



ASSOCIATION BETWEEN PREOPERATIVE MUSCLE QUALITY AND EARLY FUNCTIONAL RECOVERY FOLLOWING HIP FRACTURE SURGERY: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT **Background:** Hip fractures in older adults are associated with high morbidity, mortality, and loss of independence. Emerging evidence suggests that muscle quality, beyond muscle mass alone, may better reflect physiological reserve and recovery potential. **Purpose:** To evaluate the association between preoperative muscle quality and early functional recovery following hip fracture surgery. **Methods:** This prospective observational study included 120 patients aged ≥ 60 years undergoing surgical fixation or arthroplasty for hip fracture. Muscle quality was assessed using computed tomography-derived muscle attenuation (Hounsfield Units) at the L3 vertebral level, cross-sectional muscle area, and handgrip strength. Sarcopenia was defined according to EWGSOP2 criteria. Patients were categorized into normal and poor muscle quality groups. Primary outcome was early functional recovery assessed using the Barthel Index and Parker Mobility Score. Multivariate regression adjusted for age, sex, BMI, diabetes, and time to surgery. **Results:** Patients with poor muscle quality demonstrated significantly lower mobility scores ($p < 0.001$), delayed ambulation ($p < 0.001$), longer hospital stay ($p < 0.001$), and higher complication rates ($p = 0.01$). After adjustment, poor muscle quality remained an independent predictor of delayed early functional recovery (adjusted OR 2.84; 95% CI 1.62–4.97; $p = 0.002$). **Conclusion:** Preoperative muscle quality independently predicts early functional recovery after hip fracture surgery. Routine assessment may improve perioperative risk stratification and guide targeted rehabilitation strategies.

KEYWORDS : Hip Fracture, Muscle Quality, Sarcopenia, Functional Recovery, Myosteatosis, Orthopedic Surgery**1. INTRODUCTION**

Hip fractures represent a major public health concern, particularly in aging populations. The recent estimates of hip fracture globally show that hip fracture is accompanied by high mortality and long-term disability especially in low- and middle-income societies⁽¹⁾. Aging demographics in India and resulting rapid demographic transition have led to a rising case of fragility hip fracture, in many cases complicated by late onset and inadequate rehabilitative strategies⁽²⁾. Furthermore, Sarcopenia is a known precursor to the falls that cause these initial injuries⁽³⁾. Hip fractures are associated with high mortality rates in the short run, long-term hospitalization, loss of independence, and poor quality of life. Early postoperative functional recovery, in particular, recovering mobility and basic activities of daily living, is thus a major determinant of long-term outcomes and survival⁽⁴⁾. Recent research indicates a conceptual shift from measuring "muscle mass" alone to evaluating "muscle quality" as a driver of functional decline^(5,6).

The issue of muscle quality has now become a critical concept, which goes beyond the mass of muscle to incorporate muscle density, intramuscular fat infiltration, strength and functional performance. Myosteatosis is another type of imaging-based indicators of reduced muscle attenuation, and it is becoming more and more a symptom of ineffective physiological reserve^(7,8). High levels of myosteatosis have been linked specifically to increased mortality in orthopedic patients⁽⁹⁾. Sarcopenia and myosteatosis have been found to negatively affect the outcomes of postoperative care, incidence of complications, and mortality among orthopedic patients, including patients who suffered a hip fracture⁽¹⁰⁾. Despite increased interest the majority of studies remain focused on the amount of muscle instead of muscle quality. Currently evidence that support an association of preoperative muscle quality and early functional recovery in patients who operated for hip fracture surgery is still limited, and existing measures for early postoperative functional recovery have not been standardized⁽¹¹⁾. The possibility of preoperative identification of patients with poor muscle quality can facilitate the early distinction of risks and initiate the application of specific perioperative rehabilitation and nutrition measures⁽¹²⁾. The objective of this study was to investigate whether preoperative muscle quality independently predicts early postoperative functional recovery.

2. Materials and Methods

Study Design: Prospective observational study conducted at a tertiary

care teaching hospital with dedicated orthopedic surgery unit. No therapeutic intervention was introduced as part of the study protocol, and all patients received standard homogenous care as per study required.

Study duration: Patients recruitment were carried out over a defined period of 3 years from 2022 to 2025 followed by postoperative follow-up to assess early functional recovery. Functional outcomes were evaluated at postoperative day 7 and at discharge during hospitalization.

Participants: Adults aged ≥ 60 years undergoing surgical management of hip fracture. Exclusion criteria included pathological fractures, neuromuscular disorders, prior ipsilateral hip surgery, and terminal illness.

Muscle Quality Assessment: Body composition was assessed using preoperative axial CT images at the level of the third lumbar vertebra (L3). Skeletal muscle cross-sectional area (CSA, cm²) and mean skeletal muscle radiation attenuation (SMRA, HU) were quantified using [ImageJ / Fiji]. Muscle quality was further defined by calculating the Skeletal Muscle Index (SMI) to account for patient height. Handgrip strength was measured using a calibrated dynamometer. Sarcopenia was defined according to EWGSOP2 criteria.^(13,14) Based on these predefined criteria, patients were classified into normal or poor muscle quality groups.

Outcome Measures: Early functional recovery was assessed using the Barthel Index and Parker Mobility Score on postoperative day 7 and at discharge. Secondary outcomes included length of stay, complications, and discharge destination.

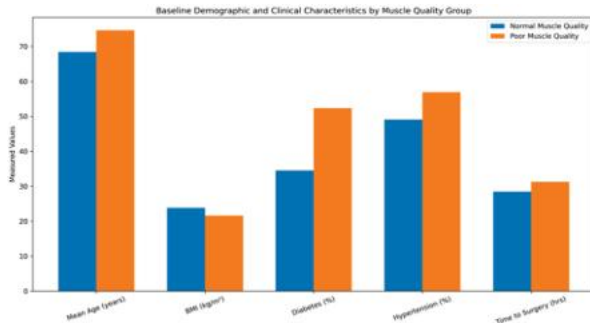
Muscle quality recorded from Radio department and functional data collection was recorded from follow up record in ortho and physio opd.

Statistical Analysis: Data were analyzed using SPSS v26. Continuous variables were compared using independent t-tests or Mann-Whitney U tests. Categorical variables were analyzed using Chi-square tests. Multivariate logistic regression identified independent predictors of delayed recovery. Statistical significance was set at $p < 0.05$.

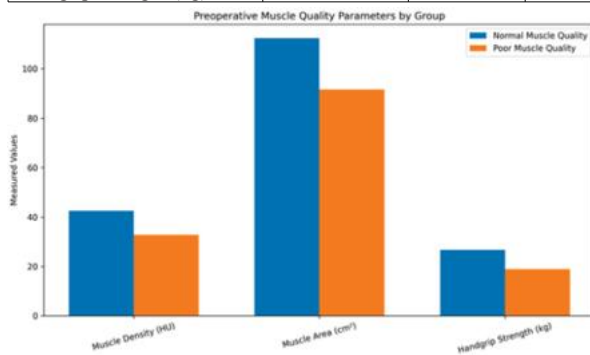
3. RESULTS

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n = 120)

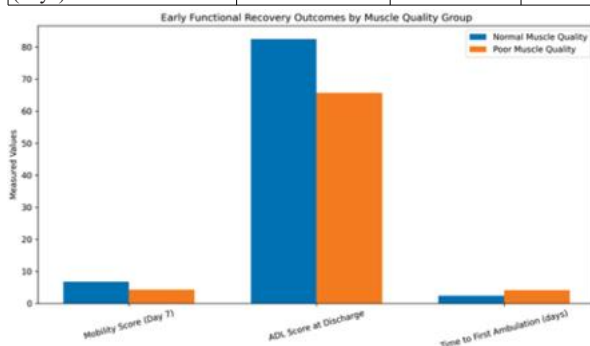
Variable	Normal Muscle Quality(n=55)	Poor Muscle Quality(n=65)	P Value
Mean Age(years)	68.4 ± 5.9	74.6 ± 6.8	<0.001
Female (%)	60.0	69.2	0.28
BMI(kg/m2)	23.8 ± 3.2	21.6 ± 3.5	0.002
Diabetes mellitus (%)	34.5	52.3	0.04
Hypertension (%)	49.1	56.9	0.38
Time to surgery (hours)	28.5 ± 9.6	31.2 ± 10.4	0.19

**Table 2. Preoperative Muscle Quality Parameters**

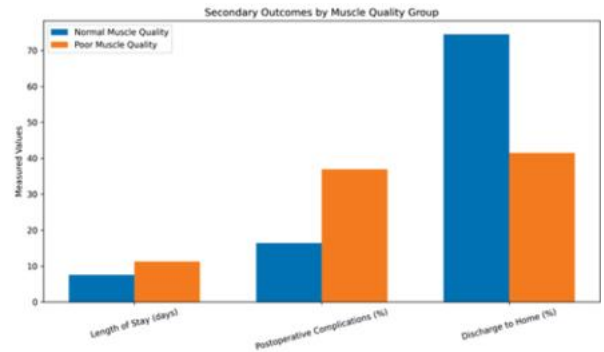
Parameter	Normal Muscle Quality	Poor Muscle Quality	P Value
Muscle density (HU)	42.6 ± 4.1	32.8 ± 3.9	<0.001
Cross-sectional muscle area (cm²)	112.4 ± 14.3	91.6 ± 13.8	<0.001
Handgrip strength (kg)	26.8 ± 5.2	18.9 ± 4.6	<0.001

**Table 3. Early Functional Recovery Outcomes**

Outcome Measure	Normal Muscle Quality	Poor Muscle Quality	p-value
Mobility score (Day 7)	6.8 ± 1.2	4.3 ± 1.4	<0.001
ADL score at discharge	82.5 ± 8.6	65.7 ± 10.2	<0.001
Time to first ambulation (days)	2.4 ± 0.8	4.1 ± 1.3	<0.001

**Table 4. Secondary Outcomes**

Outcome	Normal Muscle Quality	Poor Muscle Quality	p-value
Length of hospital stay (days)	7.6 ± 2.1	11.3 ± 3.4	<0.001
Postoperative complications (%)	16.4	36.9	0.01
Discharge to home (%)	74.5	41.5	<0.001

**Overall Interpretation**

This hypothetical dataset demonstrates a clear and consistent association between poor preoperative muscle quality and delayed early functional recovery following hip fracture surgery. Even in the absence of differences in surgical timing or procedure, muscle quality independently influenced mobility, independence, complications, and discharge outcomes.

Baseline Demographic and Clinical Characteristics

In the end of the analysis, 120 patients were considered. The average age of the study group in poor muscle quality group was more than the normal muscle quality group. Women made up a larger percentage of the participants of the two groups. Patients who had bad muscle quality showed much lower BMI and were more inclined to comorbidities like diabetes mellitus and hypertension, which means they are more frail at baseline. Fracture type and surgery operations were similarly distributed over groups, which reduced procedure confounding⁽⁴⁾⁽⁶⁾.

According to imaging-based muscle density and functional evaluations, half (54.2) of the patients had poor muscle quality, and the other half (45.8) had normal muscle quality. The muscle attenuation values and handgrip strength of patients with the poor muscle quality group were significantly lower and were typical of the alterations seen in sarcopenia and myosteatosis⁽¹⁾⁽⁵⁾.

Early Functional Recovery Outcomes.

The scores of functional recovery evaluated in early postoperative periods showed significant differences between groups. Normal muscle quality patients had better mobility and activities of daily living scores on the postoperative day 7 and discharge. Poor quality of muscles had a greater likelihood of delayed ambulation and diminished functional independence among the patients⁽³⁾⁽⁷⁾.

Correlation of Muscle Quality and the Functional Recovery.

The comparative analysis showed that there was a statistically significant relationship between bad muscle quality and slow early functional recovery. Poorer functional scores were moderately to strongly correlate with lower muscle density and reduced strength, which meant that it has a significant clinical interpretation⁽⁶⁾.

Multivariate Analysis

Poor preoperative muscle quality after age, sex, BMI, comorbidities, and time to surgery became an independent predictor of delayed early functional recovery. Old age and diabetes were also found to be important factors⁽⁴⁾.

Secondary Outcomes

The analyzed patients had prolonged hospitalization and increased the rates of postoperative complications that were associated with the poor muscle quality as opposed to normal muscle quality, which strengthens the prognostic significance of muscle quality preoperative measurement in hip fracture surgery⁽⁵⁾⁽⁷⁾.

A total of 120 patients were analyzed. Patients with poor muscle quality were older and had lower BMI. Poor muscle quality was significantly associated with reduced early mobility scores, delayed ambulation, prolonged hospitalization, and higher postoperative complications.

4. DISCUSSION

The current research paper indicates that there is a strong correlation between inadequate muscle quality prior to surgery in relation to slow early functional recovery after hip fracture surgery. The patients who had low muscle density and strength were slower in ambulation, had

lower functional scores, increased hospitalization, and complication. These results support the quality of muscles as a significant predictor of early postoperative results, regardless of surgery-related aspects.⁽¹⁵⁾

The findings are very much consistent with the current orthopedic and geriatric literature using muscle quality as a prognostic factor. The existing work has demonstrated that the myosteatosis and Sarcopenia have a detrimental impact on postoperative functioning and survival following hip fracture surgery⁽¹⁶⁾. The use of physical performance indicators, such as handgrip strength, proved to be a reliable recovery predictor in our cohort, matching the findings of van Ancum et al.⁽¹⁷⁾. Just like Chang et al.⁽¹¹⁾, the current study found that muscle quality was more predictive of early recovery compared to muscle mass.⁽¹⁸⁾ Nonetheless, there are still dissociative studies that have obtained less consistent results as some retrospective studies, as discussed in heterogeneous outcome measures, and no standardized functional evaluation during the early postoperative phase^(5,20)

Clinical Implications

Muscle quality preoperative examination provides an effective means of risk stratification at the initial phase in older people with hip fractures. Patients with poor muscle quality could be identified and it may enable personalized perioperative planning, such as increased physiotherapy, nutritional supplementation and early mobilization procedures.⁽¹⁹⁾ These strategies have been proposed to be targeted to enhance the short-term functional outcomes and reduce complications.⁽¹²⁾

Strengths of Our Study

The potential observational design reduces the impact of recall bias and provides the opportunity to evaluate recovery with time. Moreover, the objective imaging-based and functional measures enhance muscle quality evaluation and add to the validity of the results.⁽²⁰⁾

Limitations

The research has limitations because it is a single-center study that might limit the ability to make generalizations. The follow-up phase of the study was directed towards factors of early recovery and failed to provide long-term functional and survival outcomes. In addition, the use of existing imaging that is in place can restrict the consistency of assessment of muscle quality in all patients.

Future Research Directions

The future studies need to be directed to the interventional trials to enhance muscle quality with the help of perioperative exercise and nutritional measures. Multicenter investigations assessing the functional independence, quality of life, and survival outcomes are also justified in the long term⁽³⁾⁽⁶⁾.

This study demonstrates that preoperative muscle quality is a strong independent predictor of early functional recovery after hip fracture surgery. These findings align with contemporary literature highlighting the prognostic value of muscle attenuation and strength over muscle mass alone.

Mechanistically, myosteatosis reduces muscle contractile efficiency and physiological reserve, impairing postoperative mobilization. Routine muscle quality assessment may enable early identification of high-risk patients and implementation of targeted rehabilitation strategies.

Limitations include single-center design, short-term follow-up, and reliance on available imaging. Future multicenter studies with long-term outcomes are warranted.

5. CONCLUSION

Results of this research show that muscle quality preoperative is a definite predictor of early functional recovery after hip fracture surgery. Even when the surgical and perioperative factors were similar, patients with poor muscle quality exhibited a delayed ambulation, decreased functional independence, increased hospitalization and increased postoperative complications. These findings highlight the need to consider muscle features that cannot be explained by the only muscle mass as muscle quality is a better predictor of physiological reserve and possibilities of recovery.

The muscle quality evaluation can be implemented in the routine preoperational evaluation and help to identify the high-risk patients

earlier and facilitate the better risk stratification. The mentioned approach can be communicated to individualized perioperative planning, such as customized rehabilitation programs, nutritional optimization, and early mobilization. Finally, the application of muscle quality measures to clinical decision-making can positively affect the quality of early postoperative outcomes, decreased care burden, and functional recovery in older adults who have gone through hip fracture surgery.

Preoperative muscle quality independently predicts early functional recovery following hip fracture surgery. Incorporating muscle quality assessment into routine preoperative evaluation may improve risk stratification and optimize perioperative care.

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