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# Frailty defined by 19 items as a predictor of short-term functional recovery in patients with hip fracture

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ABSTRACT

*Introduction:* Many hip fracture patients have decreased functional status inhibiting recovery to pre-fracture functional status. The prevalence of frailty in patients with hip fracture is high, but little is known how frailty is associated with functional recovery. The aim of this study was to determine whether frailty can predict functional recovery and clinical outcomes during the acute phase in hip fracture.
*Patients and Methods:* This study was retrospective observational study from two acute hospitals. Participants were recruited from hip fracture patients who underwent surgery. The main exposure was frailty defined using 19-item modified Frailty Index (mFI). The main outcome was functional recovery, evaluated by postoperative efficiency on the motor-Functional Independence Measure (FIM) score. Secondary outcomes included postoperative complication and discharge disposition. Multiple logistic regression analyses were performed using each outcome as a dependent variable and mFI as an independent variable.
*Results:* Sample included 274 patients (mean age 83.7 ± 7.4 years, female 80.7%). Patients with higher mFI exhibited lower functional recovery, defined by efficiency on the motor-FIM score, and tended to run into complications and not return home ($P < .001$). In multiple logistic regression analyses, higher mFI was significantly associated with increased likelihood of lower functional recovery (odds ratio [OR], 1.60; 95% CI, 1.32–1.93; $P < .001$), occurrence of postoperative complication (OR, 1.32; 95% CI, 1.13–1.54; $P < .001$) and not returning home (OR, 1.77; 95% CI, 1.38–2.26; $P < .001$).
*Conclusions:* Frailty defined by 19-item mFI can predict short-term functional recovery during acute phase following hip fracture. Frailty is also associated with postoperative complication and discharge disposition.



## Introduction

Hip fracture is the most severe osteoporotic fracture, and many patients have decreased functional status after fracture; >40% of patients do not regain their pre-fracture functional ability [1]. Dubljanin-Raspopović et al. reported that the functional status at discharge from the acute care hospital was the only independent predictor of one-year mortality after hip fracture [2]. Therefore, functional recovery during the acute phase is a critical outcome in patients with hip fracture.

Frailty is defined as a state of vulnerability with various preliminary reductions in the ability to maintain or regain homeostasis when exposed to stressors [3–5]. Many hip fractures result from frailty [6] but there have been no reports investigating the association between frailty and functional recovery. Elucidating the impact of frailty on postoperative functional recovery will allow clinicians to identify those patients at high risk of low recovery after surgery. The identification of a high risk of low recovery after surgery might lead to early effective intervention by a multidisciplinary team.

Thus, the purpose of this investigation was to determine whether frailty can predict functional status during the acute phase in patients following hip fracture. We investigated whether

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frailty could predict clinical outcomes (i.e. the occurrence of postoperative complication and discharge disposition).

## Patients and methods

### *Setting and sample*

This retrospective cohort study was conducted from February 2014 to December 2015. Subjects were recruited and consecutively admitted to two acute hospitals in Kobe, the capital of Hyogo prefecture in Japan.

All subjects were patients with femoral neck, trochanteric, subtrochanteric and basicervical hip fractures. Inclusion criteria included age ≥65 years and fractures caused by falling. We excluded those who had a terminal malignant disease, were unfit for surgery or died during hospitalisation.

Individual postoperative rehabilitation was provided by physical therapists for 20–40 min per day, five to six days per week. Physical therapists enhanced the range of motion of the joint, lower extremity muscle strength and ability to perform standing and walking exercises to improve the functional status from postoperative day 1.

## Measures

### *Modified frailty index*

The main exposure in this study was frailty, as defined by the modified Frailty Index (mFI) reported by Patel et al. [7]. The mFI has 19 items, which were chosen from among 70 items from the Canadian Study of Health and Ageing (Table 1) [8]. It considers comorbidities, cognitive function and walking ability. We scored 1 point if it applied to each item, and 0 points otherwise. According to Patel et al.'s study [7], the pre-fracture ambulatory item was scored 0 points only if the patient were ambulatory with no assistive devices. Otherwise, the score was 1 point if the patient were ambulatory with a walker or cane or 2 points if the patient were nonambulatory or used a scooter/wheelchair. Therefore, we scored a total of 20 points from the 19 items. Generally, mFI presented the ratio of each deficit to the total number of items, and the value from 0 to 1 as an accumulation of deficits [9]. In the present study, we treated mFI as the total number of deficits, rather than as a ratio, for ease of interpretation [10]. For example, if the patient had a cognitive impairment, Parkinson's disease and used a wheelchair before fracture, we scored 4 points for this patient.

### *Outcome measures*

#### *Functional status*

The main outcome of this study was functional recovery during the acute phase. We evaluated the functional status with the Functional Independence Measure (FIM) on postoperative day 1 (baseline FIM) and at discharge from the hospital in the acute postoperative stage (discharge FIM). This validated tool is a comprehensive scale used to evaluate patients based on how they perform activities of daily living (ADL). The FIM consists of 13 motor (eating, grooming, bathing, dressing upper and lower body, toileting, bladder and bowel management, bed transfer, chair transfer, wheelchair transfer, toilet transfer, tub transfer, walk/wheelchair and the use of stairs) and five cognitive items (comprehension, expression, social interaction, problem solving and memory). All items were scored from 1 (demonstrated full dependence) to 7 (demonstrated full independence) points, with a total possible score of 128 points. We used the motor-FIM score for analysis, which reflects ADL scores ranging from 13 to 91 points. To evaluate functional recovery during the acute phase, we calculated efficiency on the motor-FIM score (discharge motor-FIM score – baseline motor-FIM score / postoperative length of hospital stay). The physical therapists in our hospitals have evaluated all patients' functional status using this tool as part of the rehabilitation protocol and are well experienced in its use. For statistical analysis, patients with the lowest quarter inefficiency with regard to the motor-FIM score were included in a low recovery group and the other patients were included in a normal recovery group.

#### *Clinical outcomes*

A history of postoperative complications were collected from the medical records, including delirium, deep thrombophlebitis, pneumonia, urinary tract infection and pressure sores, as diagnosed by the attending physician. Discharge disposition was also recorded, which was classified home or others from acute hospitals. For statistical analysis, we classified patients based on occurrence of complications (complication group or no complication group) and whether they returned home or went to another location upon discharge (home group or others group).

### *Statistical analysis*

We used the Mann-Whitney U test to compare mFI between two groups by each outcome because mFI was nonparametric data. We also performed trend tests, using the Cochrane-Armitage test, followed by Fisher exact test for confirming differences between

**Table 1**
The 19 items of the modified Frailty Index.

- Cerebrovascular accident or transient ischaemic attack
- Impaired cognition (dementia, Alzheimer's dementia)
- History of falling
- Diabetes mellitus
- History of syncope or blackouts
- Pre-fracture ambulation
- Psychotic disorder (posttraumatic stress syndrome, bipolar disease, paranoia, schizophrenia)
- Thyroid disease
- History of seizures
- Congestive heart failure
- Depression
- History of malignancy
- Decubitus ulcers
- Cardiac disease (coronary artery disease, arrhythmia mitral valve prolapse, aortic stenosis)
- Urinary incontinence
- Parkinson's disease
- Renal disease (acute or chronic)
- Respiratory problems (chronic obstructive pulmonary disease, emphysema, obstructive sleep apnoea, chronic bronchitis
- History of myocardial infarction

the numbers of deficits of mFI and each clinical outcome. Multiple logistic regression analysis was performed to explore the effects of mFI on each outcome after adjusting for confounding factors. Each outcome was put into the dependent variable, and the mFI was put into the independent variable as a continuous variable. We adjusted for age, gender, Body Mass Index (BMI), time from fracture to surgery and fracture type as potential confounders. Then, to evaluate mFI's predictive accuracy, we described the receiving operator characteristic (ROC) curve and computed the areas under the curves (AUC). The optimal cut-offs of mFI for predicting clinical outcomes were identified using the Youden criteria. We conducted a statistical analysis using EZR (Saitama Medical Centre, Jichi Medical University, Saitama, Japan). $P < .05$ was considered statistically significant.

## Results

Two hundred and ninety-five hip fracture patients who met the inclusion criteria were consecutively admitted to the two hospitals during the observational duration. We excluded nine patients because they were unfit for surgery. Four patients died during hospitalisation (mortality rate of 0.01%) and were excluded from the analysis. We also excluded 12 patients for missing data. Ultimately, 270 patients were included in the final analysis. The patient demographics are shown in Table 2. The median length of hospital stay was 25 days (range 19–34), and the median postoperative stay was 21 days (range 16–29).

The mean mFI was $3.2 \pm 1.9$ points, with a minimum to a maximum range of 0 to 9. The top five deficits of each component within the mFI was a history of falling (170 patients, 63.1%), impaired cognition (144 patients, 54.4%), pre-fracture ambulatory use of a device or wheelchair (139 patients, 51.9%), diabetes mellitus (50 patients, 18.6%), cerebrovascular accident or transient ischaemic attack (44 patients, 16.8%).

The associations between the mFI and postoperative functional recovery and other outcomes are shown in Table 3. The median efficiency on the motor−FIM for all patients was 1.04 points/day (the minimum to a maximum range of 0.00−4.56 points/day). Patients in the low recovery group exhibited a higher mFI (median: 4 points; interquartile range [IQR]: 0–9 points) than the normal recovery group (median: 3 points; IQR: 0–9 points). Postoperative complications included delirium (25.6%), pneumonia (2.9%), urinary tract infection (2.9%), deep vein thrombosis (0.7%) and atrial fibrillation (0.4%), which occurred in some patients during hospitalisation. The occurrence of complication group had higher mFI (median: 4 points; IQR: 2–5 points) than the no complication group (median: 3 points; IQR: 1–4 points). Fifty-one patients (18.9%) returned home and 163 patients (81.1%) were others (i.e. did not return home). The others group showed a greater mFI (median: 4 points; IQR: 2–5 points) than the return to home group (median: 1 point; IQR: 0–2 points). The trend tests revealed that each clinical outcome tended to become poor as deficits in mFI increased.

**Table 2**
Baseline characteristic of patients.

| Factor | | Overall |
|---|---|---|
| *N* | | 270 |
| Age | | 83.7 ± 7.4 |
| Gender (%) | Male | 52 (19.3) |
| | Female | 218 (80.7) |
| BMI | | 20.4 ± 3.3 |
| Pre-fracture disposition (%) | Home | 207 (76.7) |
| | Other | 63 (23.3) |
| Fracture to surgery day | | 4 (2–6) |
| Fracture type (%) | Neck | 136 (50.4) |
| | Trochanteric | 114 (42.2) |
| | Basal | 9 (3.3) |
| | Subtrochanteric | 11 (4.1) |
| Operation (%) | Hemiarthroplasty | 98 (36.3) |
| | Gamma nail | 132 (48.9) |
| | Pinning | 38 (14.1) |
| | Other | 2 (0.7) |

Data were presented as mean ± standard deviation for normal distribution and as median (interquartile range) for non-normal distribution, unless indicated to be frequency (%) for categorical variables. BMI: Body Mass Index.

Multiple logistic regression analyses revealed that a higher mFI was significantly associated with an increased likelihood of each adverse outcome after adjusting for potential confounders (Table 4). In detail, as mFI increased by 1 point, the odds of admitting the low recovery of the motor-FIM group increased 1.6 times (odds ratio [OR], 1.60; 95% CI, 1.32–1.93; $P < .001$). Similarly, the odds of complications occurring increased 1.32 times as mFI increased by 1 point (OR, 1.32; 95% CI, 1.13–1.54; $P < .001$). The odds of failure to return home increased 1.77 times as mFI increased by 1 point (OR, 1.77; 95% CI, 1.38–2.26; $P < .001$).

The ROC curve analysis results are shown in Fig. 1. The AUC was 0.73 for efficiency on the motor−FIM (Fig. 1A), 0.64 for postoperative complications (Fig. 1B) and 0.77 for discharge disposition (Fig. 1C). The cut-off value was 4 points, 4 points and 3 points, respectively.

## Discussion

This retrospective observational study from two hospitals revealed that frailty, defined by 19 items, was independently associated with low functional recovery, postoperative complications and discharge disposition. To our knowledge, this is the first investigation showing that frailty predicts functional recovery in patients with hip fracture during the acute phase.

Frailty is a common status among hip fracture patients [6,7,11–13] and imposes detrimental outcomes on these patients' quality of life. Although functional status after hip fracture is becoming increasingly important [14], there have been no reports on the association between frailty and functional recovery. In addition, although several screening tools for assessing a patient's risk for adverse outcomes have been reported, there are few tools to predict the functional status in patients with hip fractures. For example, the American Society of Anesthesiologists physical score is a surgical risk scoring system that is widely used in daily practice and has been reported to be associated with postoperative in-hospital complications [15–18]; however, it is not associated with the functional status in patients with hip fractures [18]. In this study, we used 19 items as mFI, reported by Patel et al. [7], and revealed that mFI predicted low functional recovery. This 19 items scale of frailty included assessments of walking ability and cognitive function, which are associated with functional or clinical outcomes [19–21], consistent with our findings. Also, several studies reported that frailty in hip fracture patients was associated with mortality, postoperative complications, longer hospital stays and a worse discharge disposition [6,12]. These studies also supported our results, in which frailty was associated with adverse outcomes in hip fracture patients. The 19 item scale we used can be evaluated quickly. Therefore, the mFI assessed in this study can be considered as one of the postoperative risk screening tools for identifying patients with hip fractures having a high risk of poor functional recovery in a clinical setting. The ROC curve demonstrated the efficiency on the motor−FIM, and the occurrence of postoperative complications showed the best predictive accuracy, at 4 points, and discharged disposition, at 3 points, of mFI. Patel et al., reported that patients with an mFI of 4.0 or greater had a higher odds ratio for 1 and 2 years mortality [7]. Thus, the present study's cut-off value is reasonable and easy to use in a clinical setting.

**Table 3**
The association between the mFI and clinical outcomes.

| Characteristic[a] | Efficiency on the motor-FIM | | | Postoperative complication | | | Discharge disposition | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal recovery | Low recovery | *P* value | Not complication | Complication | *P* value | Home | Others | *P* value |
| Overall (*N* = 270) | 202 (74.8) | 68 (25.2) | | 166 (61.5) | 104 (38.5) | | 51 (18.9) | 219 (81.1) | |
| mFI | | | | | | | | | |
| Median (IQR) | 3 (0–9) | 4 (0–9) | <.001[b] | 3 (1–4) | 4 (2 - 5) | <.001[b] | 1 (0–2) | 4 (2–5) | <.001[b] |
| Mean (SD) | 2.80 (1.78) | 4.25 (1.61) | <.001[b] | 2.83 (1.72) | 3.80 (1.95) | <.001[b] | 1.75 (1.60) | 3.50 (1.74) | <.001[b] |
| Components present, No. | | | | | | | | | |
| 0 | 19 (95.0) | 1 (5.0) | <.001[c] | 18 (90.0) | 2 (10.0) | <.001[c] | 13 (65.0) | 7 (35.0) | <.001[c] |
| 1 | 34 (89.5) | 4 (10.5) | | 25 (65.8) | 13 (34.2) | | 13 (34.2) | 25 (65.8) | |
| 2 | 41 (91.1) | 4 (8.9) | | 30 (66.7) | 15 (33.3) | | 12 (26.7) | 33 (73.3) | |
| 3 | 35 (83.3) | 7 (16.7) | | 27 (64.3) | 15 (35.7) | | 5 (11.9) | 37 (88.1) | |
| 4 | 41 (66.1) | 21 (33.9) | | 41 (66.1) | 21 (33.9) | | 5 (8.1) | 57 (91.9) | |
| 5 | 18 (46.2) | 21 (53.8) | | 18 (46.2) | 21 (53.2) | | 1 (2.6) | 38 (97.4) | |
| 6 | 9 (60.0) | 6 (40.0) | | 7 (46.7) | 8 (53.3) | | 2 (13.3) | 13 (86.7) | |
| 7 | 4 (66.7) | 2 (33.3) | | 2 (33.3) | 4 (66.7) | | 0 (0.0) | 6 (100) | |
| 8 | 0 (0.0) | 1 (100) | | 0 (0.0) | 1 (100) | | 0 (0.0) | 1 (100) | |
| 9 | 1 (50.0) | 1 (50.0) | | 0 (0.0) | 2 (100) | | 0 (0.0) | 2 (100) | |

mFI: modified Frailty Index; FIM: Functional Independence Measure; IQR: Interquartile range; SD: Standard deviation;.
[a] Data were presented as number (percentage) of patients.
[b] Mann-Whitney U test.
[c] Cochrane-Armitage test.

**Table 4**
Logistic regression analysis of clinical outcomes.

| | Dependent variable | | | | | |
|---|---|---|---|---|---|---|
| | Efficiency on the motor-FIM | | Postoperative complication | | Discharge disposition | |
| Independent variable | Odds ratio (95% CI) | *P* value | Odds ratio (95% CI) | *P* value | Odds ratio (95% CI) | *P* value |
| mFI | 1.60 (1.32–1.93) | <.001 | 1.32 (1.13–1.54) | <.001 | 1.77 (1.38–2.26) | <.001 |
| Age | 1.05 (1.00–1.11) | .042 | 1.04 (0.99–1.08) | .086 | 1.09 (1.03–1.15) | <.001 |
| Gender (Male) | 0.36 (0.14–0.93) | .034 | 1.70 (0.87–3.33) | .118 | 9.51 (0.38–2.37) | .913 |
| BMI | 0.95 (0.86–1.05) | .315 | 0.96 (0.88–1.04) | .359 | 1.04 (0.93–1.17) | .482 |
| Fracture to surgery day | 1.01 (0.94–1.07) | .855 | 0.98 (0.93–1.04) | .672 | 0.98 (0.91–1.05) | .576 |
| Fracture type (Ref. Neck) | | | | | | |
| Trochanteric | 1.41 (0.70–2.80) | .336 | 0.50 (0.27–0.90) | .025 | 0.79 (0.37–1.70) | .558 |
| Subtrochanteric | 1.58 (0.37–9.81) | .538 | 1.98 (0.51–7.56) | .312 | 0.80 (0.51–7.56) | .319 |
| Basal | 1.92 (0.37–9.81) | .434 | 1.31 (0.29–5.90) | .734 | 1.31 (0.29–5.90) | .734 |

mFI: modified Frailty Index; BMI: Body Mass Index; FIM: Functional Independence Measure; CI: Confidence Interval.

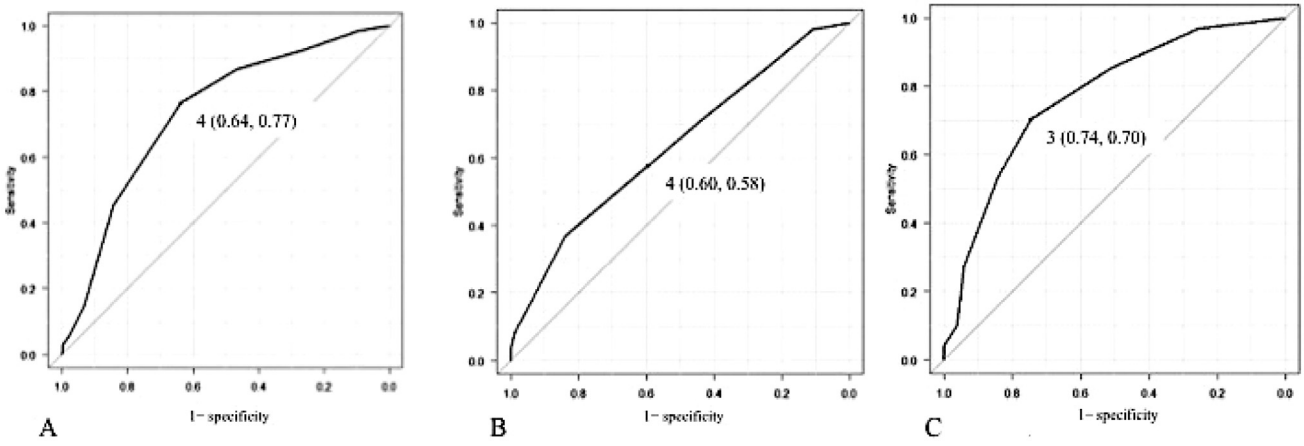


**Fig. 1.** The predicted value of modified Frailty Index at each clinical outcomes.
(A). The area under the curve of modified Frailty Index for efficiency on the motor-FIM was 0.73 (95% CI 0.67–0.80).
(B) The area under the curve of modified Frailty Index for postoperative complication was 0.64 (95% CI 0.57–0.70)
(C). The area under the curve of modified Frailty Index for discharge disposition was 0.77 (95% CI 0.70–0.85).

The present investigation also demonstrated that mFI could predict postoperative complications and discharge disposition. Several studies reported that frailty in hip fracture patients was associated with these outcomes. Gleason et al., reported that frailty was associated with length of hospital stay, complications and discharge to rehabilitation facilities in geriatric fracture patients [6,12]. Krishnan et al. also reported that frailty is a predictor of mortality, length of hospital stay and discharge disposition [12]. In addition, postoperative complications and discharge to an institution from the hospital could predict 1 or 3 years mortality [22,23]. The evaluation of mFI is important because it could predict these critical factors related to long-term mortality. As various interventions

are required, it is important to share information regarding a patient's complication risk and rehabilitation delay among members of multidisciplinary teams and deal with individual deficit items of the mFI.

There are several limitations to the present investigation. First, the blind assessments between mFI and FIM were not performed. However, FIM is a validated and objective tool; therefore, the assessment results are credible. It is possible that residual confoundings remained while we attempted to adjust for many confounders, including age, gender, BMI, fracture to surgery days, fracture type in the multiple logistic regression analysis. Our study was conducted in two facilities, which may have introduced some potential sources of error. Finally, our study's follow-up period was limited to the acute phase following a fracture. A multicentre study at more hospitals with a longer follow-up period would be needed.

## Conclusions

Frailty assessed by mFI can predict short-term functional recovery during the acute phase in patients with hip fracture. Frailty is also associated with postoperative complications and discharge disposition other than home.

## Ethics

This study was conducted in accordance with the Helsinki Declaration. Also, the study was reviewed and approved by the institutional review board of each hospital. Informed consent was waived since this was a retrospective study.

## Declaration of Competing Interest

None declared.

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