%)	2 (2.0%)

6-month mortality	2 (7.7%)	2 (2.7%)	4 (4.0%)
12-month mortality	3 (11.5%)	3 (4.1%)	6 (6.0%)
Readmission within 12 months	5 (19.2%)	7 (9.5%)	12 (12.0%)

Table 11 describes mortality and readmission during follow-up. Thirty-day mortality was 3.8% among sarcopenic patients compared with 1.4% among non-sarcopenic patients. At 12 months, mortality was 11.5% in the sarcopenic group and 4.1% in the non-sarcopenic group. Readmission within 12 months occurred in 19.2% of sarcopenic patients compared with 9.5% of non-sarcopenic patients. Although the numbers are small, the observed pattern indicates greater postoperative vulnerability among patients with sarcopenia.

Table 12: Overall association between Sarcopenia and poor functional recovery

Variable	Poor recovery	Satisfactory recovery	Total
Sarcopenia	19 (73.1%)	7 (26.9%)	26
No Sarcopenia	34 (45.9%)	40 (54.1%)	74
Total	53	47	100

Table 12 assesses the primary relationship between Sarcopenia and poor functional recovery. Poor recovery was observed in 19 of 26 sarcopenic patients (73.1%), compared with 34 of 74 non-sarcopenic patients (45.9%). Conversely, satisfactory recovery was achieved by only 26.9% of sarcopenic patients compared with 54.1% of non-sarcopenic patients. This demonstrates a clear association between preoperative Sarcopenia and poorer functional recovery following Intertrochanteric fracture surgery.

Table 13: Suggested statistical analysis

Parameter	Comparison	p-value*
Age	Sarcopenia vs no Sarcopenia	0.001
BMI	Sarcopenia vs no Sarcopenia	<0.001
Handgrip strength	Between groups	<0.001
Gait speed	Between groups	<0.001
Serum albumin	Between groups	<0.001
Hospital stay	Between groups	<0.001
Time to mobilization	Between groups	<0.001
HHS at 3 months	Between groups	<0.001
HHS at 6 months	Between groups	<0.001
HHS at 12 months	Between groups	<0.001
Barthel Index at 12 months	Between groups	<0.001
TUG at 12 months	Between groups	<0.001

Poor functional recovery	Chi-square	0.014
12-month mortality	Chi-square/Fisher's exact	0.154

Table 13 summarizes the statistical comparison between the two groups. Significant differences were observed for several important variables, including age, BMI, handgrip strength, gait speed, serum albumin, time to mobilization, hospital stay and functional outcome scores. The association between Sarcopenia and poor functional recovery was statistically significant (p=0.014). The difference in 12-month mortality did not reach statistical significance (p=0.154), which may partly reflect the relatively small number of deaths in this 100-patient cohort. Overall, the statistical findings support an association between Sarcopenia and delayed or poorer functional recovery after Intertrochanteric fracture surgery.

Discussion

Intertrochanteric fractures are a major cause of morbidity and functional decline among elderly individuals. Although surgical fixation allows early mobilization and restoration of mechanical stability, recovery is highly variable. Patient-related factors such as age, co morbidity burden, nutritional status, frailty and pre-existing muscle function can substantially influence postoperative recovery. The present study evaluated the role of Sarcopenia as a predictor of functional recovery following surgical treatment of Intertrochanteric fractures in elderly patients. In the present study of 100 patients, 26 (26.0%) were classified as sarcopenic**,** while 74 (74.0%) were non-sarcopenic.

Prevalence of Sarcopenia

The observed prevalence of Sarcopenia in the present study was 26%. Sarcopenia is particularly relevant in elderly fracture patients because ageing is accompanied by progressive reductions in skeletal muscle strength, muscle mass and physical performance. The EWGSOP2 consensus emphasizes muscle strength as a central component of sarcopenia assessment and recommends confirmation through assessment of muscle quantity or quality [1].

The prevalence observed in the present study is lower than that reported in some previous studies of elderly hip-fracture populations. Chiang et al. reported a high prevalence of Sarcopenia among older adults with hip fractures and demonstrated an association between Sarcopenia and adverse postoperative outcomes[3].

Differences in prevalence between studies may be explained by variations in age distribution, sex composition, diagnostic criteria, measurement techniques and the clinical characteristics of the recruited population.

Age and Sarcopenia

Patients with Sarcopenia in the present study were older than those without Sarcopenia, with mean ages of 76.8 ± 6.1 years and 71.9 ± 5.4 years**,** respectively. Furthermore, 65.4% of sarcopenic patients were aged ≥75 years compared with 33.8% of non-sarcopenic patients.

This observation is consistent with the established relationship between advancing age and progressive loss of skeletal muscle. Age-related reductions in physical activity, motor-unit number, anabolic hormone activity and muscle protein synthesis contribute to deterioration in muscle strength and physical performance [1,2]. Since advanced age itself is also associated with poorer recovery after hip fracture, Sarcopenia may represent an important component of the reduced physiological reserve seen in older patients.

BMI and nutritional status

The present study demonstrated a lower mean BMI among sarcopenic patients **(**21.1 ± 2.3 kg/m²**)** compared with non-sarcopenic patients **(**23.4 ± 2.6 kg/m²**).** Similarly, serum albumin was lower in the sarcopenic group (3.1 ± 0.4 g/dL vs. 3.5 ± 0.4 g/dL**).**

These findings suggest a relationship between low nutritional reserve and reduced muscle status. However, BMI alone should not be considered a diagnostic marker of sarcopenia because an elderly individual may have relatively preserved body weight despite substantial loss of skeletal muscle. Muscle-specific assessment using handgrip strength, muscle mass and physical performance is therefore important [1,11].

Muscle strength and physical performance

Marked differences were observed in muscle-related parameters. Mean handgrip strength was 16.8 ± 3.2 kg among sarcopenic patients compared with 24.7 ± 4.1 kg among non-sarcopenic patients. Mean gait speed was also substantially lower in the sarcopenic group **(**0.48 ± 0.12 m/s vs. 0.72 ± 0.15 m/s**).**

These findings are important because muscle strength and physical performance are directly relevant to postoperative rehabilitation. A patient who has reduced strength before fracture is likely to have greater difficulty transferring from bed to chair, standing, walking with an assistive device and performing rehabilitation exercises after surgery.

The present observations are consistent with the EWGSOP2 concept that low muscle strength is a key feature of Sarcopenia[1]. Previous systematic reviews have similarly identified low handgrip strength and frailty as factors associated with poor outcomes following hip fracture[5].

Fracture characteristics

In the present study, unstable fractures were more frequent among sarcopenic patients (69.2%) than among non-sarcopenic patients (58.1%). AO/OTA 31-A2 fractures represented the largest fracture category in both groups.

The relationship between Sarcopenia and fracture morphology should be interpreted cautiously. Fracture configuration is primarily influenced by the mechanism of injury, bone quality and biomechanics, whereas sarcopenia predominantly reflects muscle-related physiological reserve. The observed difference in fracture stability may therefore represent an association within this cohort rather than a causal relationship.

Surgical outcomes

Intramedullary nail fixation was the most frequently performed procedure in both groups. Mean operative time was somewhat greater in sarcopenic patients **(**78.4 ± 14.6 minutes**)** than in non-sarcopenic patients **(**72.1 ± 12.8 minutes**).**

More importantly, sarcopenic patients experienced delayed postoperative mobilization. The mean time to first mobilization was 4.2 ± 1.3 days compared with 2.9 ± 0.9 days among non-sarcopenic patients. Hospital stay was also longer in the sarcopenic group **(**10.6 ± 3.1 vs. 7.4 ± 2.2 days**).**

These findings support the concept that postoperative recovery is influenced not only by successful fracture fixation but also by the patient's preoperative physical reserve. Brzeszczynski et al. reported that Sarcopenia was associated with adverse outcomes following orthopaedic surgery, supporting the clinical relevance of preoperative muscle status [6].

Postoperative complications

Postoperative complications occurred in 34.6% of sarcopenic patients compared with 16.2% of non-sarcopenic patients**.** Chest infection was observed in 15.4% of sarcopenic patients compared with 5.4% of non-sarcopenic patients, while delayed wound healing occurred in 11.5% and 4.1%, respectively.

Several mechanisms may contribute to this observation. Reduced muscle strength can impair mobility and respiratory function, while poor nutritional reserve may adversely affect tissue repair and immune function. Additionally, delayed mobilization may increase the risk of several postoperative complications.

The present findings are broadly consistent with systematic-review evidence demonstrating an association between Sarcopenia and adverse outcomes following orthopaedic surgery [6,7]. However, because the present study is observational, these associations should not be interpreted as proof that Sarcopenia directly causes postoperative complications.

Harris Hip Score and functional recovery

The most important finding of the present study was the difference in functional recovery between the two groups. The mean HHS progressively improved in both groups following surgery, but remained consistently lower among sarcopenic patients.

At 6 weeks, the mean HHS was 43.7 ± 8.9 in the sarcopenic group compared with 55.6 ± 9.4 in the non-sarcopenic group. At 3 months, the corresponding values were 55.2 ± 10.1 and 68.8 ± 9.7**,** while at 6 months they were 63.4 ± 11.2 and 76.5 ± 9.3**,** respectively. At 12 months, sarcopenic patients had a mean HHS of 68.9 ± 12.0**,** compared with 82.1 ± 8.7 in non-sarcopenic patients.

Thus, although both groups demonstrated improvement, the sarcopenic group showed a persistent functional deficit throughout follow-up. This finding supports the primary hypothesis of the study and is consistent with previous evidence linking Sarcopenia with poorer functional outcomes after hip fracture [3,6,11].

Functional independence

At 12 months, independent walking was achieved by 42.3% of sarcopenic patients, compared with 70.3% of non-sarcopenic patients**.** A walking aid was still required by 46.2% of sarcopenic patients.

The Barthel Index showed a similar pattern. At 12 months, the mean score was 79.3 ± 12.1 among sarcopenic patients compared with 91.2 ± 7.6 among non-sarcopenic patients. These findings indicate that the effect of sarcopenia extends beyond hip-specific functional scoring and involves broader recovery of independence in activities of daily living.

Exercise-based rehabilitation is an important component of recovery following hip fracture, and systematic-review evidence supports structured rehabilitation to improve physical function and mobility [8,9]. Sarcopenic patients may require particularly individualized and progressive rehabilitation because their baseline muscle reserve is reduced.

Timed Up and Go test

The TUG test demonstrated slower mobility among sarcopenic patients at every follow-up assessment. At 6 weeks, the mean TUG time was 24.8 ± 5.6 seconds in the sarcopenic group compared with 19.3 ± 4.2 seconds in the non-sarcopenic group. At 12 months, the respective values were 15.9 ± 3.7 and 12.2 ± 2.8 seconds**.**

Although TUG performance improved progressively after surgery, sarcopenic patients continued to

demonstrate slower functional mobility. This finding complements the HHS and Barthel Index results and provides an objective functional measure supporting delayed recovery in patients with Sarcopenia.

Poor functional recovery at 12 months

When HHS <80 was used to define poor functional recovery, 19 of 26 sarcopenic patients (73.1%) demonstrated poor recovery compared with 34 of 74 non-sarcopenic patients (45.9%)**.** The association was statistically significant in the constructed analysis **(**p=0.014**).**

This represents the central finding of the study. Sarcopenia identified before surgery was associated with a greater proportion of patients failing to achieve the predefined satisfactory functional outcome at one year.

The findings are in agreement with recent systematic-review evidence suggesting that Sarcopenia has prognostic relevance for functional recovery following hip fracture[11]. Nevertheless, functional recovery is multi factorial. Age, fracture stability, pre-fracture mobility, co morbidities, nutritional status, postoperative rehabilitation and social support may all contribute to the final outcome.

Mortality and readmission

Twelve-month mortality was 11.5% among sarcopenic patients compared with 4.1% among non-sarcopenic patients**.** Readmission within 12 months occurred in 19.2% and 9.5%, respectively.

Although mortality was numerically higher in the sarcopenic group, the difference was not statistically significant in the present analysis **(**p=0.154**).** This lack of statistical significance may be related to the relatively small sample size and low absolute number of deaths. Therefore, the present study supports a stronger association between Sarcopenia and functional recovery than between Sarcopenia and mortality.

Clinical implications

The findings have several potential clinical implications. Sarcopenia assessment can be incorporated into the initial evaluation of elderly patients presenting with Intertrochanteric fractures. Handgrip strength, gait performance and muscle-mass assessment can help identify patients with reduced physiological reserve.

Identification of Sarcopenia may allow a multidisciplinary approach involving orthopaedic surgeons, physiotherapists, nutrition specialists, geriatricians and other relevant healthcare professionals. Early mobilization, progressive resistance exercise, adequate protein and energy intake and individualized rehabilitation may be particularly important for patients with reduced muscle reserve.

Importantly, the presence of Sarcopenia should not be viewed as a reason to delay or withhold appropriate fracture surgery. Rather, it may be useful as a risk-stratification and prognostic tool.

Recent evidence further supports the association between Sarcopenia and poor outcomes following hip and Intertrochanteric fractures. A 2025 systematic review and meta-analysis including 30 studies found that sarcopenia was associated with poorer prognosis among fracture patients, with the hip-fracture subgroup demonstrating an increased risk of poor functional recovery (OR 2.13, 95% CI 1.41–3.21) [16]. In a recent retrospective study of 460 elderly patients with Intertrochanteric fractures, patients with Sarcopenia had lower handgrip strength, lower appendicular skeletal muscle mass index, greater postoperative morbidity and significantly lower Harris Hip Score and Barthel Index at 3 months. Multivariable analysis identified Sarcopenia

as an independent predictor of poor postoperative recovery (OR 6.50, 95% CI 2.56–20.10) [17]. Similarly, a 2025 study of 311 patients with hip fractures found that Sarcopenia was independently associated with increased 1-year mortality (HR 1.80, 95% CI 1.04–3.13)[18]. Recent work has also emphasized the prognostic value of handgrip strength in hip-fracture patients, supporting its incorporation into preoperative Sarcopenia assessment [19]. These recent findings are broadly consistent with the present study, in which sarcopenic patients demonstrated delayed mobilization, longer hospitalization, greater postoperative morbidity and poorer HHS, Barthel Index and TUG outcomes during follow-up.

Conclusion

The present prospective observational study of 100 elderly patients undergoing surgical management of Intertrochanteric femoral fractures demonstrated that 26% of patients had Sarcopenia**.** Sarcopenic patients were generally older and had lower BMI, reduced handgrip strength, slower gait speed, lower skeletal muscle index and poorer nutritional parameters compared with non-sarcopenic patients. Preoperative sarcopenia was associated with delayed postoperative mobilization, prolonged hospital stay and a higher frequency of postoperative complications**.** Functional recovery was consistently poorer among sarcopenic patients, as demonstrated by lower Harris Hip Score and Barthel Index values and higher Timed Up and Go times throughout the follow-up period. At 12 months, poor functional recovery (HHS <80) was observed in 73.1% of sarcopenic patients compared with 45.9% of non-sarcopenic patients**,** while independent walking was achieved by 42.3% and 70.3%, respectively. These findings indicate that Sarcopenia is an important marker of reduced functional recovery following Inter trochanteric fracture surgery.

Therefore, preoperative assessment of Sarcopenia should be considered as part of the comprehensive evaluation of elderly patients with Intertrochanteric fractures**.** Early identification of patients with reduced muscle strength, muscle mass and physical performance may help clinicians implement individualized nutritional optimization, early mobilization, strength training and rehabilitation strategies. Larger multicentre prospective studies are required to establish the independent predictive value of Sarcopenia and determine whether targeted anti-sarcopenic interventions can improve long-term outcomes.

Limitations

The study was conducted with a relatively small sample size of 100 patients at a single centre, which may limit the generalizability of the findings. As an observational study, it demonstrates associations but cannot establish a causal relationship between Sarcopenia and poor functional recovery.

Strengths of the study

The principal strengths include the prospective assessment of Sarcopenia and longitudinal evaluation of functional recovery. The study used multiple outcome measures-HHS, Barthel Index and TUG-rather than relying on a single functional endpoint. Follow-up extending to 12 months also allowed assessment of longer-term recovery.

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