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ORIGINAL ARTICLE

Performance of the Nottingham Hip Fracture Score and Clinical Frailty Scale as predictors of short and long-term outcomes: a dual-centre 3-year observational study of hip fracture patients

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Abstract

Introduction Hip fractures account for a growing number of hospital admissions worldwide and are associated with significant morbidity and mortality. The Nottingham Hip Fracture Score (NHFS) was developed to help risk-stratify these patients. Frailty is increasingly recognised to be a predictor of adverse outcomes. The aim of this study, using prospectively collected data from two non-specialist UK hospitals, was to report contemporaneous outcomes for patients with a hip fracture and compare the performance of the NHFS with the Clinical Frailty Scale (CFS).

Materials and methods Data were collected over a 3-year period (2016–2018) from patients admitted with a hip fracture. In-patient and 1-year mortality and length of stay were compared between the NHFS, CFS and other variables. For discrimination to predict mortality, area under the receiver operating characteristic (AUC) curves were produced.

Results 2422 patients (70.6% female), median age 85 (interquartile range 78–90) were included, with 93% undergoing an operation. 30-day mortality was 5.8% and 1-year mortality 23.5%. Average hospital stay was 18.0 days (Standard deviation 13.7). For in-patient mortality AUC for NHFS was 0.69 (95% CI 0.64–0.74) and for CFS 0.63 (0.57–0.69); for 1-year mortality AUC for NHFS was 0.71 (0.68–0.73) and for CFS 0.67 (0.64–0.71). Neither score predicted extended hospital stay.

Conclusion Both CFS and NHFS predict 1-year survival with similar, moderate discrimination. Future research could explore whether other factors could be combined to allow better risk stratification following a hip fracture to inform patients and clinicians.

Keywords Hip fracture · Frailty · Prediction · Mortality · Older people

Introduction

Hip fractures represent a significant problem predominantly affecting the growing demographic of older adults worldwide. In the United Kingdom (UK) alone 66,313 patients suffered a hip fracture in 2018, with a 30-day mortality of 6.1% ($n = 4007$) [1]. These patients stayed on average in-hospital 15.1 days, accounting for over 1.29 million inpatient bed days, [1] with 31% not returning to their original residence. Although mortality rates and hospital stay have decreased since the National Hip Fracture Database (NHFD) was first reported in 2010, the total number of hip fractures has continued to increase [1, 2].

The Nottingham Hip Fracture Score (NHFS), first described and validated in 2007, was developed with the aim of classifying hip fracture patients into low- or high-risk groups. Such risk stratification can help clinicians identify who is more likely to have poorer outcomes, target more effectively and inform patients and their kin. The NHFS incorporates seven independent predictors of mortality into a risk score out of 10 [3].

Frailty becomes increasingly prevalent with age and frail individuals are at greater risk of falls, hospitalisation, institutionalisation, morbidity and death [4]. 50% of the UK population aged over 65 have mild to severe frailty [5]. A frailty tool commonly utilised in acute NHS Trusts is the 9-point Clinical Frailty Scale (CFS), developed in 2005 to help assess patients' frailty [6].

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The aim of this study was to compare the NHFS with the CFS in predicting short- and longer-term mortality, hospital stay and discharge destination amongst patients presenting with a hip fracture.

Materials and Methods

A dual-centre 3-year observational study was performed. All patients admitted to two non-specialist hospitals on the South Coast of England with a hip fracture (fractured femoral neck) over a 3-year period from 1st January 2016 had data prospectively collected for the NHFD alongside physiological and operative information. Demographical information was retrieved from the hospitals' electronic server and past medical history from the International classification of diseases version 10 (ICD-10) coded history.

The NHFS is a weighted score considering the patient's age, sex, admission haemoglobin, abbreviated mental test score (AMTS), residence before admission, number of comorbidities and presence of malignancy to predict 30-day mortality of hip fracture patients. A NHFS of 0 is associated with an estimated 0.7% risk whilst a score of 10 has a 45% risk [7]. For the primary analysis, this study looked at patients with a NHFS completed.

The CFS ranges from very fit (a score of 1) to terminally ill (score of 9). It is based on how active and how independently the patient can perform activities of daily living and is an assessment of the persons' state 2 weeks prior to the hospital admission.

Age, NHFS, CFS, AMTS, weight, admission National Early Warning Score (NEWS), previous residence and presence of malignancy were collected. Outcomes included 30-day, 1-year mortality, hospital stay and residence at 120 days following admission. To discriminate between mortality predictions, we reported area under the receiver operating characteristic (AUC) curves. For dichotomous variables, Chi-squared test with odds ratios and 95% confidence intervals were performed and for continuous variables Mann–Whitney *U* test or 2-tailed *t* tests were employed depending on whether the data were normally distributed. Logistic regression was employed to assess whether the scores were independent of one another as predictors and correlation assessed by the Pearson correlation coefficient. All statistics were performed using SPSS V24 IBM®. Ethical approval was given by NHS South Central—Hampshire B Research Ethics Committee (REC reference 18/SC/0513).

Results

Of the 2422 patients that presented with a hip fracture over the 3 years, 2124 (87.7%) underwent operative management. The median age was 85 (interquartile range, IQR 78–90) and 1709 (70.6%) were female. 79.1% of patients with a pre-admission residence recorded were previously living in their own home. 671 and 1013 patients did not have a NHFS or CFS recorded, respectively. The median NHFS was 5 (4–6) and median CFS 3 (0–6). Baseline characteristics are shown in Table 1 and the study flowchart in Fig. 1.

155 (6.4%) of the 2422 patients died during their hospital admission, 141 (5.8%) of these within 30 days. The mean length of stay was 18.0 days (13.7 SD) and 1022 (47.0%) of 2173 patients were discharged to their own home (the total number of patients is reduced on account of missing follow-up data). 106 of 1719 patients who were previously living in their own home (7 of 1726 had discharge destination data missing) were subsequently discharged into a nursing home—a rate of 6.2%. 1-year mortality was 23.5% ($n = 568/2422$). Patients who did not receive an operation were excluded from statistical analysis. 671 patients did not have a NHFS recorded and 1013 patients did not have a CFS and were excluded from the primary analysis. The AUC of the NHFS for in-patient mortality was 0.69 (95% confidence interval 0.64–0.74). The AUC of the CFS by in-patient mortality was 0.63 (0.57–0.69). For 1-year mortality, AUC was 0.71 (0.68–0.73) for NHFS and 0.67 (0.64–0.71) for CFS, respectively Figs. 2 and 3.

Upon logistic regression analysis, the CFS was not independent of the NHFS as a significant predictor of in-patient mortality. However, with respect to 1-year mortality, both scores were independent predictors. The NHFS and CFS were weakly correlated (Pearson correlation coefficient 0.26, $p < 0.001$).

Patients were split into a low- or high-risk group using a NHFS or CFS of 5 as cut-offs (Table 2). A score of ≥ 8 was taken as the low-risk AMTS group and < 8 for the high-risk. An admission NEWS of 0–2 was classed as low-risk and ≥ 3 as high-risk. Both median age and weight of patients who survived to discharge and one year later were significantly different from those who died either during the index admission or within one year (Table 3). Both the NHFS and CFS were poor predictors of the likelihood that a patient, previously living in their own home, would be discharged into a nursing home. The NHFS by discharge destination had an AUC 0.54 (95% CI 0.46–0.61) and the CFS by discharge destination had an AUC 0.52 (95% CI 0.45–0.60).

Discussion

This study found that both the NHFS and CFS can help stratify hip fracture patients into low- and high-risk groups, with both scores predicting 30-day and 1-year mortality rates, with similar, moderate discrimination. The NHFS performed marginally better than the CFS when assessing discrimination however neither had an AUC of approaching 0.80 which

Table 1 Baseline characteristics of the 2422 patients

Variable	Overall *n*/known *n* (%)
Demographics	
Age*	85 (78–90)
Female	1709/2422 (70.6)
Residential status	
Own home	1726/2181 (79.1)
Residential care	170/2181 (7.8)
Nursing care	285/2181 (13.1)
Clinical variables	
Congestive cardiac failure	96/2422 (4.0)
Chronic kidney disease	648/2422 (26.8)
Diabetes	151/2422 (6.2)
Community-acquired AKI	146/2422 (6.0)
Malignancy	5/2176 (0.2)
Clinical scores*	
NHFS	5 (4–6)/1751
CFS	3 (0–6)/1409
NEWS	1 (0–2)/2422
MUST	0 (0–1)/2422
AMTS	9 (4–10)/2119
ASA	3 (3–3)/2131
Operation performed	
No operation	298/2422 (12.3)
Arthroplasty	1143/2422 (47.2)
Internal fixation	978/2422 (40.4)
Other	3/2422 (0.1)
Outcomes	
In-patient mortality	155/2422 (6.4)
1-year mortality	568/2422 (23.5)
Length of stay**	18.0 (13.7)
Hospital-acquired AKI	324/2422 (13.4)
30-day Readmission	269/2422 (11.1)
Discharge destination (where known)	
Own home	1022/2173 (47.0)
Residential care	181/2173 (8.3)
Nursing care	339/2173 (15.6)
Other e.g. rehabilitation unit	487/2173 (22.4)
Dead	144/2173 (6.6)

AKI acute kidney injury, *SD* standard deviation, *AMTS* abbreviated mental test score (range 0–10), *ASA* American Society of Anaesthesiologists Grade, *IQR* interquartile range, *MUST* malnutrition universal screening tool, *NEWS* National Early Warning Score, *SD* standard deviation

*Median (IQR)

**Mean (SD)

would be considered excellent for a prediction model [8], suggesting further refinement could be investigated. This may not be necessary for the CFS, whose primary function is to assess patient frailty rather than risk stratify hip fracture patients specifically.

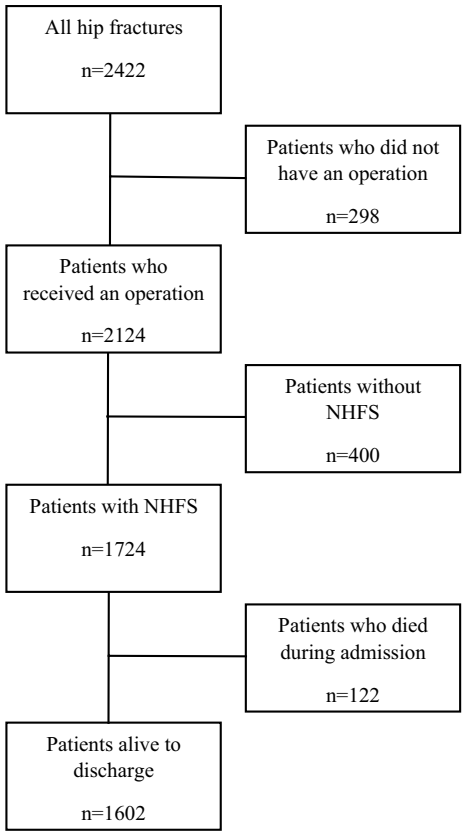

Fig. 1 Flowchart of patients included in the NHFS analyses

The NHFS has been validated as a useful predictor for 30-day and 1-year mortality of hip fracture patients in previous studies [3, 7, 9–12]. Alternative risk stratification tools have been researched to see which ones perform better, most notably: American Society of Anaesthesiologists (ASA) grade, Charlson Comorbidity Index (CCI), Estimating the Physiologic Ability and Surgical Stress (E-PASS) score and Orthopaedic Physiological and Operative Severity Score for enumeration of Mortality and morbidity (O-POSSUM). The NHFS had the greatest discriminative power of these [13, 14]. The E-PASS and O-POSSUM are complex and require intra-operative data, making them less convenient to complete. The ASA grade, CCI and NHFS are all simple, inexpensive and can be easily done at the bedside. However, the ASA grade and CCI utilise subjective variables whereas the NHFS has only objective variables. For these reasons, the NHFS could be considered the most appropriate of the currently available scoring systems [13, 14] and it would be logical to improve upon the model using data collected from this study than create a risk stratification tool anew.

We found that the patient's NEWS upon admission and weight (being underweight increased risk) were objective variables not included in the NHFS that were statistically significant on 30-day and 1-year mortality rates.

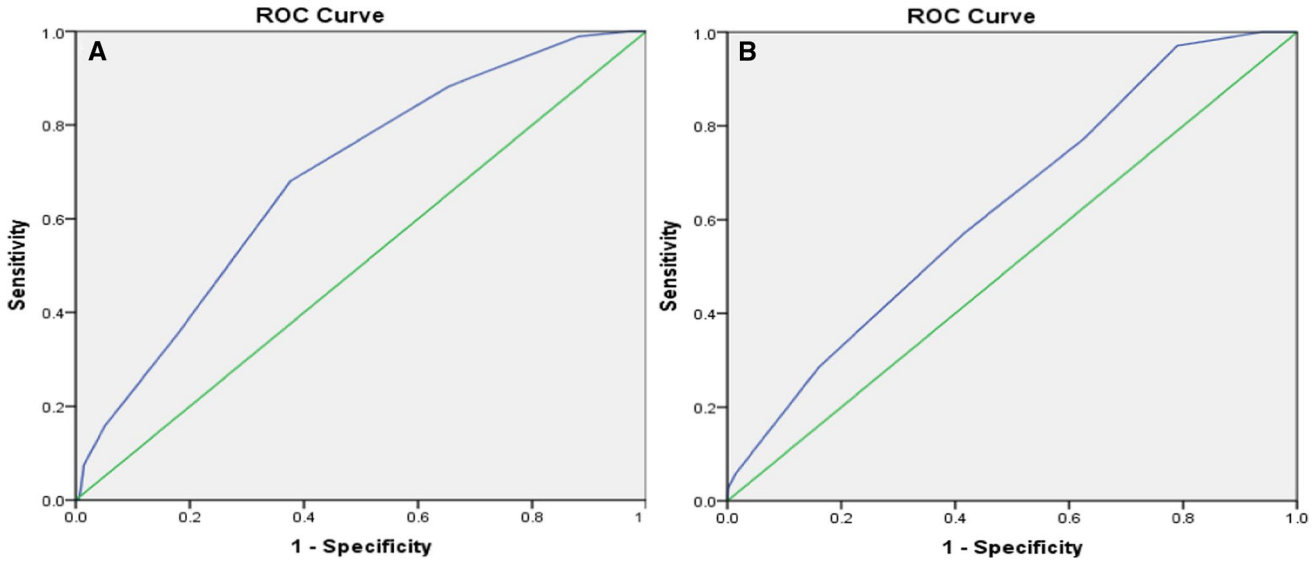

Fig. 2 Receiver operating characteristic curves (AUCs) for **a** NHFS by in-patient mortality and **b** CFS by in-patient mortality. *CFS* Clinical Frailty Scale, *NHFS* Nottingham Hip Fracture Score

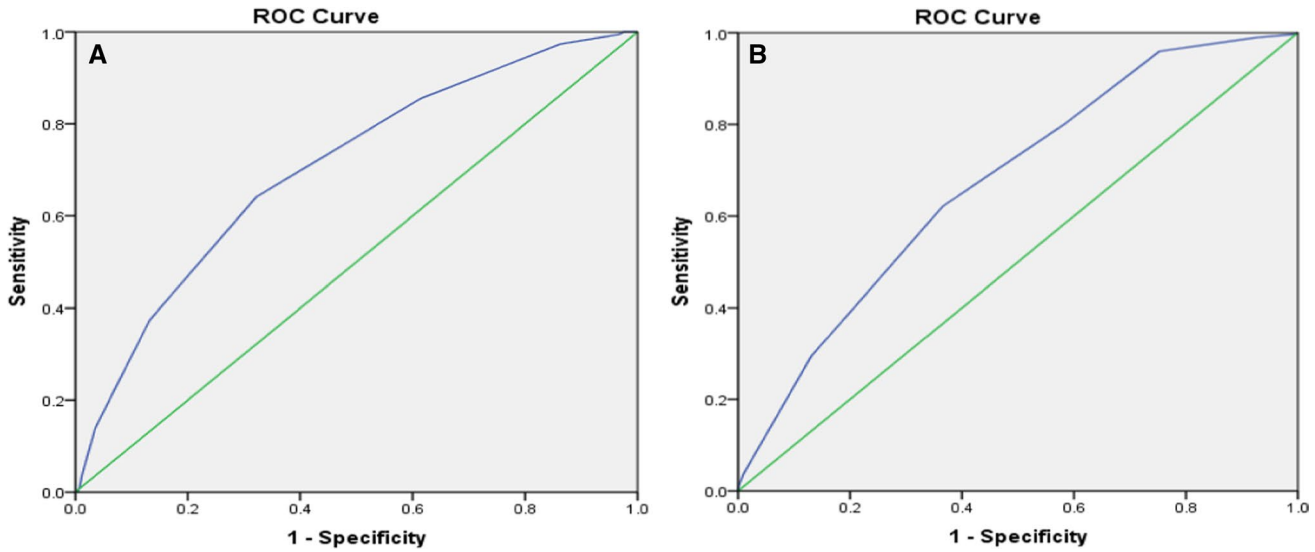

Fig. 3 Receiver operating characteristic curves (AUCs) for **a** NHFS by 1-year mortality and **b** CFS by 1-year mortality. *CFS* Clinical Frailty Scale, *NHFS* Nottingham Hip Fracture Score

This concurs with Menéndez-Colino et al. who identified a low Body Mass Index (BMI) as a risk factor for increased 1-year mortality in hip fracture patients [15]. The NEWS and weight constitute information routinely collected when a patient is admitted to hospital following a hip fracture, so would not reduce the practicality of performing a NHFS should they be included. Further research is required to see if integrating these factors would improve the predictive power of the NHFS.

The 1-year mortality rate of hip fracture patients is not reported in the NHFD; however, the nationwide mortality rate has been reported at 20.5% [16]. The 23.5% mortality rate we observed is slightly higher and significantly greater than the 5.8% 30-day mortality rate which suggests that many patients remain vulnerable after discharge. Male hip fracture patients have a 3.5-fold increased risk of dying within a year relative to the general population and for females, the increased risk is 2.4-fold. This reflects the increased frailty and multimorbidity within the patient group and highlights the need to improve the package of care they receive, including, but not limited to, reducing

Table 2 Statistical significance of clinical scores on hip fracture patient outcomes

Variable	Outcome	Low-risk *n* (% of low-risk group)	High-risk *n* (% of high-risk group)	*p* value	Odds ratio (95% CI)
NHFS	In-patient mortality	11 (1.9)	83 (7.2)	< 0.001	3.98 (2.11–7.53)
CFS		16 (3.4)	54 (6.6)	< 0.001	2.03 (1.15–3.58)
AMTS		45 (3.4)	73 (9.5)	< 0.001	0.34 (0.23–0.50)
NEWS		93 (4.9)	43 (12.2)	< 0.001	2.50 (1.77–3.51)
NHFS	1-year mortality	56 (9.7)	329 (28.5)	< 0.001	3.71 (2.74–5.02)
CFS		59 (12.4)	237 (28.8)	< 0.001	2.87 (2.10–3.92)
AMTS		216 (16.5)	261 (33.9)	< 0.001	0.39 (0.31–0.48)
NEWS		404 (21.1)	132 (37.4)	< 0.001	1.77 (1.50–2.07)
NHFS	LOS ≥ 21 days	154 (26.7)	348 (30.1)	0.137	1.18 (0.95–1.48)
CFS		139 (29.1)	243 (29.6)	0.872	1.02 (0.80–1.31)
NHFS	Institutionalised*	24 (5.9)	48 (6.3)	0.785	1.07 (0.65–1.78)
CFS		24 (7.2)	31 (5.9)	0.424	0.80 (0.46–1.39)

AMTS abbreviated mental test score, *CFS* Clinical Frailty Scale, *LOS* length of hospital stay, *NEWS* National Early Warning Score, *NHFS* Nottingham Hip Fracture Score

*Patients who were previously living in their own home and subsequently discharged into a nursing home. Patients with missing data were already institutionalised or died during this spell were excluded

Table 3 Statistical significance of weight and age on hip fracture patient mortality

Variable	Outcome	Median of survivors (IQR)	Median of deceased (IQR)	*p* value
Age	In-patient mortality	85 (78–90)	89 (84–94)	< 0.001
Weight (kg)		62 (53–71)	58 (51–68)	0.013
Age	1-year mortality	84 (77–89)	89 (84–93)	< 0.001
Weight (kg)		64 (54–72)	60 (51–68)	< 0.001

time to operation, reducing LOS and encouraging early mobilisation [16, 17].

There was no statistically significant difference between low- and high-risk NHFS and CFS groups on hospital stay or discharge destination. Hospital stay does not serve as the best measure of a good clinical outcome, as there are many other factors that can influence how long a patient remains as an in-patient, for example, delays in providing care packages and equipment can prolong stay. The lack of a statistical difference between the low- and high- risk groups regarding discharge destination in the presented study do not support the findings of Lisk et al. [11], Doherty et al. [12] and Moppett et al. [18] who reported that the NHFS was a useful clinical tool in predicting the likelihood of a patient returning to their own home.

Strengths

This study has several strengths. This large dual-centre study validated the NHFS as a useful clinical tool for predicting short and longer-term mortality in hip fracture patients, to a degree consistent with the results seen in other studies [3, 7, 9, 10]. Mortality, hospital stay and discharge destination rates observed are similar to that reported on a national level [16], increasing confidence that the cohort and subsequent care delivered was representative of hip fracture patients seen more widely. The source of the data used contained detailed longitudinal information on risk factors that could affect patient outcomes such as co-morbidities, patient demographics and risk of malnutrition. This enabled us to account for these risk factors and what, if any, effect they had on outcomes.

There have been several studies validating the predictive power of the NHFS on hip fracture mortality rates [3, 7, 9–12, 15], however, to the best of our knowledge, there are only three studies that have looked for a possible correlation between the NHFS and discharge destination [11, 12, 18] and only one study that has compared the NHFS with frailty (the frailty index) [19]. Therefore, this study is the first to compare the NHFS with the CFS in predicting mortality, hospital stay and discharge destination in hip fracture patients.

Limitations

There are several limitations to this study. The main purpose was to assess the performance of the NHFS as a predictor of outcomes and compare this with the CFS, yet 28% of patients did not have a NHFS and 42% did not have a CFS. Furthermore, 36% did not have a 120-day residence recorded. Secondly although much of the data was collected contemporaneously as part of the NHFD Audit, we did not prospectively recruit patients which

may have been able to provide more accurate, in-depth data. The probability of the patient having another hip fracture and a major osteoporotic fracture within the next 10 years, evaluated using the Fracture Risk Assessment Tool (FRAX), along with the patient's hand-grip strength, were not available for appraisal. Thirdly the results reflect the working practises and patient population of a single hospital Trust. Even though the care is akin to the standard seen in trusts across the UK, nevertheless we recognise that some aspects may differ to other trusts. Finally, the quality of life of hip fracture patients following admission could be a superior indicator of successful treatment rather than mortality, which is dichotomous by nature. Observing this, as well as having a longer patient follow-up, could be explored in future research.

Implications

This study has demonstrated that the NHFS and CFS both risk stratify hip fracture patients with similar, moderate discrimination. The CFS is not intended to replace the NHFS, however, doctors are encountering increasingly heterogeneous and complex hip fracture patients, so incorporating the CFS when assessing the patient's clinical picture and formulating a package of care may prove beneficial. Understanding an individuals' frailty status, interventions such as nutritional support and early mobilisation can be introduced to those patients who could benefit from a potential delay in the onset or worsening of frailty.

The NHFS may benefit from further refinement. For example, in our cohort the identification of weight and admission physiological derangement captured by the NEWS are possible additional factors that may influence patient outcomes. A weak hand-grip strength has also been recently cited as a potential indicator of a poor prognosis in hip fracture patients [12, 15]. The NHFS remains a useful indicator for clinicians to identify high-risk patients and facilitate prognostic conversations with the patient and their family.

Conclusion

Previous studies have validated the NHFS as a discriminator of low- and high-risk hip fracture patients yet there is limited research comparing it with frailty. This study concludes that both the NHFS and CFS can risk-stratify patients with similar, moderate discrimination with regards to 30-day and 1-year mortality. Further research could explore revision of the NHFS to improve its predictive power to help patients and clinicians.

Compliance with ethical standards

Conflict of interest All authors have no conflicts of interest.

Ethical approval Ethical approval was given by NHS South Central – Hampshire B Research Ethics Committee (REC reference 18/SC/0513).

Informed consent No informed consent was gained for this retrospective study of anonymised routinely collected data.

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