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The clinical frailty scale is associated with an increased risk of postoperative complications and the development of post-traumatic osteoarthritis in elderly patients with trimalleolar ankle fractures - a retrospective study

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Abstract

Background The Clinical Frailty Scale (CFS) is a tool to assess the overall health of older adults. There are few reports of CFS and prognosis of ankle fracture. The objective of this study was to determine the predictive power of the CFS for adverse clinical and radiographic outcomes after surgery in elderly patients with trimalleolar fractures.

Method All patients aged 65 and older underwent open reduction and internal fixation for trimalleolar fractures between January 2015 to January 2023 were selected. Follow-up time was at least 1 year. Patients with post-traumatic osteoarthritis, bone tumors, bone infection, and other diseases before surgery were excluded. According to the CFS score, the patients were divided into three groups: not frail, vulnerable, and frail. Multivariate logistic regression analysis was used to evaluate the effect of the clinical frailty scale on postoperative complications.

Result Excluding 3 cases of death during the follow-up process, and 4 cases lost to follow-up, the study included a total of 146 patients, who were grouped based on their degree of frailty: the Healthy Group (CFS = 1–3, $n = 69$), the Vulnerable Group (CFS = 4, $n = 50$), and the Frail Group (CFS = 5–9, $n = 47$). In comparison with the not frail group, frail (CFS 5–9) emerged as an independent predictor of any complications (OR = 6.90, CI: 1.43–11.56, $P = 0.009$), adverse discharge destination (OR = 7.53, CI: 2.06–77.50, $P = 0.006$), and post-traumatic osteoarthritis (OR = 8.90, CI: 1.94–24.66, $P = 0.003$).

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Conclusions The frailty assessed by the CFS is associated with adverse discharge destination, any complications, and post-traumatic osteoarthritis in elderly patients undergoing open reduction and internal fixation for trimalleolar fractures.

Keywords Frail, Clinical frailty scale, Trimalleolar fracture

Introduction

As the population ages, there is an increasing incidence of ankle fractures in the elderly, making it the third most common musculoskeletal injury. Because elderly patients may be associated with multiple chronic diseases and osteoporosis, fractures often involve the medial, lateral, and posterior malleoles, and the treatment of elderly ankle fractures is more challenging [1]. It has been reported that the one-year mortality rate of elderly ankle fractures is as high as 12%, 81% of patients have more than 3 severe comorbidities, and 60% of patients cannot go home due to fractures and need to be admitted to rehabilitation centers [2–4]. With the implementation of the Enhanced Recovery After Surgery (ERAS) concept in treating ankle fractures, research on elderly ankle fractures is progressing toward enhancing treatment efficacy, minimizing complications, and expediting patient recovery [5]. Currently, there is still debate about the best treatment methods for ankle fractures in the elderly. Treating ankle fractures in older adults requires a comprehensive consideration of the patient's overall health status, the type and stability of the fracture, and the selection of appropriate treatment methods. Open reduction and internal fixation(ORIF) is one of the main treatment methods that can reduce and fix fractures, helping patients exercise their functions early. However, while bringing good results, it also increases the risk of complications. Therefore, surgeons must fully assess and weigh the pros and cons before surgery [6]. Many studies have been published concerning predicting complications that may occur during the treatment of elderly ankle fractures and other orthopedic diseases [7–10].

Frailty is a multidimensional clinical syndrome closely related to the health and diseases of the elderly. Frailty can increase the susceptibility of the elderly to stress, reduce their ability to cope with various medical interventions and increase the risk of adverse health outcomes. The frailty assessment can predict the elderly's response to surgery, diseases, other medical interventions, potential complications, and recovery time [11]. Currently, the three most used frailty assessment tools are the frailty index, the frailty phenotype, and the Clinical Frailty Scale (CFS) [12]. The CFS is a tool used to assess the overall health status of the elderly, categorizing patients' frailty levels from high to low into 9 grades. From 1 (very fit) to 9 (severely frail with terminal illness), individuals with a score of 5 or above are considered frail [13, 14]. Compared to the CFS, the frailty phenotype requires the measurement of gait speed, and the assessment of patients with lower limb fractures who cannot walk is affected; the frailty index involves too many variables, and the assessment upon emergency admission of patients may be limited. The CFS is easy to use in clinical settings and can be easily measured by non-geriatric physicians. No special equipment, such as a stopwatch or additional personnel, is required during the measurement process [15]. Previous studies on the CFS found that the higher the CFS score, the worse the prognosis of orthopedic-related diseases. The CFS has predictive value for the discharge destination and complications of elderly patients with hip fractures [12, 14].

At present, to our knowledge, there is little research on the correlation between CFS and postoperative complications in elderly patients with trimalleolar fractures. Therefore, the purpose of this present is to determine whether frailty assessed by the CFS can predict the prognosis of elderly patients with trimalleolar fractures after ORIF.

Method

A retrospective analysis was conducted on patients aged 65 and above who underwent open reduction and internal fixation surgery for trimalleolar fractures at our hospital from January 2015 to January 2023. The Institutional Review Board approved the study.

Inclusion criteria

The ankle fracture was the only musculoskeletal injury; the same team of surgeons performed all surgeries, and the follow-up period was at least one year.

Exclusion criteria

Incomplete medical records, preoperative comorbidities such as post-traumatic osteoarthritis, bone tumors, bone infections, and other diseases.

Baseline data

Record the age, gender, body mass index (BMI), smoking, alcohol consumption, operation time, and blood loss of each patient.

Postoperative outcomes

Record any diagnosed postoperative complications, adverse discharge destinations defined as discharge to a long-term care facility, incisional complications (incisional complications include incision infection, poor

wound healing, wound dehiscence, postoperative incision pain, etc.), deep vein thrombosis(DVT), post-traumatic osteoarthritis, and nonunion of the bone. Nonunion of the bone is defined as a fracture that has not healed at least 9 months postoperatively and has shown no further tendency to heal for at least 3 months [16]. The development of post-traumatic osteoarthritis is defined as the presence of any narrowing of the ankle joint space, subchondral sclerosis or cysts, and the formation of osteophytes after surgery [17].

Clinical frailty scale (CFS)

It is a tool used to assess the overall health status of the elderly, categorizing patients' frailty levels from high to low into 9 grades (see Fig. 1). Based on the cutoff determined by previous studies, the score is further divided into Not Frail (1 to 3 points), vulnerable (4 points), and frail (5–9 points) [14, 18].

Statistical analysis

The data were statistically analyzed using the SPSS 22.0 software. Continuous numerical variables conform to a normal distribution and are represented as $\bar{x} \pm s$, and one-way ANOVA (Analysis of Variance) is used to compare the differences between groups. Categorical data are compared for differences between groups using the Pearson chi-square test. Multivariate logistic regression analysis was used to assess the impact of different indicators on postoperative complications. The significance level for all tests was set at $\alpha = 0.05$, where $P<0.05$ indicates a statistically significant difference.

Result

Baseline data

Excluding 3 cases of death during the follow-up process, and 4 cases lost to follow-up, the study included a total of 146 patients, who were grouped based on their degree of frailty: the Healthy Group (CFS = 1–3, $n = 69$), the Vulnerable Group (CFS = 4, $n = 50$), and the Frail Group (CFS = 5–9, $n = 47$). There were significant differences in age among the three groups, with the Frail group being significantly older than the Not Frail and Vulnerable groups. There were no significant differences among the three groups in terms of gender, BMI, smoking, alcohol consumption, blood loss, and operation time (see Table 1).

Postoperative complications

There were significant differences among the three groups in terms of any complications, adverse discharge destinations, DVT, and post-traumatic osteoarthritis, with the Frail group having a notably higher incidence compared to the Not Frail group. There were no significant differences among the three groups regarding

Score	Grade	Description
1	Very Fit	Robust, active, energetic, and regularly engaged in physical exercise, representing the healthiest status within their age group.
2	Fit	No obvious signs of disease, but not as fit as those in grade 1, often participate in physical exercise, occasionally very active, such as seasonally.
3	Managing Well	Health issues are manageable, and there is no regular physical exercise beyond routine walking.
4	Vulnerable	Capable of performing daily living activities without assistance, but certain symptoms may limit activities, with common complaints of being "slow-moving" during the day and feeling fatigued.
5	Mildly Frail	Noticeably slow movements, requiring assistance with IADLs (Instrumental Activities of Daily Living, such as going to the bank, taking public transportation, doing heavy housework, and medication management).
6	Moderately Frail	Requires assistance for all outdoor activities, and help is needed for indoor activities like climbing stairs and bathing, with dressing possibly requiring some assistance.
7	Severely Frail	Completely unable to take care of personal needs, but in a stable condition without the risk of death in the near future.
8	Very Severely Frail	Completely unable to take care of personal needs, approaching the end of life, and unable to recover from any illness.
9	Terminally Ill	Approaching the end of life, with an expected survival of less than 6 months.

Fig. 1 Clinical Frailty Scale

Table 1 Baseline patient data

	Not Frail (CFS 1–3)	Vulnerable (CFS 4)	Frail (CFS 5–9)	*P*-value
Age (years)	68.62 + 2.43	71.64 + 3.45	74.30 + 2.87	**0.00**
Gender (M/F)	38/31	21/29	26/21	0.30
BMI	30.40 + 8.44	30.70 + 9.10	30.59 + 7.43	0.98
Smoking History (Yes/No)	35/34	22/28	23/24	0.76
Drinking History (Yes/No)	42/27	29/21	27/20	0.92
Blood Loss (ml)	31.07 + 7.90	30.44 + 7.13	33.51 + 8.80	0.13
Operation Time (minutes)	54.64 + 25.04	54.48 + 24.22	55.87 + 26.79	0.96

Table 2 Patient postoperative complications

	Not Frail (CFS 1–3)	Vulnerable (CFS 4)	Frail (CFS 5–9)	*P*-value
Any Complications n(%))	18(26.1%)	15(30.0%)	28(59.6%)	**0.00**
adverse discharge destination n(%)	3(4.3%)	3(6.0%)	8(17.0%)	**0.04**
incisional complications n(%)	3(4.3%)	2(4.0%)	5(10.6%)	0.29
DVT n(%)	2(2.9%)	2(4.0%)	7(14.9%)	**0.03**
post-traumatic osteoarthritis n(%)	8(11.6%)	6(12.0%)	17(36.2%)	**0.00**
Nonunion of Bone n(%)	4(5.8%)	3(6.0%)	6(12.8%)	0.33

incisional complications and nonunion of the bone (see Table 2). Confirmed by CT imaging, 31 cases of post-traumatic osteoarthritis were found during follow-up. An increase in the degree of frailty significantly increased the incidence of post-traumatic osteoarthritis (CFS 1–3: 11.6%, CFS 4: 12.0%, CFS 5–9: 36.2%; $P = 0.00$).

Multivariate regression analysis of the entire cohort of patients.

Compared to the Not Frail group, the Frail group (CFS 5–9) was an independent predictor for any complications (OR = 6.90, CI: 1.43–32.56, $P = 0.009$), adverse discharge destinations (OR = 7.53, CI: 2.06–77.50, $P = 0.006$), and post-traumatic osteoarthritis (OR = 8.90, CI: 1.94–42.66, $P = 0.003$) (see Table 3).

Table 3 Multivariate Regression Analysis

	OR	95% CI	*P*-value
Any Complications			
Vulnerable (CFS 4) versus not frail	0.35	0.53–3.24	0.556
Frail (CFS 5–9) versus not frail	6.90	1.43–11.56	**0.009**
Age	0.07	0.90–1.14	0.790
Gender	6.05	1.19–4.71	0.014
BMI	0.17	0.95–1.03	0.684
adverse discharge destinations			
Vulnerable (CFS 4) versus not frail	0.85	0.40-12.55	0.355
Frail (CFS 5–9) versus not frail	7.53	2.06–77.50	**0.006**
Age	3.06	0.68–1.02	0.08
Gender	0.16	0.40–3.99	0.688
BMI	0.32	0.95–1.09	0.57
incisional complications			
Vulnerable (CFS 4) versus not frail	0.03	0.17–8.27	0.85
Frail (CFS 5–9) versus not frail	1.77	0.53–26.78	0.183
Age	0.30	0.75–1.18	0.582
Gender	1.29	0.56–9.20	0.255
BMI	0.13	0.94–1.10	0.715
DVT			
Vulnerable (CFS 4) versus not frail	0.04	1.48–10.25	0.847
Frail (CFS 5–9) versus not frail	2.18	0.61–35.65	0.14
Age	0.14	0.84–1.30	0.708
Gender	0.01	0.31–3.82	0.905
BMI	0.25	0.94–1.11	0.615
post-traumatic osteoarthritis			
Vulnerable (CFS 4) versus not frail	0.28	0.42–4.58	0.600
Frail (CFS 5–9) versus not frail	8.90	1.94–24.66	**0.003**
Age	1.18	0.80–1.07	0.277
Gender	1.27	0.70–3.73	0.261
BMI	0.09	0.96–1.06	0.770
Nonunion of Bone			
Vulnerable (CFS 4) versus not frail	0.09	0.25–6.66	0.765
Frail (CFS 5–9) versus not frail	1.76	0.57–18.51	0.185
Age	0.29	0.78–1.16	0.593
Gender	0.51	0.47–4.97	0.476
BMI	0.07	0.92–1.06	0.799

Discussion

The association between frailty and orthopedics is primarily manifested in elderly patients, especially those with osteoporosis. Elderly patients are more prone to fractures due to brittle bones, and the recovery process after a fracture may exacerbate the state of frailty. Orthopedic treatment should not only focus on repairing fractures but also consider the patient's overall health status and degree of frailty to ensure the treatment plan's safety and effectiveness. Although there have been many studies on the relationship between frailty and orthopedic diseases, we are the first to use the CFS to predict postoperative complications in elderly patients with trimalleolar fractures [12, 19, 20]. The significant advantage of the CFS is its feasibility for use upon the admission of ankle fracture patients. Compared to other well-validated frailty assessment tools, the CFS requires fewer devices, fewer assessment indicators, and less time [14, 21]. Studies in the emergency medical environment have also confirmed the feasibility of non-geriatric physicians obtaining CFS scores using routine admission clinical assessments without specific training [22, 23].

Our study indicates that an increase in frailty predicts adverse outcomes. Multivariate regression analysis revealed that, compared to the not frail group, the frail group had a significantly higher risk of postoperative adverse discharge destinations and any complications.

Frailty is a multidimensional clinical syndrome characterized by a decline in physiological reserves and a reduction in the function of organ systems, which increases the vulnerability of the elderly to stress, especially in the postoperative setting. Additionally, we analyzed the relationship between frailty and the long-term postoperative complications of ankle fractures in the elderly, specifically post-traumatic osteoarthritis and nonunion of the bone. The study found that an increase in the degree of frailty is significantly correlated with a higher incidence of post-traumatic osteoarthritis (CFS 1–3: 11.6%, CFS 4: 12%, CFS 5–9: 36.2%, $P = 0.000$). Previous studies have shown that increasing age and BMI are predictive factors for post-traumatic osteoarthritis [24, 25]. However, in our multivariate regression analysis (which included age and BMI), it was found that only frailty was independently associated with an increased likelihood of developing post-traumatic osteoarthritis (OR = 12.5, $P = 0.037$). These findings suggest that, compared to other specific variables of the patient, frailty may be a more accurate surrogate indicator for predicting post-traumatic osteoarthritis. From a biomechanical perspective, elderly patients with a high degree of frailty often have osteoporosis and poor bone quality. The degree of ankle fractures is generally more severe, and it is more challenging to achieve anatomical reduction and stable fixation during surgery. Simultaneously, elderly patients experience slower bone healing and declines in physical coordination, muscle strength, and balance abilities, which may lead to joint instability and ongoing pain, potentially culminating in the development of post-traumatic osteoarthritis. Furthermore, frail patients may experience limited mobility after a joint injury, leading to reduced joint usage, which can further accelerate the degenerative process of the joint [24].

Frailty is a multisystem syndrome, and due to a lack of metabolic and musculoskeletal reserves, frail patients are more susceptible to degenerative and traumatic bone and joint injuries. Currently, many studies strongly advocate using the CFS as a predictive tool for assessing orthopedic surgery outcomes. Comparisons of the CFS with other predictive indicators have consistently found it compelling and, in some cases, even superior [26, 27]. The CFS is an excellent screening tool that broadly describes a patient's preoperative functional status. However, it is not a comprehensive representation of frailty and cannot measure all aspects of a patient's clinical frailty condition. Frailty should be considered part of a broader comprehensive assessment of the patient's condition, emphasizing the combination of the CFS with other specific indicators. This study on the correlation between CFS and postoperative complications in elderly patients with trimalleolar fractures is valuable. In the current context of increasing medical demands, orthopedic care based on effective scoring systems for specific patient populations can improve decision-making and the efficiency of resource allocation. Identifying patients at risk of complications based on their CFS scores can effectively allocate resources and pave the way for targeted interventions and optimizing care and rehabilitation plans [28].

This study has some limitations. Being retrospective and using data from a single institution, the sample size of this study is relatively small compared to studies based on more extensive databases. During the scoring process, the results of the CFS assessment are significantly influenced by the subjectivity of the assessors. Therefore, we have selected three experienced geriatricians to conduct the scoring. The final result will be the average of the scores given by the three assessors, and if the average is not an integer, it will be rounded to the nearest whole number. Additionally, before the assessment, we trained the assessors and established uniform assessment criteria and procedures to enhance the accuracy and objectivity of the evaluation. At the same time, for patients with cognitive impairments, such impairments may lead to inaccurate scoring and affect the sensitivity and specificity of the CFS. Therefore, In this experiment, we have excluded patients with cognitive impairments that significantly affect the assessment as subjects with incomplete data. However, in actual clinical practice, when assessing patients with cognitive impairments, it may be necessary to enhance the training of medical staff and potentially combine other cognitive function assessment tools to improve the accuracy and comprehensiveness of the assessment. Additionally, our long-term follow-up focused only on imaging outcomes and did not include ankle joint functional scores, such as the American Orthopaedic Foot & Ankle Society (AOFAS) scoring system, the Visual Analog Scale (VAS), the Foot Function Index (FFI), etc. This should be an area for future research. Future research should conduct prospective analyses of frailty while controlling for potential confounding variables in a larger patient sample, including bone density and other patient comorbidities. Despite these limitations, our analysis of the CFS scores has assessed the impact on elderly patients following trimalleolar fracture surgery and evaluated the link between frailty and the development of post-traumatic ankle arthritis. Our findings can serve as reference points for surgeons to better inform patients of the relative risks of postoperative complications based on their frailty status. They can also manage high-risk patients more effectively through targeted interventions and frequent follow-ups.

Conclusions

The frailty assessed by the CFS is associated with adverse discharge destination, any complications, and post-traumatic osteoarthritis in elderly patients undergoing open reduction and internal fixation for trimalleolar fractures.

Author contributions

YY and HSY designed this study. All authors were involved in drafting, revising and iteratively finalizing the manuscript. QZ and DW collected and analysed the data and performed the statistics. All authors have read the final version of the manuscript and approved it. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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