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Spinal fractures incurred by a fall from standing height

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ABSTRACT

Objective: Falls from standing are common, particularly amongst the aging population, due to declining mobility, proprioception and vision. They are often complicated by fragility fractures, including vertebral fractures, that are associated with significant morbidity and may represent a pre-terminal condition with high one-year mortality rates.

Patients and methods: A retrospective review of the Trauma Audit and Research Network database for a major trauma centre was conducted for all patients admitted between January 2011 and December 2016. Patients with a spinal fracture and a confirmed fall from standing height were eligible for inclusion. Case notes were reviewed for demographics, Injury Severity Score, Charlson co-morbidity score, treatment, complications and outcomes.

Results: Of 1408 patients with a spine fracture admitted during the study period, 229 (16.3%) were confirmed to be secondary to a fall from standing height. The average age of this cohort was 76.6 ± 14.5 years and 134 (58.5%) cases were female. The average ISS score was 9.7 ± 5.4. The 229 patients sustained 283 fractures with a distribution of: cervical (n = 140), thoracic (n = 65) and lumbar (n = 78) spine. Fifty-six (24.5%) patients underwent surgical intervention. Forty-three patients (18.7%) died within 6 months of admission and all-cause mortality was significantly higher in patients with increasing age and Charlson co-morbidity score.

Conclusion: Spinal fractures due to a fall from standing height represent one sixth of the fracture workload of the emergency spinal service at a major trauma centre. Whilst the majority of patients can be managed conservatively there are still considerable implications for hospital bed usage and patient mortality.

1. Introduction

The incidence of spinal fractures is increasing [1–3]. The aetiology of spinal fractures can be broadly classified into the mechanism in which they are sustained; road traffic accidents, sporting injuries and falls [4,5]. Falls from standing height are low energy traumas and usually result in only minimal injury in younger adults. However in elderly patients, who are likely to have concomitant osteoporosis, these low energy insults can cause vertebral fractures [6]. The inclusion criteria for studies on low energy falls is variable and has included falls from standing [7], less than 3 feet [8], less than 1 m [9], or even up to 3 m [10].

It is well recognised that falls from standing height represents up to 58% of trauma admissions in the elderly [8,9,11] and the proportion of major trauma due to low level falls increases proportionally with age [12]. Fifty-eight percent of all spinal fractures are as a result from a fall from standing [13] with falls alone representing half of all causes of spinal fractures in the over 50 year olds [14]. The risk of spinal fractures from low energy injury in adults < 50 years is potentially a reflection of post-menopausal osteoporosis which begins to develop after the age of 50 [15]. Series on all admissions due to falls from standing report that 0.4–4.3% of admissions were associated with spinal injuries [7,16]. Amongst patients with spinal trauma due to a fall from standing, there is a preponderance towards cervical spine injuries [8] and falls

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from standing represent 47% of C2 fractures in those over 70 years old [17].

In the current aging population, falls from standing and the resulting fractures will require increased allocation of time and resources from the emergency spinal services. The average cost per admission for osteoporotic vertebral fractures was $11,681 in the USA [14] and €3330 for vertebral fractures without neurological injury in the UK. Although under 10% of these injuries will require a surgical intervention, only 21% will be discharged back to their usual place of residence [8]. The frequency of falls from standing in the elderly, and the subsequent socio-economic burden sustained as a result of the ensuing fractures, make this an important topic for both spinal surgeons and the units in which they work. There are currently no reports from a UK based trauma service on this subject and the aim of this article is to describe the management and outcomes of these injuries in a single trauma unit.

2. Material and methods

The Trauma and Audit Research Network (TARN) database was reviewed for all patients admitted to a single major trauma centre between January 2011 and December 2016. The TARN database is a national collaborative which, whilst not mandatory, is subscribed to by all major trauma centres and trauma units in England. Patient data is populated by dedicated administrative teams at each hospital and all patients with an Injury Severity Score ≥1 and hospital length of stay ≥3 days are eligible for inclusion into TARN. Despite TARN being national the patient cohort was limited to a single major trauma centre to allow for additional patient data to be reliably collected. No age restrictions are placed on inclusion into TARN.

All patients on the TARN database admitted to our major trauma centre with a spine Abbreviated Injury Scale (AIS) of 2 or greater were included for review. No restrictions were placed on the AIS for the other body regions. The patients were further filtered for those with an injury mechanism of *fall less than* 2 m. The medical history in the case notes was used as a final filter and only those with a confirmed history of fall from standing were included. Falls from less than standing height, e.g. falls from a chair or out of bed, were also included. Patients were deemed to have a new fracture due to the presenting fall based on clinical features of new back/neck pain immediately following the injury corresponding with radiological evidence of fracture as reported by a radiologist.

The case notes were reviewed for demographics, Charlson co-morbidity index, number of pre-injury medications, treatment and complications. The TARN database provided details on Injury Severity Score (ISS), length of stay, intensive care admission and the Glasgow Outcome Score at discharge. The Picture Archiving and Communication System (PACS) was reviewed by the lead author (SH) and the radiological studies were used to classify the fractures. The classifications used were the Anderson and D'Alonzo, and AOSpine subaxial and thoracolumbar systems as appropriate.

Neurological injury associated with the vertebral fracture was classified using the AOSpine neurological modifier score. In patients with more than one fracture the worst neurological injury for that was patient was recorded.

Data was analysed with descriptive statistics using GraphPad Prism version 7.02 (GraphPad Software, La Jolla, California, USA). All-cause mortality was compared by age groups, Charlson score and discharge destination using Kaplan Meier curves produced on SPSS version 24 (IBM Corporation, Armonk, New York, USA). Survival was calculated as the time from admission to death in days with all surviving patients being censored at one year from the end of the study period (i.e. 31 December 2017).

Table 1
Characteristics of patients in this cohort.

	Number
Age in years (mean ± SD)	76.6 ± 14.5
Female gender (n=)	134 (58.5%)
Charlson co-morbidity score (mean ± SD)	4.4 ± 2.2
Pre-admission medications (mean ± SD)	4.0 ± 3.2
Injury Severity Score (mean ± SD)	9.7 ± 5.4
Isolated spine injury (n=)	173 (75.5%)
Associated bodily injuries (n=)	
• Limbs	16
• Head	15
• Pelvis	13
• Chest	9
• Face	8
• Abdomen	2

3. Results

3.1. Demographics

The TARN database contained 1408 patients with spinal fractures in the 6-year study period. Of these spinal fractures 229 (16.3%) patients had a history of fall from standing height. The mean age of this cohort was 76.6 ± 14.5 years and 134 (58.5%) were female. The mean patient's Charlson co-morbidity index was 4.4 ± 2.2 and the number of pre-admission medications taken by each patient was 4.0 ± 3.2. The cohort characteristics are shown in Table 1. A pre-existing diagnosis of osteoporosis was identified in 56 (24.5%) of the patients in this cohort. Patients with osteoporosis were significantly older (81.1 vs 75.3, p = 0.008) and more likely to be female (n = 45; 80.3% vs n = 89; 51.4%, p = 0.0001) than those without osteoporosis.

The average ISS score for the cohort was 9.7 ± 5.4. One hundred and seventy-three (75.5%) patients had isolated spinal injuries (AIS score 0–1 in all non-spine body regions). The other body regions sustaining significant injury (AIS 2 or more) were; limbs (n = 16), head (n = 15), pelvis (n = 13), chest (n = 9), face (n = 8) and abdomen (n = 2).

3.2. Fracture patterns and neurological deficits

The 229 patients sustained 283 fractures, which were distributed in the cervical (n = 140), thoracic (n = 65) and lumbar (n = 78) regions. Seventy-five (53.6%) of the cervical fractures were in C1 and C2, with the remainder in the subaxial cervical spine. The atlanto-axial fractures included: odontoid peg (n = 52; Anderson and D'Alonzo type 2 n = 47 and type 3 n = 5), C1 (n = 15) of which 2 had a Jefferson fracture involving both the anterior and posterior arches, Hangman's fracture (n = 3), C1-2 dislocation (n = 3), and C2 body (n = 2). The AOSpine classification of the subaxial cervical spine and the thoracolumbar spine are displayed in Table 2. The patients with AOSpine A0 fractures that

Table 2
The distribution of fractures in this series by location and AOSpine classification.

AOSpine classification	Subaxial cervical (n = 65)	Thoracic (n = 65)	Lumbar (n = 78)
A0	15	3	6
A1	6	44	46
A2	0	3	11
A3	2	8	5
A4	1	3	8
B1	4	2	1
B2	29	0	0
B3	6	0	1
C	2	2	0

Table 3
The distribution of neurological injuries associated with spinal fractures.

AOSpine neurological classification	Cervical	Thoracic	Lumbar
N1	4	1	0
N2	6	0	0
N3	14	1	1
N4	4	1	0

were admitted despite it being a minor injury all had either other vertebral fractures, injures to other body regions or a central cord syndrome.

One hundred and eighty-nine (82.5%) patients sustained a single fracture and the remaining 40 (17.5%) had two or more fractures. Twenty-four of the forty patients with more than one fracture had non-contiguous fractures separated by at least one un-injured vertebrae.

Neurological injury was identified in 32 patients which comprised N1 (transient paraesthesia) n = 5, N2 (radiculopathy) n = 6, N3 (incomplete cord/cauda equina syndrome) n = 16 and N4 (complete cord syndrome) n = 5. Of the 21 incomplete/cauda equina and complete spinal cord syndromes, 18 had an injury level in the cervical spine, 2 were in the thoracic spine and 1 was in the lumbar spine (Table 3). Eight patients had documented full recovery of their neurology (N1 = 3, N2 = 3, N3 = 2), and a further 9 showed improvement without full recovery (N1 = 2, N2 = 1, N3 = 5, N4 = 1). Seven patients with neurological deficit died in the acute period (less than 3 months) and so did not have documented follow-up examinations. The remaining 8 patients underwent follow-up with their local spinal service and so examination records were unavailable.

3.3. Treatment

There were 40 (17.5%) patients who underwent surgical intervention for their fracture. The decision to proceed with surgical intervention was based on the opinion of the individual surgeon responsible for the patient. Three of these patients had two non-contiguous fractures that were fixed with separate constructs. The 43 procedures performed were: anterior cervical discectomy with fusion (ACDF) (n = 24), pedicle screw fixation (n = 12), corpectomy with strut graft (n = 3), anterior odontoid screw (n = 2), laminectomy for haematoma evacuation (n = 2). One patient in this group underwent both odontoid screw and ACDF. Of the 12 pedicle screw fixations 4 were performed percutaneously and 4 incorporated decompression of the spinal cord. The distribution of spinal fracture patterns for each surgical procedure is shown in Table 4. Both anterior odontoid screws were for Anderson and D'Alonzo Type 2 fractures.

Four patients underwent traction prior to their fixation. A further 8 patients whose fractures would have been stabilised surgically were deemed medically unwell/frail for surgery and so were managed conservatively. Fifteen patients underwent external immobilisation with a HALO jacket.

There were 39 patients (17.0%) admitted to neuro-intensive care during their stay who spent a median of 4 days (IQR 1–8.75) in intensive care. Eleven of the admissions were for traction or HALO jacket application and 6 were for post-operative observation only. The remaining admissions were for medical optimisation including respiratory support for high spinal cord injuries.

Table 4
The distribution of AOSpine classification of injuries for the surgically managed patients (ACDF: anterior cervical discectomy with fusion).

Surgical procedure	A3	A4	B1	B2	B3	C
ACDF			1	17	5	1
Pedicle screws	1	5	2	2	1	1
Corpectomy	1			2		
Epidural haematoma evacuation				1	1	

3.4. Complications

The medical notes recorded 59 complications in 55 (23.7%) patients. There was no significant difference in the number of patients experiencing complications between the surgical and conservatively managed groups (n = 16, 28.6% v n = 39, 22.5%; p = 0.37). Fifty-one complications were medical issues of which the majority were lower respiratory tract infections (n = 26) and urinary tract infections (n = 15). The remaining medical complications were: acute kidney injury (n = 2), respiratory failure (n = 2), pulmonary embolism (n = 1), deep vein thrombosis (n = 1), cellulitis (n = 1), pulmonary oedema (n = 1), atrial fibrillation (n = 1) and myocardial infarction (n = 1).

The eight spinal complications included 6 cases of non-union in odontoid peg fractures (all Anderson and D'Alonzo Type 2) which were initially conservatively managed. The median length of follow-up to confirm non-union was 12 months (range 3–21 months) although the patient displaying non-union at 3 months died 2 months later limiting further imaging. Two of these non-unions later required surgical intervention. The remaining spinal complications were one patient with a new foot drop after posterior lumbar fixation and one patient with progressive vertebral collapse at 5 weeks in a conservatively managed thoracic fracture which subsequently required posterior fixation. These three patients who underwent delayed surgery for complications are not included in the 40 surgical patients above.

3.5. Discharge

The median length of stay was 11 days (IQR 6–20). There was no difference in the length of stay for the surgically (median: 9, IQR 5.75–18.5) or conservatively (median: 11, IQR: 6–20) managed patients (p = 0.35). The discharge destination was recorded for 228 (99.6%) of the patients which included the 18 patients who died during their hospital stay.

The major trauma centre uses a hub-and-spoke model transferring patients from surrounding district general hospitals/trauma units who require surgical intervention as well as admitting all spinal trauma within its own catchment area. Patients can thus be discharged directly home or repatriated to their local hospital for on-going physiotherapy or general medical care. One hundred and twenty-six (55.0%) patients were discharged directly from the major trauma centre to their usual place of residence. A further 82 (35.8%) patients were transferred to another institution for ongoing physiotherapy and rehabilitation, of these 46 went back to their local district general hospital and 36 went to a rehabilitation centre in close proximity to the major trauma centre. Three (1.3%) patients were discharged to a specialist centre for spinal injury rehabilitation.

3.6. Mortality

At discharge the Glasgow Outcome Score was available for 224 (97.8%) patients and was recorded as death (n = 18, 7.9%), severe disability (n = 5, 2.2%), moderate disability (n = 44, 19.2%) and good recovery (n = 157, 68.6%). The causes for the in-hospital deaths were: LRTI (n = 8), respiratory failure due to spinal cord injury (n = 4), urosepsis (n = 1), pulmonary oedema (n = 1), carcinomatosis (n = 1), stroke sustained at the time of fall (n = 1), respiratory arrest – cause unknown (n = 1) and hypoglycaemic brain injury sustained pre-hospital (n = 1). At 6 months post-admission 43 of the 229 (18.7%) patients had died.

Kaplan-Meier survival curves using three age-groups (< 65, 65–79 and ≥80 years old at admission) demonstrated that all-cause mortality rates significantly increased for each age group following a spinal

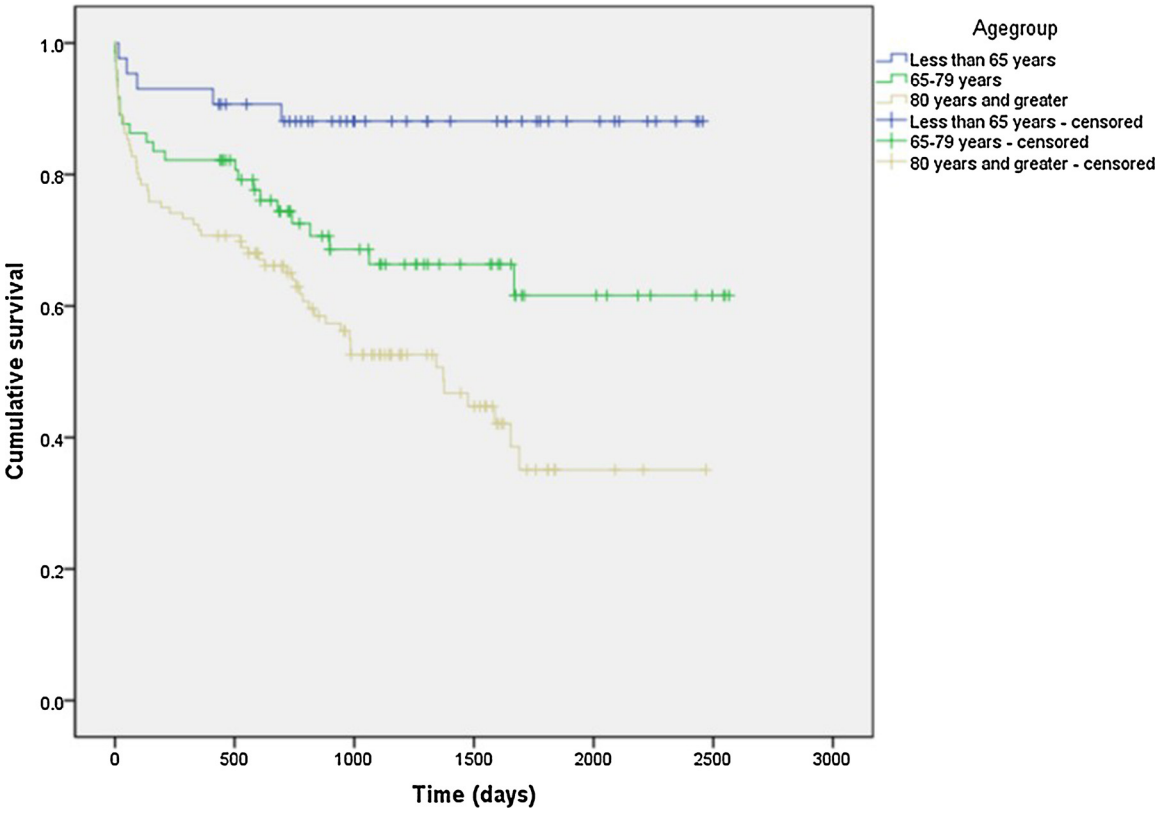

Fig. 1. All cause mortality curves based on different age groups.

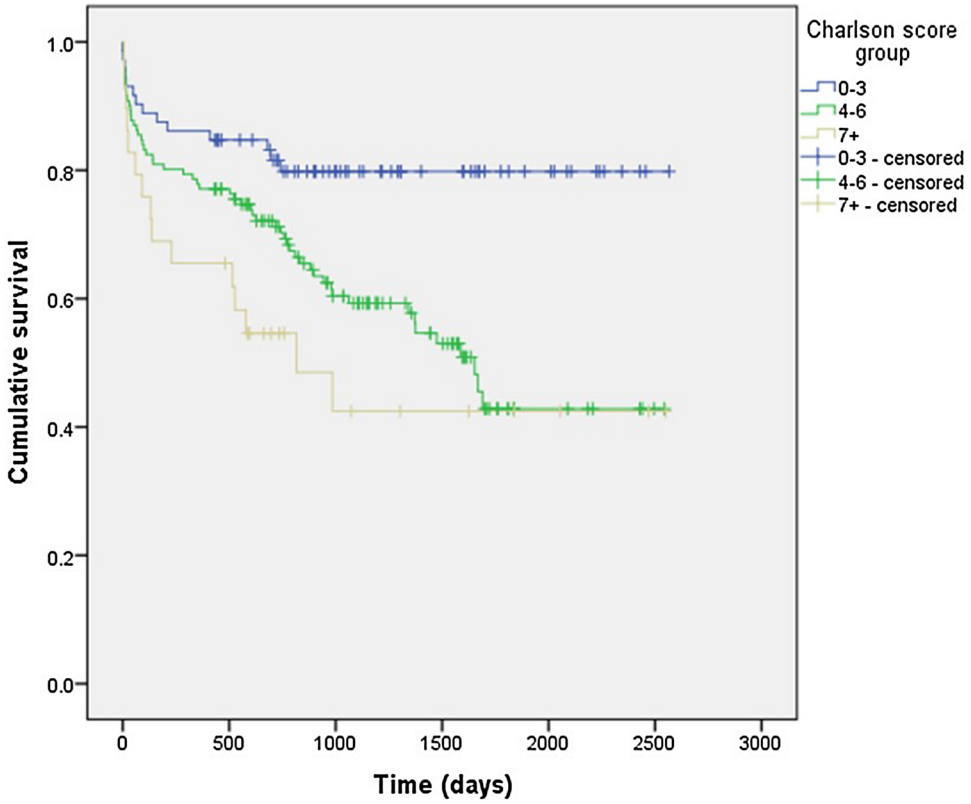

Fig. 2. All cause mortality curves based on Charlson co-morbidity scores.

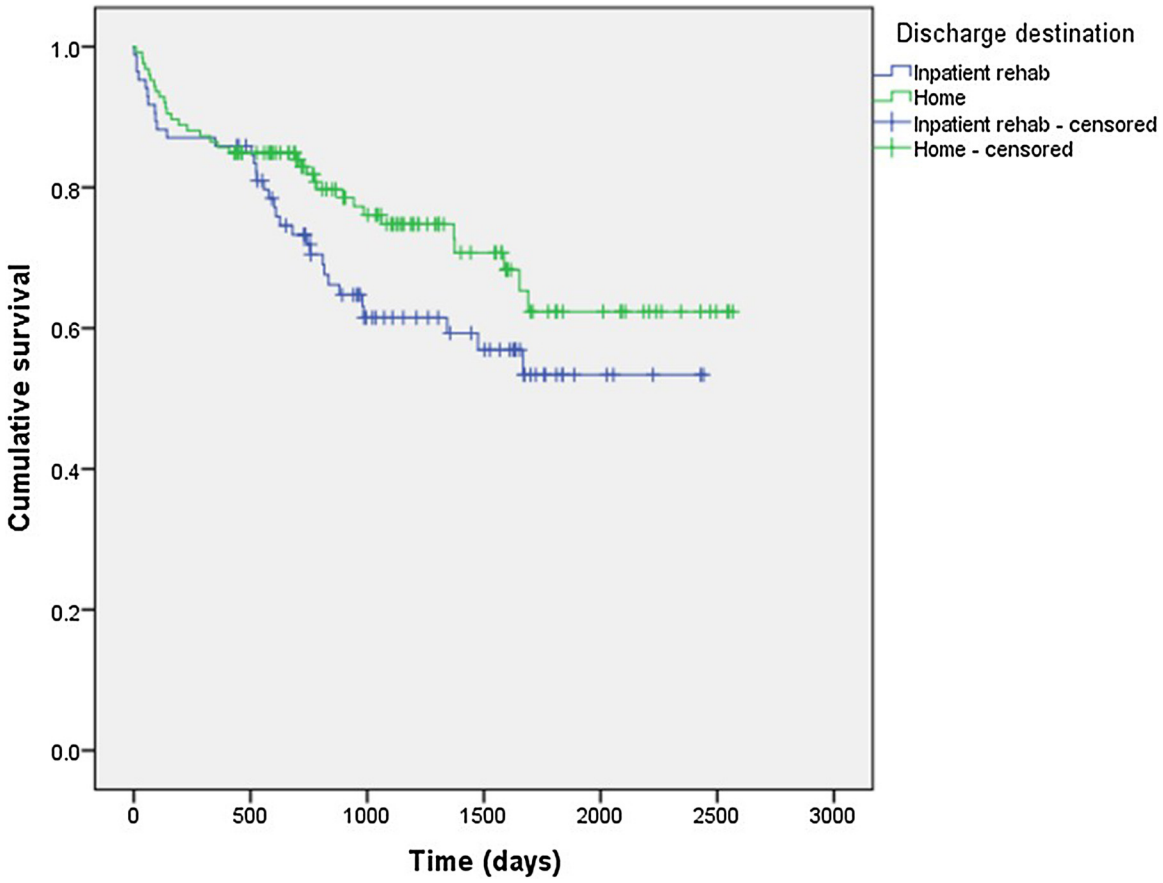

Fig. 3. All cause mortality curves for discharge destination.

fracture caused by a fall from standing (p = 0.001, Fig. 1). Survival curves using the patient's Charlson co-morbidity score divided into three tranches (0–3, 4–6, 7 +) also showed that a greater Charlson score at admission is associated with a higher all-cause mortality (p = 0.001, Fig. 2). The discharge destination (home n = 126 vs inpatient rehabilitation n = 85) showed a trend towards an association with higher mortality if the patient was not discharged home but did not reach statistical significance (p = 0.09, Fig. 3). Patients who underwent surgical intervention for their fracture did not have higher all cause mortality than conservatively managed patients (p = 0.55, Fig. 4) however those with a spinal cord injury (AOSpine modifier N3 or N4) did (p < 0.0001, Fig. 5).

4. Discussion

Falls from standing height are a particular area of interest for geriatricians due to their frequency amongst the elderly population. However they are a problem which is not limited to geriatricians because of the high rates of associated fractures [7]. Spinal surgeons are also likely to see an increase in the proportion of their workload formed of vertebral fractures sustained by a fall from standing height. This study identified that 16% of all spinal fractures admitted to a major trauma centre over a 6-year period were sustained due to a fall from standing height. This confirms the burden that this pathology already places on emergency spinal services.

In younger patients, vertebral fractures due to falls from standing height are caused by accidental falls however in elderly patients they are a multi-factorial combination of declining proprioception and mobility, failing vision and delayed righting mechanisms. The elderly population may also have other medical contributors such as postural hypotension and syncope. Aging is also associated with lower bone density [18] thus low energy trauma as seen in a fall from standing height is more likely to result in fracture in the elderly [19]. In the UK there are expected to be 25% of the population above 65 years of age by 2036 [20] which means that falls from standing are likely to be an increasing problem for medical services in the forthcoming years.

As expected the patients in this case series show a strong elderly preponderance with an average age of 76 years which is consistent with previous series on spinal fractures due to falls from standing [14]. The relatively low ISS, which is also seen in other series on ground level falls [21], and the fact that three quarters of the patients suffered an isolated spine fracture is a reflection of the low energy nature of the injury. The fact that injury is sustained from an innocuous event is likely the impact of frailty and osteoporosis in this patient population.

Osteoporosis is present in up to 47% of patients over 80 years old [22]. Biomechanical models demonstrate that the maximum axial load sustainable before fracture is reduced by up to 22% in osteoporotic vertebrae [23]. Changes in bone trabeculations favour a loss of horizontal trabeculations in osteoporotic bone [24]. This increases the susceptibility to buckling and fracture in the vertical trabeculae following axial loading/ flexion forces which are typically the mechanism in ground level falls. The subchondral trabecular bone is particularly important in determining the extent of vertebral endplate deflection and subsequent vertebral failure following axial loading [25].

Despite this reduced bone mineral density the fractures sustained tend to be stable injuries with 82.1% managed conservatively in our case series. This rate of conservative management is similar to the large cohort of thoracolumbar fractures in patients over 75 years old reported by Purvis et al. [26]. Evidence from Purvis et al. shows that surgically fixing vertebral fractures in patients > 75 years old is associated with higher hospital costs, longer in-patient length of stay and more frequent complications [26]. The high rate of conservative management is likely

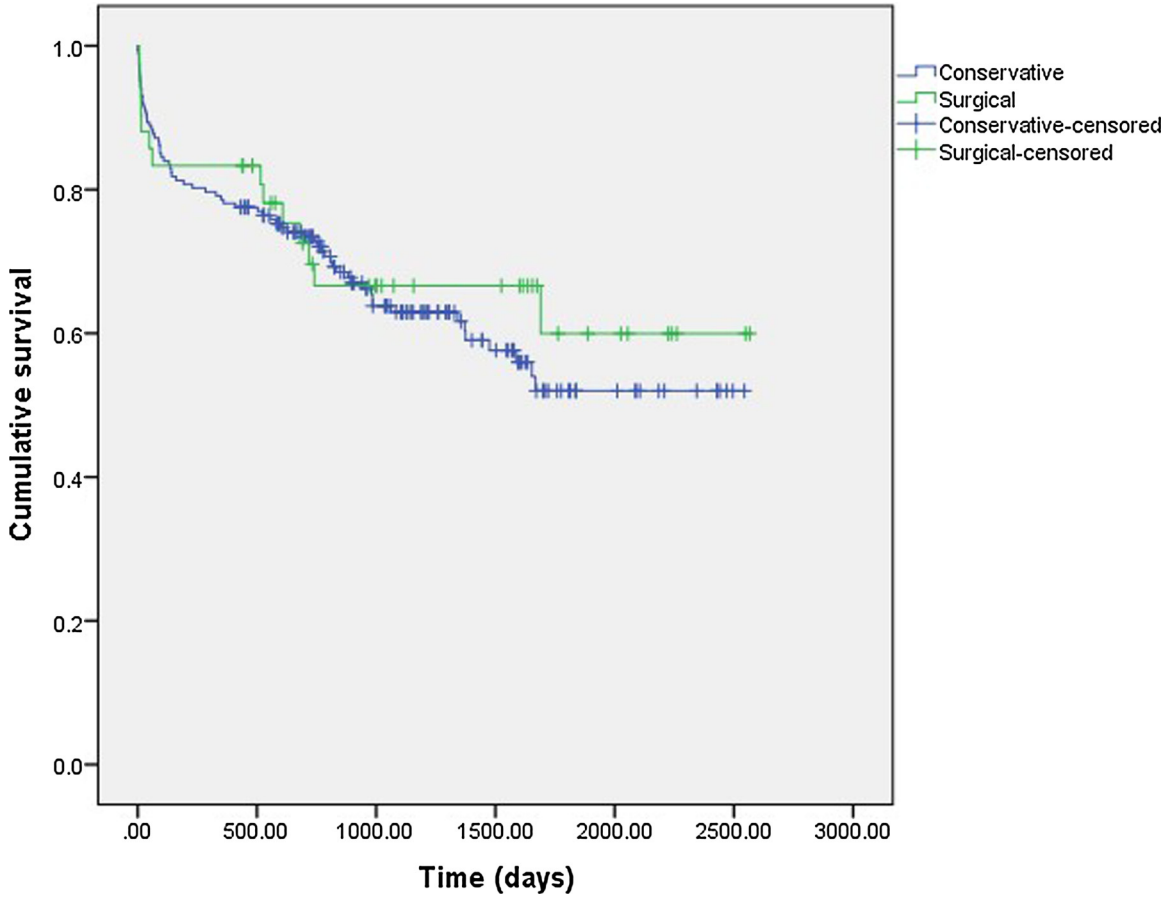

Fig. 4. All cause mortality curves for treatment methods.

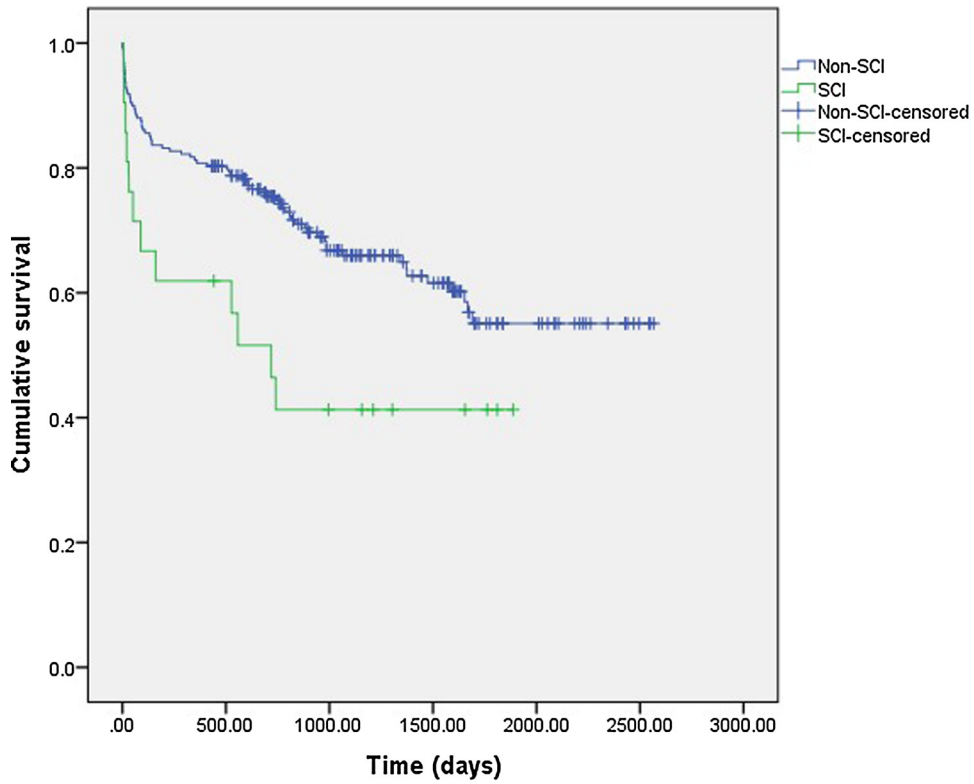

Fig. 5. All cause mortality curves for patients with a Spinal Cord Injury (SCI) compared to those without.

to be a reflection of both the high rate of stable fractures (Table 2) sustained by low energy trauma and the fact that surgical fixation is undertaken with caution in an elderly population due to the poorer bone quality and higher surgical risks. It is important to note that the percentage of conservatively managed cases in this study may be an underestimate as it only includes fractures managed at the major trauma centre. Patients in the surrounding region with severe fractures will be transferred for surgery and those with stable fractures remain in the district general hospitals for conservative management. An analysis of different mechanisms of trauma is beyond the scope of this article but may demonstrate that high energy mechanisms result in different fracture patterns and higher rates of neurological/other body region injury which influence treatment choice and outcomes.

Despite the majority of spinal fractures incurred by a fall from standing being managed conservatively they still generate a considerable burden on hospital resources. The improvements in disability and quality of life can take up to 6 months to reach their maximum levels [27]. The average length of hospital stay was 11 days (IQR 6–20), which is comparable to other similar studies which report a range of 5–25 days [8,13,14] although these figures do not represent patients with long hospital admissions required to treat complications or medical optimisation. The trend towards higher mortality in those sent for further in-patient physiotherapy (Fig. 3) is likely a reflection of these on-going medical issues. However, only 55% of patients could be discharged directly home and this length of stay does not include the time spent by the remaining 45% in rehabilitation centres or district general hospitals who are receiving additional physiotherapy. The true number of bed-days spent on inpatient physiotherapy will therefore be underrepresented in this study. Despite this, the percentage of people discharged directly home still compares favourably to figures of 21–37% reported in USA based series [7,8]. The healthcare provisions in the UK and USA differ, with better access to rehabilitation services in a privately funded system compared to the challenges of social care in the UK. This may also affect the rate of patients who are discharged directly home without further inpatient rehabilitation.

In addition to the socioeconomic implications of rehabilitation costs there are also significant implications on patient mortality. In a USA based study using a trauma registry, in-hospital mortality following a fracture incurred by a fall from standing has been reported at 8.5% [8] which is comparable to the 7.9% in this study. The incidence of associated spinal cord injury in falls from standing is rising [28] and likely an important influence on mortality, particularly in the elderly [29], due to the preponderance for cervical injuries [30] which are naturally more disabling due to the more severe neurological deficit. Furthermore, this study demonstrates that 18.7% of patients will die in the 6 months following admission which is in keeping with other frailty associated injuries such a neck of femur fractures which also have a reported of 6-month mortality of 25% [31]. This study demonstrates that mortality is significantly influenced by increasing age, co-morbidity and spinal cord injury (Figs. 1, 2 and 5) which has been observed both in other series on elderly trauma [32] and specifically on falls from standing height [7]. This finding supports the use of pragmatic, and holistic, management of these patients which should involve geriatricians to help manage their complex medical and rehabilitation needs.

There are several limitations to this study which must be acknowledged. Whilst the TARN database is collected prospectively the data collected from the patient notes was all retrospective and thus is at risk of inaccuracies from missing data. The data is collected from a single major trauma which may not be representative of patients throughout the UK and different units may have different practises for managing spinal fractures. Further work on a national level will create a clearer picture on the true outcomes of these patients. Lastly, data was not collected from the district general/ rehabilitation hospitals and so medical complications encountered after leaving the trauma centre will not have been collected.

5. Conclusions

This study is the first to report on spinal fractures due to falls from standing height in the UK. It demonstrates that the majority of fractures can be managed conservatively with more than half of patients being discharged to their usual place of residence. However, spinal fractures incurred due to a fall from standing height are still associated with a high inpatient rehabilitation burden and a high mortality rate. The combination of age, frailty and co-morbidity means that despite the benign mechanism of injury, these fractures have significant impacts on patient outcomes.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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