Acute phase nutritional screening tool associated with functional outcomes of hip fracture patients: A longitudinal study to compare MNA-SF, MUST, NRS-2002 and GNRI

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博士論文

Acute phase nutritional screening tool associated with functional outcomes of hip fracture patients: A longitudinal study to compare MNA-SF, MUST, NRS-2002 and GNRI

（大腿骨近位部骨折患者を対象とした急性期における機能予後を予測する為の栄養スクリーニングツールの検討：MNA-SF，MUST，NRS-2002，GNRI の比較）

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ABSTRACT

Background & aims: Several hip fracture patients are malnourished, but no study has attempted to determine the optimal nutritional screening tool for predicting functional outcomes. We investigated the association between each nutritional status assessed by four nutritional screening tools at admission and functional outcomes during the postoperative acute phase in hip fracture patients.

Methods: The Mini Nutritional Assessment-Short Form (MNA-SF), the Malnutrition Universal Screening Tool (MUST), the Nutritional Risk Score 2002 (NRS-2002) and the Geriatric Nutritional Risk Index (GNRI) were assessed at admission before surgery. We evaluated the motor domain of the functional independent measure (motor-FIM) score at discharge, efficiency on the motor-FIM (change in the motor-FIM score after postoperative rehabilitation divided by postoperative length of hospital stay), and 10-m walking speed at postoperative 14 days as functional outcomes.

Results: Two hundred and five patients (mean patient age, 83.5 ± 7.0 years; range, 65–100 years; 82% female) were included. The MNA-SF evaluation classified 56 patients as well-nourished, 103 as at risk of malnutrition and 46 as malnourished. The MUST evaluation classified 97 patients as low risk, 42 as medium risk and 66 as high risk. The NRS-2002 evaluation classified 89 patients as well-nourished, 69 as medium risk and 47 as nutritionally at risk. The GNRI evaluation classified 44 patients as no risk, 74 as low risk and 87 as a major risk. Multiple linear regression analysis revealed that MNA-SF had a significant association with discharge motor-FIM (well-nourished vs. at risk of malnutrition, standardised $\beta = -0.06$, $p = 0.04$; vs. malnourished, standardised $\beta = -0.32$, $p < 0.01$), efficiency on the motor-FIM (well-nourished vs. malnourished, standardised $\beta = -0.19$, $p = 0.02$) and 10-m walking speed (well-nourished vs. malnourished, standardised $\beta = -0.30$, $p < 0.01$). The GNRI was significantly associated with 10-m walking speed (no risk vs. mild risk, standardised $\beta = -0.23$, $p = 0.02$; vs. major risk, standardised $\beta = -0.37$, $p < 0.01$), but not of motor-FIM and efficiency on the motor-FIM. No significant relationships were found among MUST and NRS-2002 and any functional outcomes.

Conclusions: The MNA-SF was found to be an optimal nutritional screening tool to associate with functional outcomes during the postoperative acute phase of elderly hip fracture patients.

Keywords: Hip fracture, Nutritional screening tools, Mini Nutritional Assessment - Short Form, Functional outcome, Elderly

1. Introduction

The increasing number of patients with age-related hip fractures has become a major problem worldwide [1]. The 1-year mortality rate after hip fracture ranges from 20% to 30% [2,3]. Therefore, hip fracture is one of the most serious conditions for the elderly. Many hip fracture patients have reduced functional status after fracture and >40% of patients could not recover to their pre-fracture functional ability [4]. Dubljanin-Raspopović et al. showed that the functional status at discharge from acute care hospital was the only independent predictor of 1-year mortality after hip fracture [5]. Therefore, postoperative functional recovery by rehabilitation is one of the most important goals during the postoperative acute phase.

At hospital admission, approximately ≥60% of hip fracture patients were malnourished or at risk of malnutrition [6–8], and the pre-fracture nutritional status with hip fracture has been reported to affect the functional status [9,10]. These reports indicated that a validated and user-friendly tool that can predict functional outcomes with high accuracy is needed in early nutritional screening.

There are many nutritional screening tools, but no studies have assessed the available nutritional screening tools for prediction of functional outcomes. The European Society for Clinical Nutrition and Metabolism recommends the Mini

Nutritional Assessment–Short Form (MNA-SF), the Malnutrition Universal Screening Tool (MUST) and the Nutritional Risk Score 2002 (NRS-2002), because they have been validated for diagnosis of malnutrition and prediction of clinical outcomes [11–15]. Recently, reports using the Geriatric Nutritional Risk Index (GNRI) for elderly hospitalised patients have been increasing [16,17]. The GNRI may be useful for patients with elderly hip fracture who have cognitive impairment because it is an objective index. However, no research has been published using the GNRI for hip fracture patients.

The aim of this study was to determine the optimal nutritional screening tool to associate with functional outcomes longitudinally in hip fracture patients among MNA-SF, MUST, NRS-2002 and GNRI.

2. Materials and methods

2.1. Study design

We conducted a single centre, retrospective, observational study from June 2013 to December 2015. Subjects were patients with femoral neck, trochanteric, sub-trochanteric and basicervical hip fractures who were consecutively admitted to the

Nishi-Kobe Medical Centre (a 475-bed facility) in Kobe, Hyogo prefecture, Japan. The inclusion criteria were age ≥65 years, fractures caused by falling and surgical treatment. The exclusion criteria were terminal malignant disease, uncontrolled chronic liver disease and/or pre-fracture ambulation difficulty. During postoperative rehabilitation, patients with limited partial or no weight-bearing indications after surgery were excluded. Patients were also excluded if they could not complete postoperative rehabilitation because of death or dislocation of bone. Individual postoperative rehabilitation was provided by physical therapists for 20–40 min per day, 5 to 6 days per week. Physical therapists enhanced the range of motion of the joint, lower extremity muscle strength and standing and walking exercises to improve the functional status from postoperative day 1. This study was conducted in accordance with the Declaration of Helsinki. Additionally, the study was reviewed and approved by Nishi-Kobe Medical Centre institutional review board, with a waiver of informed consent because of retrospective study.

2.2. Data collection

2.2.1. Measurements

Demographic data (age, sex, type of residence, pre-fracture ambulation and fracture type) on admission were collected from the patients or their caregivers. Clinical data (comorbidity, fracture-to-surgery day, surgical procedure, length of hospital stay and postoperative complications) during hospitalisation were collected from the medical records. Hand-grip strength, calf circumference and cognitive function were assessed by physical therapists within 24 h of admission. To assess hand-grip strength, a digital hand dynamometer (T.K.K.5401; Takei Scientific Instruments, Niigata, Japan) was used. Measurements were taken three times with the dominant hand and the highest value was recorded. Calf circumferences were measured by using an elastic tape stretched vertically against the long axis of non-fractured lower leg to avoid oedema. We assessed cognitive function using the Hasegawa Dementia Scale-Revised (HDS-R), which is a Japanese screening test. The HDS-R comprises 10 items and has a total score of 30. This screening tool correlates well with the Mini-Mental State Examination [18]. We classified our patients as normal (≥20 points) or impaired cognitive function (<20 points).

2.2.2. Nutritional screening tool

The patients’ baseline nutritional statuses were assessed using four screening tools: MNA-SF, MUST, NRS-2002 and GNRI. The assessments were performed by physical therapists within three days after admission and before surgery.

The MNA-SF includes six items as follows [12,13]: decrease in food intake over the past 3 months, involuntary weight loss during the past 3 months, mobility, psychological stress or acute disease in the past 3 months, neuropsychological problems and body mass index (BMI) or calf circumference. We selected calf circumference from the last item pair to use because we recorded the self-reported height and weight and the calculated BMI might be inaccurate. According to the total scores, the patients were divided into three categories: 12–14 points indicated ‘well-nourished’, 8–11 points indicated ‘at risk of malnutrition’ and 0–7 points indicated ‘malnourished’. In the cases of patients with delirium and/or cognitive impairment, we asked the caregiver the relevant questions with reference to previous research [19].

The MUST consists of three items: BMI, weight loss from 3 to 6 months and reduced nutritional intake by acute disease [20]. This screening tool was developed and validated in community-dwelling people and expanded to include patients in hospitals

[14]. Depending on the total score, the patients were divided into three categories: 0 indicated low risk (routine clinical care), 1 indicated medium risk (observe) and ≥2 indicated high risk (treat). We calculated the BMI from self-reported or caregiver-provided height and weight according to the explanatory booklet from the British Association for Parenteral and Enteral Nutrition [21].

The NRS-2002 was calculated from the three nutritional parameters (BMI, weight loss, recent decrease in food intake, disease severity and age) [15]. The total score is 6 points. For the purpose of this study comparing several screening tools, we divided the total score into three categories as described in other reports: 0–2, well-nourished; 3 to 4, medium risk, and 5 to 6, nutritional risk [22].

The GNRI is an objective screening tool that uses serum albumin and body weight for predicting health complications [17]. The formula is as follows:

GNRI = (1.489 × albumin (g/l)) + (41.7 × weight (kg)/ideal body weight) [17].

We calculated the ideal body weight using the Lorentz equations. If weight/ideal body weight was ≥1.0, the ratio was set to 1. For the purpose of this study comparing screening tools, we only used three classes instead of the standard four classes [17]. Patients were classified according to the method described in a previous report: no risk (GNRI >98), mild risk (GNRI 92 to ≤98) and major risk (GNRI <92) [23].

2.2.3. Functional outcomes

We evaluated the Functional Independence Measure (FIM) on postoperative day 1 (baseline FIM) and at discharge from the hospital in the postoperative acute stage (discharge FIM). This validated tool is a comprehensive scale used to evaluate activities of daily living (ADL) that the patients actually performed. The FIM consists of 13 motor (eating, grooming, bathing, dressing upper and lower body, toileting, bladder and bowel control, transfer to bed, chair or wheelchair, transfer to toilet and transfer to tub, 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, and the total score is 128 points. We used the motor-FIM score for analysis, which reflects ADL scores ranging from 13 to 91 points. Additionally, we calculated the efficiency on the motor-FIM score (change in the motor-FIM score after postoperative rehabilitation divided by postoperative length of hospital stay) to evaluate the effectiveness of rehabilitation during the acute phase. The physical therapists in our hospital have evaluated the functional status for all patients by using this tool as part of the rehabilitation protocol and are well experienced in its use.

We also evaluated 10-m walking speed at postoperative 14 days. Walking speed was measured at the same walking course setting 1 m behind the starting line and finish line. We instructed the patients to walk at their usual walking speed independently with a walking aid because most patients were in the middle of functional recovery. The measurements were performed only for the patients who could walk without support. The physical therapists measured twice the 10-m walking speed and the better time was recorded. If a patient was discharged from the acute hospital before 14 days, we measured the 10-m walking speed at discharge. The 10-m walking speeds of 120 (58.5%) patients were measured.

2.3. Statistical analysis

We used EZR (Saitama Medical Centre, Jichi Medical University, Saitama, Japan) for statistical analyses. The Kruskal–Wallis test was used to compare the functional outcomes (discharge motor-FIM, efficiency on the motor-FIM and 10-m walking speed) between nutritional categories from each nutritional screening tool because these variables were non-normally distributed. Post-hoc analyses were performed by using the Steel–Dwass test. Multiple linear regression analyses were performed to confirm the effects of nutritional status assessed by each nutritional screening tool on functional outcomes during hospitalisation. The independent variable was the nutritional screening tool. For each nutritional screening tool, three multiple regression models were developed using discharge motor-FIM, efficiency on the motor-FIM or 10-m walking speed as the dependent variable. Log transformation was applied before performing multiple regression analysis because all outcomes were non-normally distributed. Potential confounders, theoretically related to functional outcomes as described in other reports [4,10,24], were forcibly included into the models as independent variables. We included age, sex, fracture-to-surgery day, pre-fracture ambulatory status, cognitive function, hand-grip strength, calf circumference, stroke, Parkinson's disease, chronic heart disease and depression as independent variables. Differences and regressions were considered significant for $p < 0.05$.

3. Results

A total of 223 patients were admitted to our hospital and 213 patients met the inclusion criteria. Seven patients were excluded because of pre-fracture inability to walk. One patient was also excluded because of a lack of data. No one died. Finally, we analysed 205 patients in this study (Fig.1).

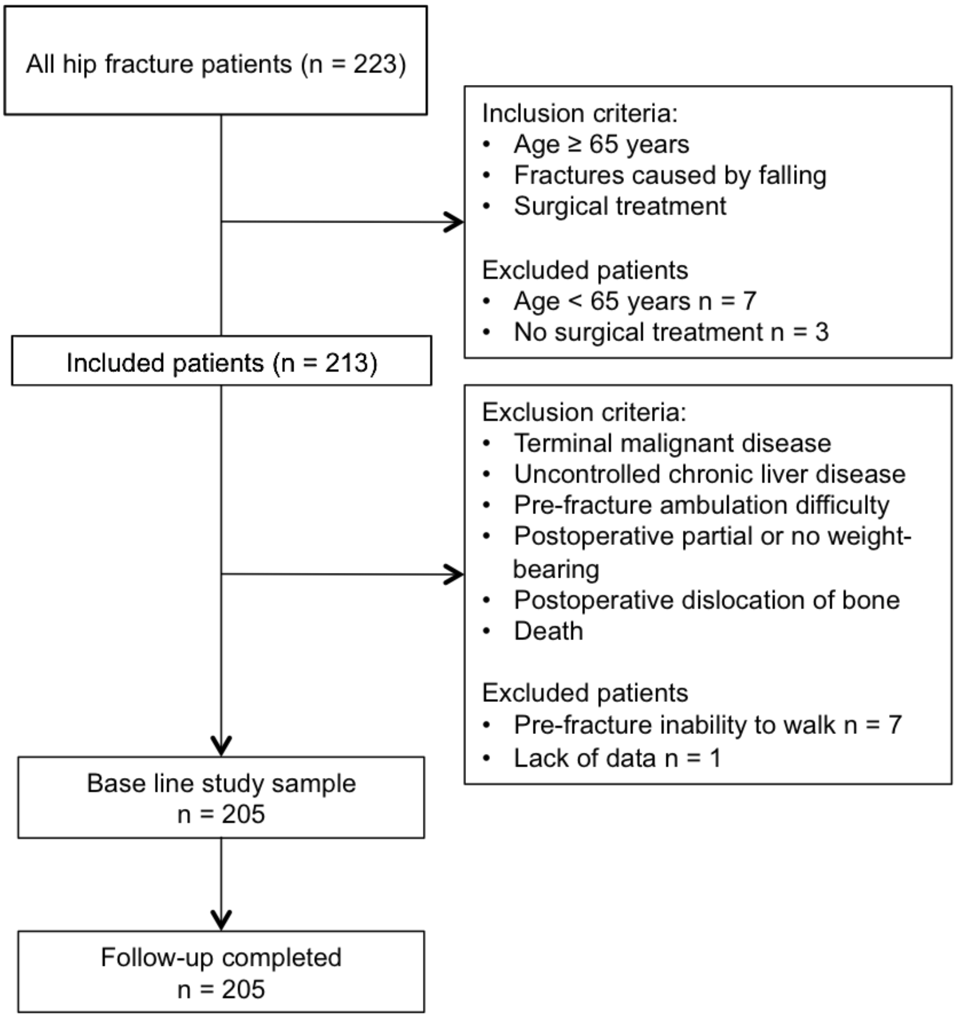

Fig.1. Flow chart of the study.

The mean patient age was 83.5 ± 7.0 years (range, 65–100 years) and females accounted for 82.0% (n = 168) of the patients. One hundred and four (50.7%) patients underwent Gamma nail, 64 (31.2%) underwent hemiarthroplasty, and 37 (18.1%)

underwent pinning for surgical treatment. The characteristics of all patients and their functional and clinical outcomes are shown in Table 1.

Table 1. Characteristics of the participants.

Variable	n = 205
Pre-fracture disposition (%)	
Home	173 (84.4)
Hospital or nursing home	32 (15.6)
Pre-fracture ambulation (%)	
Independence	117 (57.1)
With device	88 (42.9)
Fracture type (%)	
Neck	102 (49.8)
Trochanteric	86 (42.0)
Sub-trochanteric	11 (5.4)
Basal	6 (2.9)
Fracture-to-surgery day (days)	4 (0–26)
Cognitive function (%)	
Impairment (HDSR < 20)	106 (51.7)

Normal (HDSR ≥ 20)	99 (48.3)
Hand-grip strength (kg)	12.7 ± 6.8
Length of hospital stay (days)	23 (9–71)
Comorbidity	
Diabetes (%)	52 (25.4)
Stroke (%)	32 (15.6)
Chronic heart disease (%)	30 (14.6)
Gastrointestinal disease (%)	28 (13.7)
Gastric cancer (%)	22 (10.7)
Chronic renal failure (%)	11 (5.4)
Depression (%)	11 (5.4)
Ischaemic heart disease (%)	11 (5.4)
Parkinson disease (%)	10 (4.9)
Rheumatoid arthritis (%)	7 (3.4)
Complication (%)	90 (43.9)
Delirium (%)	65 (31.7)
Pneumonia (%)	6 (2.9)
Urinary tract infections (%)	6 (2.9)

Others (%)	10 (4.9)
Discharge disposition (%)	
Home	16 (7.8)
Rehabilitation hospital	170 (82.9)
Nursing home	19 (9.3)

HDSR = The Hasegawa Dementia Scale-Revised.

All patients were divided into three nutritional categories by the results of each nutritional screening tool (MNA-SF, MUST, NRS-2002 and GNRI) (Table 2). According to the MNA-SF, 56 (27.3%) patients were well-nourished, 103 (50.2%) were at risk of malnutrition and 46 (22.4%) were malnourished. When evaluated by the MUST, 97 (47.3%) patients were at low risk, 42 (20.5%) were medium risk, and 66 (32.2%) were high risk. Based on the NRS-2002, 89 (43.4%) patients were well-nourished, 69 (33.7%) were medium risk, and 47 (22.9%) were nutritionally at risk. According to the GNRI, 44 patients (21.5%) were no risk, 74 (36.1%) were mild risk, and 87 (42.4%) were major risk.

Table 2. Patient's nutritional status or risk assessed by the four nutritional screening tools.

Nutritional status/risk	MNA-SF (%)	MUST (%)	NRS-2002 (%)	GNRI (%)
Well-nourished/Low or No risk	56 (27.3)	97 (47.3)	89 (43.4)	44 (21.5)
At risk/Medium or Mild risk	103 (50.2)	42 (20.5)	69 (33.7)	74 (36.1)
Malnourished/High or Major risk	46 (22.4)	66 (32.2)	47 (22.9)	87 (42.4)

Abbreviations: MNA-SF, Mini Nutritional Assessment-short form; MUST, Malnutrition Universal Screening Tool; NRS-2002, Nutrition Risk Screening 2002; GNRI, Geriatric Nutritional Risk Index

Table 3 shows the comparisons of functional outcomes between the groups based on nutritional status. The malnourished patients categorised by the MNA-SF had significantly lower discharge motor-FIM, efficiency on the motor-FIM and 10-m walking speed scores than those of the well-nourished patients ($p < 0.01$). Categorised by the MUST, the high-risk patients had significantly lower discharge motor-FIM and 10-m walking speed scores than the medium-risk patients ($p = 0.04$). Categorised by NRS-2002, the low-risk patients had better discharge motor-FIM scores than the high-risk patients ($p < 0.01$). Categorised by the GNRI, significant relationships were found between nutritional status and motor-FIM and 10-m walking speed ($p < 0.01$).

Table 3. Associations between the four nutritional screening tools and functional outcomes during acute hospitalisation in hip fracture patients.

Nutritional status / risk	Discharge motor-FIM		Efficiency on the motor-FIM		10m walking speed (m/sec)		
	Median (IQR)	*p*-value [a)]	Median (IQR)	*p*-value [a)]	No./Total No (%) [b)]	Median (IQR)	*p*-value [a)]
MNA-SF							
Well-nourished	66 (57–78)**[c) d)]		1.37 (0.81–1.89)**[c)]		45/56 (80.3)	0.59 (0.49–0.77)**[c) d)]	
At risk of malnutrition	51 (40–63)**[c)]	<0.01	1.00 (0.72–1.59)*[c)]	<0.01	55/103 (53.4)	0.43 (0.30–0.60)	<0.01
Malnutrition	40 (25–50)		0.78 (0.38–1.15)		20/46 (43.5)	0.34 (0.27–0.49)	
MUST							
Low risk	56 (40–67)	0.04	1.00 (0.72–1.68)	0.55	60/97 (61.9)	0.54 (0.34–0.67)	0.04
Medium risk	58 (44–68)*[c)]		1.14 (0.76–1.72)		28/42 (66.7)	0.58 (0.38–0.71)*[c)]	

High risk	50 (36–56)		1.05 (0.47–1.51)		32/66 (48.5)	0.42 (0.29–0.54)	
NRS-2002							
Low risk	24 (13–35)[*c)]		1.15 (0.76–1.76)		60/89 (67.4)	0.56 (0.37–0.68)	
Medium risk	18 (11–29)	0.02	0.90 (0.55–1.53)	0.18	33/69 (47.8)	0.49 (0.36–0.64)	0.10
High risk	18 (11–28)		1.00 (0.54–1.49)		24/47 (51.1)	0.40 (0.29–0.54)	
GNRI							
No risk	62 (52–70)[**c)*d)]		0.99 (0.76–1.90)		34/44 (77.3)	0.63 (0.50–0.77)[**c)*d)]	
Mild risk	52 (40–65)	<0.01	1.10 (0.73–1.64)	0.45	44/74 (59.5)	0.48 (0.33–0.63)	<0.01
Major risk	49 (37–57)		1.00 (0.57–1.55)		42/87 (48.3)	0.36 (0.28–0.55)	

Abbreviations: FIM, Functional Independence Measure; IQR, Interquartile range; MNA-SF, Mini Nutritional Assessment-short form; MUST, Malnutrition Universal Screening Tool; NRS-2002, Nutrition Risk Screening 2002; GNRI; Geriatric Nutritional Risk Index.

[a)] Kruskal–Wallis test

[b] The measurements were performed for the patients who could walk without support.

[c] Significant differences compared with malnourished patients by Steel–Dwass test; *$p < 0.05$, **$p < 0.01$.

[d] Significant differences compared with at risk of malnutrition by Steel–Dwass test; *$p < 0.05$, **$p < 0.01$.

The results of the multiple regression analyses are shown in Tables 4–6. After adjustment for potential confounders, a significant association between the MNA-SF and the discharge motor-FIM (well-nourished vs. at risk of malnutrition patients, standardised $\beta = -0.06$, $p = 0.04$; vs. malnourished, standardised $\beta = -0.32$, $p < 0.01$), the efficiency on the motor-FIM (well-nourished vs. malnourished patients, standardised $\beta = -0.19$, $p = 0.02$) and the 10-m walking speed (well-nourished vs. malnourished, standardised $\beta = -0.30$, $p < 0.01$) remained. The MUST and NRS-2002 were not significantly associated with any functional outcome measures (discharge motor-FIM, efficiency on the motor-FIM and10-m walking speed) after adjustment. The GNRI identified 10-m walking speed as a significant associated functional outcome (no risk vs. mild-risk patients, standardised $\beta = -0.23$, $p = 0.02$; vs. major risk, standardised $\beta = -0.37$, $p < 0.01$), but not discharge motor-FIM and efficiency on the motor-FIM after adjustment for confounding factors.

Table 4. Adjusted and unadjusted analysis of the association between discharge motor-FIM and each nutritional status at admission by the four nutritional screening tools.

	Unadjusted Analysis			Adjusted Analysis [a)]			
Nutritional status/risk	Standardised β	*p*-value	R^2	Standardised β	*p*-value	R^2	*p*-value [b)]
MNA-SF							
Well-nourished	Reference			Reference			
At risk of malnutrition	−0.13	<0.01	0.19	−0.06	0.04	0.48	<0.01
Malnourished	−0.24	<0.01		−0.32	<0.01		
MUST							
Low risk	Reference			Reference			

Medium risk	0.03	0.29	0.01	0.06	0.83	0.44	<0.01
High risk	−0.05	0.09		−0.04	0.94		
NRS-2002							
Low risk	Reference			Reference			
Medium risk	−0.07	0.01	0.03	−0.04	0.10	0.45	<0.01
High risk	−0.08	0.01		−0.03	0.68		
GNRI							
No risk	Reference			Reference			
Mild risk	−0.06	0.05		0.01	0.90		<0.01
Major risk	−0.12	<0.01		−0.02	0.56		

Abbreviations: FIM, Functional Independence Measure; MNA-SF, Mini Nutritional Assessment-Short Form; MUST, Malnutrition

Universal Screening Tool; NRS-2002, Nutrition Risk Screening 2002, GNRI; Geriatric Nutritional Risk Index.

[a] Multiple linear regression analyses were performed with the dependent value as discharge motor-FIM and the independent value as the nutritional screening tool.

All adjusted analyses were adjusted for age, sex, fracture-to-surgery day, pre-fracture ambulatory, cognitive function, hand-grip strength, calf circumference, Parkinson disease, chronic heart disease, depression and stroke.

[b] *P*-value of entire model

Table 5. Adjusted and unadjusted analysis of the association between efficiency on the motor-FIM and each nutritional status at admission by the four nutritional screening tools

	Unadjusted Analysis			Adjusted Analysis [a)]			
Nutritional status / risk	Standardised β	*p*-value	R^2	Standardised β	*p*-value	R^2	*p*-value [b)]
MNA-SF							
Well-nourished	Reference			Reference			
At risk of malnutrition	−0.14	<0.01	0.05	−0.12	0.15	0.16	<0.01
Malnutrition	−0.24	<0.01		−0.19	0.02		
MUST							
Low risk	Reference		0.01	Reference		0.15	<0.01

Medium risk	0.08	0.17			0.08	0.40		
High risk	−0.02	0.62			0.04	0.48		
NRS-2002								
Low risk	Reference				Reference			
Medium risk	−0.09	0.08	0.01		−0.15	0.29	0.17	<0.01
High risk	−0.09	0.14			−0.03	0.09		
GNRI								
No risk	Reference				Reference			
Mild risk	−0.01	0.91	0.01		0.03	0.41	0.15	<0.01
Major risk	−0.06	0.29			0.03	0.73		

Abbreviations: FIM, Functional Independence Measure; MNA-SF, Mini Nutritional Assessment-Short Form; MUST, Malnutrition

Universal Screening Tool; NRS-2002, Nutrition Risk Screening 2002, GNRI; Geriatric Nutritional Risk Index.

[a] Multiple linear regression analyses were performed with the dependent value as efficiency on the motor-FIM and the independent value as the nutritional screening tool.

All adjusted models were adjusted for age, sex, fracture-to-surgery day, pre-fracture ambulatory, cognitive function, hand-grip strength, calf circumference, Parkinson disease, chronic heart disease, depression and stroke.

[b] *P*-value of entire model

Table 6. Adjusted and unadjusted analysis of the association between 10-m walking speed and each nutritional status at admission by the four nutritional screening tools [a)]

	Unadjusted Analysis			Adjusted Analysis [b)]			
Nutritional status/risk	Standardised β	*p*-value	R^2	Standardised β	*p*-value	R^2	*p*-value [c)]
MNA-SF							
Well-nourished	Reference			Reference			
At risk of malnutrition	−0.16	<0.01	0.14	−0.13	0.05	0.29	<0.01
Malnourished	−0.21	<0.01		−0.30	<0.01		
MUST							
Low risk	Reference			Reference			

Medium risk	0.04	0.39	0.02	−0.01	0.92	0.23	<0.01
High risk	−0.07	0.09		−0.04	0.69		
NRS-2002							
Low risk	Reference			Reference			
Medium risk	−0.02	0.58	0.01	−0.04	0.94	0.23	<0.01
High risk	−0.09	0.06		−0.09	0.46		
GNRI							
No risk	Reference			Reference			
Mild risk	−0.15	<0.01	0.12	−0.23	0.02	0.35	<0.01
Major risk	−0.02	<0.01		−0.37	<0.01		

Abbreviations: FIM, Functional Independence Measure; MNA-SF, Mini Nutritional Assessment-Short Form; MUST, Malnutrition

Universal Screening Tool; NRS-2002, Nutrition Risk Screening 2002, GNRI; Geriatric Nutritional Risk Index.

[a] The measurements were performed for the patients who could walk without support.

[b] Multiple linear regression analyses were performed with the dependent value as 10-m walking speed and the independent value as the nutritional screening tool.

All adjusted models were adjusted for age, sex, fracture-to-surgery day, pre-fracture ambulatory, cognitive function, hand-grip strength, calf circumference, Parkinson disease, chronic heart disease, depression and stroke.

[C] *P*-value of entire model

4. Discussion

The aim of this study was to assess the association between each nutritional status assessed by four standard nutritional screening tools at admission and functional outcomes (discharge motor-FIM, efficiency on the motor-FIM and 10-m walking speed at discharge) during the acute phase in patients with operated hip fractures. The MNA-SF identified motor-FIM and 10-m walking speed as significant associated factors of functional outcomes even after adjustment for confounding factors. Although the other screening tools also showed significant associations with motor-FIM in the univariate analysis, they were not found to have significant association in the multivariate analyses. The GNRI retained its relationship with the 10-m walking speed after adjustment, although the MUST and the NRS-2002 did not. Overall, the MNA-SF was the most sensitive tool to evaluate the association with functional outcomes because it was associated to all three functional outcomes after adjustment for confounding factors. To our knowledge, this is the first study to propose an optimal nutritional screening tool to associate with functional outcomes after comparing four screening tools in hip fracture patients.

Several hip fracture patients are malnourished, and the prevalence of malnutrition has varied depending on the nutritional screening tool used. Koren–Hakim et al. reported that the prevalence of malnutrition evaluated by MNA-SF, NRS-2002 and MUST was 11.6%, 5.1% and 6%, respectively [25]. In the studies by Goisser et al. [9] and our earlier study [10] analysing the relationship between the pre-fracture nutritional status and the functional status of patients after hip fracture, the prevalence of malnutrition was 19.7% and 25.0%, respectively. In our patients, the prevalence of malnutrition assessed by the MNA-SF was 22.4%, which was comparable to the prevalences found in other reports.

Our results showed that the MNA-SF was the most sensitive tool to associate with all functional outcomes. Recently, several studies have compared some nutritional screening tools for diagnosis of malnutrition and prediction of unfavourable clinical outcomes among hip fracture patients [22,26,27]. Koren–Hakim et al. compared the MNA-SF, MUST and NRS-2002 in 215 hip fracture patients and reported that only the MNA-SF could predict readmissions and mortality up to 36 months [22]. Gumieiro et al. demonstrated that the full MNA could predict patient mobility 6 months after hip fracture, but the NRS-2002 could not [19]; this was the only study to compare nutritional screening tools for prediction of functional status to our knowledge. However, we think that our study was superior to previous studies because it compared four screening tools and investigated the relationships between screening tool results and objective functional outcomes at discharge from an acute hospital. Our results were comparable to those and confirmed that the MNA-SF was a useful tool for functional outcomes in hip fracture patients.

The MNA-SF is used worldwide for elderly patients partly because it can use calf circumference instead of BMI in the scoring, unlike other screening tools. This is an advantage because it is difficult to accurately measure body weight on admission for hip fracture patients, so self-reported values are used for scoring in a number of nutritional screening tools. Self-reported height and weight might be inaccurate because of recall bias or poor cognitive function. Additionally, the scoring for the MNA-SF includes functional, psychological and cognitive parameters. Hip fracture patients have multiple comorbidities and impaired functional status and cognitive function. For these reasons, the MNA-SF can accurately reflect the characteristics of elderly patients with hip fracture, so it may be the most appropriate nutritional screening tool for functional outcomes in these patients. Several studies have suggested that the MNA-SF was significantly predictive of functional status after hip fracture [9,10]. These studies supported that MNA-SF is useful for predicting functional outcomes.

Our results demonstrated a relationship between the GNRI and the 10-m walking speed in multiple regression analysis. Ogawa et al. showed that the nutritional status assessed by the GNRI in elderly cardiac patients predicted retardation of postoperative improvement in functional status [28]. The GNRI may be useful in hip fracture patients who have cognitive impairment and/or delirium because it is an objective index that does not depend on a caregiver or memory. However, no research has been published using the GNRI for hip fracture patients. More studies are necessary to verify the validity of the GNRI in these patients.

The MUST and the NRS-2002 were not significant association with any functional outcomes. The reliability and validity of these tools have been proved in many studies. Koren–Hakim et al. reported that the MUST did not predict any postoperative clinical outcomes (complication, length of hospital stay, readmission and mortality) [22]. Gumieiro's study compared the MNA and NRS-2002, and demonstrated that the latter did not have a significant relationship with walking ability after 6 months [19], and the tools were not considered to be useful for assessing functional and cognitive parameters. The results of the present study support the findings of Gumieiro that those tools are not appropriate for prediction of clinical outcomes in hip fracture patients.

The strength of our study was that it compared several screening tools for predicting functional outcomes in hospitalised hip fracture patients. Including the GNRI in the assessment of nutritional screening tools in the present study also provides new findings. Evidence supporting an optimal nutritional screening tool is helpful for choosing an effective nutritional intervention. No previous studies have compared the MNA-SF, MUST, NRS-2002 and GNRI. Finally, we adjusted for many confounding factors (age, sex, fracture-to-surgery day, pre-fracture ambulatory status, cognitive function, hand-grip strength, calf circumference, stroke, Parkinson’s disease, chronic heart disease and depression) in the multiple linear regression analyses, our sample size was sufficient (n = 205) to perform multivariate analysis to adjust for those confounders [29] Especially, cognitive function was considered as important confounding factor, but we adjusted it by multiple linear regression analysis.

We acknowledge several limitations in the present study. First, this was a retrospective study design. However, we adjusted for many confounding factors. Second, the follow-up period of functional outcomes was limited to the acute phase. Long-term follow-up of functional outcomes is needed. Third, our study was conducted at a single facility. A multicentre study would be needed to generalise our results to a larger patient population. Fourth, there are some items that may cause recall bias as part of nutritional screening tools, particularly in cases of patients with cognitive impairment. Fifth, the blind assessments between the nutritional screening tools and FIM were not performed. However, FIM is a validated tool; hence, objectivity and robustness are guaranteed [30]. Therefore, we consider that the influence of this blindness was minimal.

4.1 Conclusion

The MNA-SF was found to be a significant association with both motor-FIM and 10-m walking speed even after adjustment for confounding factors during the acute phase in elderly patients who had undergone hip fracture surgery. We concluded that the MNA-SF is the most appropriate nutritional screening tool to associate with functional outcomes during the acute phase in patients with operated hip fractures.

Conflict of interest

None of the authors has a conflict of interest to declare.

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Figure Legends:

Title: Figure.1. Flow chart of the study