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Outcomes and predictors of mortality following periprosthethic proximal femoral fractures

Graham Finlayson[a], Adam Tucker[a,*], Nicholas D. Black[b], Sinead McDonald[c], Mary Molloy[b], Darrin Wilson[a]

[a] C/O Fracture Clinic, Level 2, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BA, Northern Ireland, United Kingdom
[b] C/O Anaesthetic Department, Level 3, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BA, Northern Ireland, United Kingdom
[c] C/O Fracture Outcomes Research Dept., Level 4, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BA, Northern Ireland, United Kingdom

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ABSTRACT

Background: Periprosthetic fractures are a well-documented, serious complication of joint arthroplasty, occurring in up to 11% of hip replacements. We examined periprosthetic femoral fractures over an 8 year period to determine the demographics, fracture pattern and management options and associated outcomes. Furthermore, we sought to determine which comorbidities resulted in increased risk of 12 month mortality after periprosthetic fractures about hip replacements

Methods: A retrospective review of a prospective fracture database was conducted for the years 2007–2015. The Fracture Outcomes Research Database (FORD) was interrogated for patients aged >60 years, admitted with periprosthetic hip fracture. Radiographic and Electronic Clinical Record review was performed to classify fractures, record treatments, comorbidies and 12 month mortality. A multivariate analysis was performed to determine comorbidities that significantly increased the risk of 12 month mortality.

Results: A total of 189 patients were identified. The majority were Vancouver B1 fractures (61.9%); the operations were primarily cable plating (75.1%), with a smaller number of revision arthroplasties (21.2%) and only three proximal femoral replacement (1.6%). Four patients (2.1%) died before surgery. Only 27.3% returned to their usual residence post-discharge. Overall 30-day mortality was 2.1%, and one-year mortality was 11.6%. Patients who died tended to be older. In the multivariate analysis, ASA grade III/IV and active neoplasia were significant contributors to 12 month mortality.

Conclusion(s): Our 12 month mortality (11.6%) is at the lower end of existing reported literature, and serves as a benchmark for UK practice. In the multivariate analysis, only ASA grade III/IV and an active neoplastic process were significantly associated with increased risk of mortality. Whilst large, multicenter trials, utilizing standardized treatment techniques are required to fully assess risk factors for 12-month mortality, it appears that those at significant risk are elderly, frail individuals with an active malignancy.

Introduction

The NJR has recorded year on year increases in the number of total hip replacements, with 91,833 procedures performed in 2015. [1] As a result of this and an ageing population, the incidence of periprosthetic fractures (PPFs) is set to increase. PPFs can occur intra-operatively, or subsequently as a result of trauma, even low energy trauma in the elderly population. Furthermore, these injuries convey significant morbidity and mortality, particularly in the elderly. [2–7]. The risk factors associated with increased 12 month mortality have been reported in hip fractures and include many of the chronic health problems faced by society today (e.g. ischaemic heart disease, diabetes, renal disease etc.) [8], but studies examining these risk factors in PPFs around a hip arthroplasty are less frequently reported [9]. This lack of evidence restricts the ability for clinicians to correctly counsel patients and their relatives regarding the impact these injuries can have on quality of life, morbidity and mortality.

The Vancouver classification is widely utilized to classify PPFs of the femur, and is accepted throughout the literature. [10] The

* Corresponding author.
E-mail addresses: graham.finalyson@doctors.org.uk (G. Finlayson), atuc@hotmail.com (A. Tucker), nicholasdavidblack@hotmail.com (N.D. Black), sinead.mcdonald@belfasttrust.hscni.net (S. McDonald), mary.molloy@belfasttrust.hscni.net (M. Molloy), Darrin.wilson@belfasttrust.hscni.net (D. Wilson).

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classification describes the location of the fracture, as well as subclassifying those about a stem with either poor bone stock, loosening of the cement mantle, or both.

The primary aim of the current paper is to identify the demographics and treatment of periprosthetic femoral fractures in a high volume regional trauma centre, and identify comorbidities that influence the mortality rate at 12 months post operatively. As a secondary outcome, we will do a Vancouver B2 subgroup analysis to determine if there is a role for cable plating in this cohort or patients.

Methods

Patients and methods

A retrospective review of a prospectively collated Fracture Outcomes and Research Department (FORD) database as performed. This included all consecutive PPFs admitted to a regional trauma centre over an 8 year period, between January 2007 and December 2015.

Clinical data including patient demographics, American Society for Anaesthesiologists (ASA) score, Vancouver Grade fracture classification and 12 month mortality were collated and analysed. For all identified patients, pre-operativve digital radiographs on the date of injury were reviewed and classified according to the Vancouver classification system [10].

Electronic Care Record (ECR) notes were reviewed to determine all medical comorbities, the surgical treatment options, and 12 month mortality.

Internal Review Board approval was provided by the Trauma and Orthopaedic Research Group (TORG) at the study institution.

Risk factor analysis

Using the collated data univariate analysis was performed to determine significant associations of medical comorbidities that were associated with increased risk of 12 month mortality following periprosthetic femoral fractures. Those with a p value <0.05 were included, as were *a priori* determined risk factors whose p value was >0.05 (e.g IHD, respiratory disease, VTE etc.) Using this data, multivariate analysis was performed to determine the odds ratios for those clinically important medical comorbidities and their effect on 12 month mortality.

Statistical analyses

Statistical analyses were undertaken using the open-source *R* software (GBIF Secretariat, Copenhagen, Denmark) and SPSS V22 for Mac (IBM Ltd, Armonk, NY, USA). Data was tested using the Shapiro-Wilk test for normality. For normally distributed continuous data, a Students *t*-test was performed. For non-parametric data, ANOVA or Mann Whitney U Tests were utilized as appropriate. For categorical data, a chi-squared or Fishers Exact tests were applied as necessary. Kaplan Meier Survival curves were constructed, and a Mantel Cox log rank analysis was performed to determine for significant differences in survival curves. For all analyses, a p value <0.05 was considered statistically significant.

Results

We identified 189 fractures with a female preponderance (99/189; 52.4%), occurring at a mean age of 79 ± 9.8 years (median 80, IQR 74.1–87.1). A right sided preponderance was noted (100/189; 52.9%). Modal ASA grade was 3 (104/189; 55.0%). Overall, 87.8% of fractures were Vancouver Grade B, which was comprised of 61.9% B1, 22.2% B2 and 3.7% B3 subtypes.

The mean annual incidence of PPFx was 21 per annum (range 13–29), with a weak linear increase over time (R^2 = 0.02). (Fig. 1)

The mean time to theatre was 5.8 days (Median 3.7 days, IQR 2.1–6.6 days), and the average total length of hospital stay was 15.9 ± 13.3 days (median 11.8, IQR 9.0–19.1 days). A prolonged time to surgery was not significantly related to mortality (p = 0.133). All patients received continuous MDT care from the surgical and orthogerriatric medical team, physiotherapists, social workers and occupational therapists, where required, throughout their inpatient stay.

The majority of patients were admitted from their own home (161/189; 85.2%), but only 44 (27.3%)of these returned to their usual residence.

Four patients (2.1%) were medically unfit for surgery, and died before their operations. Of those patients who underwent revision surgery, a variety of implants were used according to surgeon preference. In the cases of open reduction and internal fixation, a cable plate was used for proximal femoral B type fractures (Cable Ready Zimmer Biomet, Swindon,UK or Periarticular Plating System, DePuy Synthes Ltd, Beeston Leeds, UK), and a Less Invasive Surgical Stablisation (LISS; DePuy Synthes, Beeston, Leeds UK) plate for distal Vancouver C type fractures. Table 1 demonstrates the breakdown by procedure.

In the case of stem revision, implants included the Exeter stem (Stryker Inc, Newbury, UK), Kent Revision Stem (Biomet Europe, Dordrecht, The Netherlands), the Reef Revision Stem (DePuy Synthes, Beeston, Leeds, UK) or proximal femoral replacement (METS prosthesis system, Stanmore Implants Worldwide, London, UK)

Operation time was significantly different across the Vancouver grades, with the longest surgical times for B2 subtypes. This was significantly longer than B1, B3 and C substypes (all <0.001). however, no significant difference was seen between other comparators. Table 2 summaries the demographics across the Vancouver groups.

From the univariate analysis, the following factors were found to be significantly associated with mortality at 12 months following a periprosthetic fracture – Diabetes Mellitus (p = 0.034), Active neoplastic disease (p = 0.008), Increasing ASA grade (i.e grade I/II versus grade III/IV) (p = 0.038) and increasing

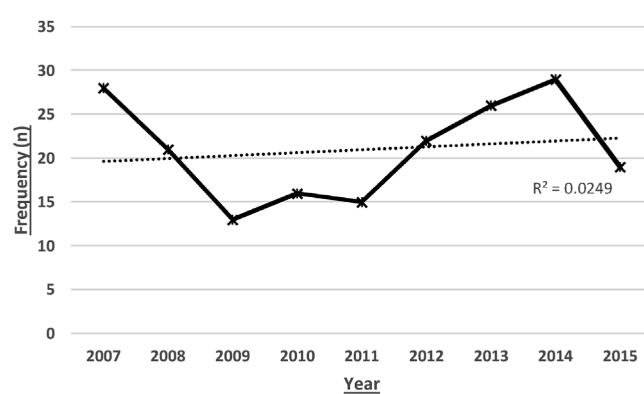

Fig. 1. Annual incidence of PPFx with an increasing linear trendline.

Table 1
Frequency of surgical interventions.

Procedure	N (%)
Internal fixation only	142 (75.1%)
Revision of stem + Internal Fixation	40 (21.2%)
Revision to Proximal Femoral Replacement	3 (1.6%)
Conservative / Death	4 (2.1%)
TOTAL	**189**

Table 2
Demographics by Vancouver Classification Grade.

Variable	A	B1	B2	B3	C	p value
n	3	117	42	7	20	
Age (Mean ± SD)	77.1 ± 13.2	80.2 ± 9.8	78.0 ± 8.9	78.0 ± 6.5	77.5 ± 11.4	0.636
median (IQR)	80 (62-88)	81.7 (47-97)	78.4 (57-91)	76.1 (68-84)	79.4 (50-91)	
Male : Female	1:2	56:63	26:16	3:4	4:16	0.043
Left : Right	2:3	60:57	19:23	3:4	5:15	0.257
ASA Grade						
1	0	2	1	0	0	0.034
2	1	24	11	4	7	
3	2	69	24	2	11	
4	0	19	4	1	2	
5	0	3	2	0	0	
Op Duration (Mean ± SD)	108 ± 71	80.4 ± 44	144.6 ± 63.6	87.6 ± 27.7	86.7 ± 35	
Median	112	77	143	110	80	<0.001
Dead 12 months	0	15	3	0	4	
%	0.0%	12.8%	7.1%	0.0%	20.0%	
Surgical Technique						
Died before Surgery	0	1	2	0	1	n/a
Cable plate	2	107	4	0	10	0.856
Dead @ 1 year	–	14 (13.1%)	–	–	2 (20%)	
Cable wire	1	9	0	0	0	
Dead @ 1 year	–	–	–	–	–	
Revision	0	0	26	3	0	
Dead @ 1 year	–	–	1 (3.8%)	–	–	
Cable plate + Revision	0	0	10	1	0	
Dead @ 1 year	–	–	–	–	–	
Proximal Femoral Replacement	0	0	0	3	0	
Dead @ 1 year	–	–	–	–	–	
LISS plating	0	0	0	0	9	
Dead @ 1 year	–	–	–	–	1 (11.1%)	

patient age ($p = 0.018$). Other *a priori* variables considered relevant included Ischaemic heart Disease ($p = 0.502$), history of venous thromboembolism ($p = 0.526$), active respiratory disease ($p = 0.361$), Chronic Kidney Disease ($p = 0.411$), Alzheimers/Dementia ($p = 0.064$) and previous cerebrovascular events ($p = 0.136$). The Vancouver grade ($p = 0.213$) and length of surgical procedures were also considered *a priori.*

Time to operating theatre from admission was not significantly associated with increased mortality ($p = 0.133$), and further substratification demonstrated that surgery within 48 h was not associated with lower mortality (14/142, 9.86%) compare to surgery after >48 h (6/48, 12.5%; $p = 0.606$).

These variables were used to perform a multivariate analysis predicting mortality at 12 months following periprosthetic fractures. Increasing patient age tended toward significance. An increasing ASA grade, and the presence of an active neoplastic process were significant predictors of 12 month mortality. Table 3 demonstrates the regression analysis.

The overall 30-day mortality was 3.2% (6/189), 5.8% at 90 days (11/189), and 12-month mortality was 11.6% (22/189).

Of those admitted from their own home (161 patients), only 44 (27.3%) returned to their usual residence upon discharge.

Kaplan-Meier (KM) survival curves stratified by Vancouver Classification grade, demonstrated that the 12 month survivorship following PPF was not significantly different across the spectrum of fracture types. Fig. 2 demonstrates the K–M curves, whilst Table 4 demonstrates the survival rates stratified by the Vancouver grade. The Mantel Cox log rank test demonstrated no significant difference in 12 month survival between fracture subtypes ($X^2(4) = 3.491$; $p = 0.479$)

B2 subgroup analysis

In total, 42 B2 fractures were identified. Of these, 2 died before surgical intervention. Of the remaining 40, there were 4 who underwent cable plating per the Ogden Technique – distal transcortical screw fixation with proximal cable application. A further 36 underwent revision arthroplasty. Comparison of demographic baseline data showed longer surgical time for revision arthroplasty as expected, despite no difference in the group characteristics, nor any significant difference in 12 month mortality rates following surgery. Table 5 demonstrates the B2 data comparing cable plating to revision arthroplasty.

Discussion

The incidence of PPFx is quoted at up to 11% following primary THR, and 7% following hemiarthroplasty [9,10]. As the number of hip replacements increases [1,11], the prevalence of PPFx will likely also increase [9].

Table 3
Multivariate analysis with Odds Ratios demonstrating the increased risk for 12 month mortality following a periprosthetic fracture.

Variable	OR	95% CI	p value
Age	1.084	0.995-1.181	0.065
ASA I/II (ref)	1		
III/IV	4.791	1.554-14.775	0.006
Vancouver Grade	1.773	0.332 - 9.462	0.502
Gender Male (ref)	1		
Female	0.898	0.369 - 2.184	0.812
Duration of Surgery	1.007	0.982 – 1.004	0.192
Medical Co-Morbidity			
IHD	1.111	0.250 - 3.244	0.872
VTE	1	∞	0.999
Resp	2.309	0.044-4.214	0.471
CVA	1.068	0.110 - 7.988	0.952
Alzheimers	1.848	0.509 - 6.718	0.351
Diabetes	1	∞	0.998
Chronic Kidney Disease	1	∞	0.999
Active Neoplasia	8.16	1.982 - 33.603	0.004

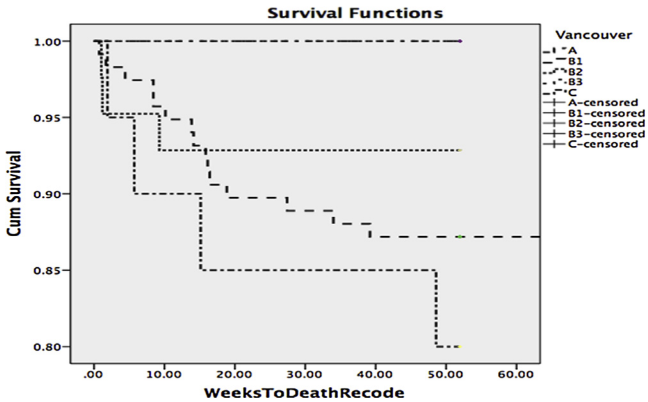

Fig. 2. Kaplan Meier 12 month survivorship curves by Vancouver Grade.

Table 4
Mortality by Vancouver Grade.

Vancouver Grade	N	Deaths	12 month survivorship		P value
A	3	0	100%		0.454
B1	117	15	87.2%		
B2	42	3	92.9%		
B3	7	0	100%		
C	20	4	80.0%		
Total	189	22	Average	88.4%	

Current literature reports that the risk of PPFx is associated with increasing age, rheumatoid arthritis and osteoporosis and low energy falls, which account for 75% of injury mechanisms. [9,12–21] Furthermore, the use of a cementless stem increases the risk of intra- and post-operative fractures of the femur, up to 14 fold [2,9]. Some neuromuscular diseases (Alzheimers, Parkinsons, Dementia etc) may increase the risk of patient falling, but have not been conclusively shown to increase the risk of PPFx *per se*. [9,22,23]

Despite improvements in fixation techniques, patient mortality rates remain significant and are quoted at 13–17%. [4,17,24–26]

However, there is a paucity of published literature providing information on risk predictors for 12 month mortality following PPF about hip replacements.

Shields demonstrated an increased risk of mortality with increasing age only. [13]. Fuchmeier and colleagues reported increased mortality is associated with increasing age, higher ASA grades and a diagnosis of dementia. [27]. Drew reported increased risk of mortality at 1 year with increasing age and obesity only [24]. The current study echoes those known demographics. However, our results not only support these findings, but also quantifies the magnitude that these health comorbidities contribute toward 12-month mortality following PPF about a hip replacement.

PPFx patients are generally unwell, frail and elderly with a high level of comorbidities. This is a significant trauma with a high mortality rate, and patients have initial difficulty returning to their own homes following treatment [17]. For this reason we believe a reasonable comparison may be made with patients who suffer proximal femoral fractures [8,28–30], and orthogerriatric care, which is standard in our unit, is essential [11,31]. In particular, we believe our 30-day mortality of 3.2% was particularly notable. Furthermore, the overall risk of mortality within 1 year of surgery is 11.6% - which is better than rates quoted in the literature. [4,5,13,24] Whilst this increase at 12 months appears relatively high, approximately a 4 fold increase, this is not dissimilar to the increase observed in hip fracture mortality [32]. Furthermore, a delay to surgery >48 h did not correlate to increased mortality and we believe that by applying our standardized, intensive pre- and post-operative, consultant led, orthogeriatric care model, we can achieve excellent results in patients not only who sustain proximal femoral fractures, but that similar positive outcomes can be achieved in patients with periprosthetic fractures.

It appears that the mortality in B subtype fractures was higher in the B1 subgroups compared to B2 and B3. Whilst there tended to be higher proportions of ASA grade IV patients whom were relatively older, this failed to reach statistical significance ($p = 0.065$ and $p = 0.397$ respectively). The small numbers limit the ability to draw firm conclusions from the results. Indeed, there are multiple methods of fracture fixation which may confound the results, and have not been taken into account for this analysis given the variation in numbers and the potential for a type II error.

Management of PPFs depends upon the Vancouver classification, which has high inter- and intra- observer agreement [33]. Vancouver A PPFs can occur intra- and post-operatively and may be managed conservatively provided the femoral calcar is intact, in which case cerclage wiring is required [34,35].

Vancouver B management depends on the subtype. B1 PPFs can be managed with cerclage wiring ± plate fixation [35–38]. Provided them implant is well fixed, these have good outcomes. B3 have characteristic loss of bone stock and require allograft-prosthetic composite reconstruction. This can be done with bone impaction grafting (BIG) or strut grafts with implant revision, or revision to proximal femoral replacement (PFR) [35,39–42]. However, BIG may not be pertinent in PPFs, with evidence favouring PFR, which have demonstrated excellent short term results in >95% of patients [43]. Optimal fixation of B2 PPFs remains contested. An appreciation of fracture configuration is crucial, as these fractures are associated with higher reoperation rates, especially if stem revision is not performed [4,44,45]. Various constructs are reported, with the Ogden construct utilising a distal screw and proximal cable configuration. This yields excellent results [17]. Stem revision includes revision to a long stem cemented implant, a distally fixed cementless implant, or a

Table 5
Comparison of B2 cohorts undergoing cable plating versus revision arthroplasty (NB 2 patients with B2 subtypes died before surgery and are excluded from the analysis).

Variable	B2 Subtype		p value
	Cable plating	Revision arthroplasty	
N	4	36	
Female	3 (75%)	12 (33.3%)	0.139
Age (Mean ± SD)	79.2 ± 5.1	77.8 ± 9.3	0.775
ASA I	0 (%)	1 (2.8%)	0.144
II	1 (25%)	10 (27.8%)	
III	3 (75%)	21 (58.3%)	
IV	0 (0%)	4 (11.1%)	
V	0	0	
Surgical Time (Mean ± SD)	76.0 ± 27.2	151.2 ± 62.3	0.023
Mortality within 1 year surgery	0	1 (2.8%)	1.00

proximal femoral replacement can also be used [44]. Stiffer constructs are being favoured based upon their enhanced mechanical properties in laboratory testing [46–48]. There remains a lack of heterogeneous, studies to directly compare constructs [49], however stiffer constructs have not demonstrated superior clinical outcomes [49,50]

There is evidence that PRF may be sufficient for B2 subtypes, in a specific patient cohort. Lengths of stay, post-operative mobility and outcomes have been shown to be similar when compared to stem revision [48,51]. Whilst reoperation rate are reportedly higher [45], these do no stratify patient groups, and other studies have not confirmed a risk reduction with stem revision [44]. A consensus favours stem revision in B2 and B3 subtypes [52], but there are reported exceptions – the frail, elderly, low demand individual, with osteopenia, who is unfit for prolonged surgery [35].

Limitations of the study are that it was performed in a single high volume centre, in one geographic area. As such, local variation in the patient demographics may not be extrapolated to other regions. We do not report validated functional outcomes, however these have been wide reported for PPFx and it is known that levels of mobility and functional status decline after these events. Additionally, we have not reported non-union, infection or dislocation rates.

A strength of the study is that our high volume centre is representative of the regional population. We use standardized operative techniques to restore function in all patients, using the highest levels of multidisciplinarv orthogeriatric care, and this is reflected in our low mortality rates.

Conclusion

The current study demonstrates that PPFs are a devastating event for the patient, and may be challenging for the surgeon. Poor general health (ASA III/IV) and specific risk factors are shown to be associated with increased 12 month mortality and this may be useful for prognostic information for patients and their family.

Whilst the Vancouver system relies upon accurate coding of the fracture so as to guide operative management, neither the Vancouver fracture grade, nor the length of surgical procedure, are shown to increase 12 month mortality. Our result on the B2 subtype analysis support that cable plating may be considered in a selected cohort of patients, with acceptable 12 month mortality rates.

Conflicts of interest

None

Declarations

None

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2018.10.032.

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