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ORIGINAL ARTICLE

Risk Factors for Periprosthetic Fractures of the Hip

A Survivorship Analysis

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Abstract Periprosthetic fracture is an uncommon but typically complex complication of cemented THA usually treated operatively. It is a source of reduced function, subsequent morbidity, and increased mortality. Previous studies may have underestimated the incidence of fracture through loss to followup or failure to use survivorship methodologies. The primary aim of this study was to use survivorship methodology to investigate the incidence of, and risk factors for fracture following primary arthroplasty. We examined a cohort of 6458 primary cemented femoral prostheses implanted during a 17-year period. One hundred twenty-four patients sustained fractures at the tip or below the femoral prosthesis. The incidence of fracture was 0.8% at 5 years and 3.5% at 10 years after primary implant. Patients older than 70 years had a 2.9 times greater risk of sustaining a subsequent fracture. There was no association between fracture and gender or implant type. These rates are higher than those reported for cemented arthroplasties. Older patients should be counseled regarding their higher risk of periprosthetic fracture, and additional research is required to elucidate the biologic mechanisms involved.

Level of Evidence: Level II, retrospective prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research.

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Introduction

Periprosthetic fracture of the femur is a rare but complex complication of THA, and usually require technically demanding surgery. As such, they result in considerable morbidity [16] and dysfunction [21]. As the number of primary arthroplasties continues to increase [5, 9, 22], it is likely the burden of these fractures will increase. Identification of risk factors for fracture will improve preoperative counseling and aid primary prevention.

It has been difficult to estimate the risk of this complication because of difficulty of followup, variation in implants, techniques, and inclusion of fractures after revision arthroplasty. There is also substantial geographic variability in the provision of care to patients with these fractures, and variations in the recording of postoperative complications. Most previous estimates have been derived from large, retrospective studies and have reported a crude prevalence of fracture between 0.1% and 2.3% [1, 7, 8, 12] after primary procedures and 2.8% to 7.8% [1, 11, 19] after revision procedures. The reasons for such heterogeneity include variation in demographics, risk factors, and followup between studies and geographic areas [13]. In addition, some previous studies have examined epidemiologic characteristics of a series of periprosthetic fractures, rather than performing survivorship analysis after THA [13, 14].

The primary aim of our study was to investigate the incidence of periprosthetic fractures after cemented THA, by linking a regional arthroplasty and trauma database, using survivorship methodology.

We also investigated whether any of the putative risk factors possible in this population (age, gender, and implant) were important in the etiology of periprosthetic hip fractures.

Materials and Methods

From 1983 to 1999, all primary THAs for our region were performed in one specialist arthroplasty unit. We used written and computerized records to compile a database of all primary THAs performed using a cemented stem during this period. Syntax errors were checked by examination of patient case records. Demographic data, including age and gender of the patient, clinical diagnosis, date of implantation of the prosthesis, and its design were collected in a database of primary hip arthroplasties. We examined case records to ascertain the length of clinical followup after the primary arthroplasty and whether a revision procedure had been performed. We also ascertained whether patients had died since their primary arthroplasty by matching their demographic information with local census data.

We identified 6458 THAs performed in 5482 patients for nontrauma indications. One hundred eleven patients had simultaneous bilateral replacements and 865 had nonsimultaneous bilateral replacements during the 17-year period. The average age at primary THA was 67.1 years (range, 18–95 years), and 4097 of the patients (63.4%) were female. By the end of the study, 2245 patients (34.8% of the original cohort) had died and revision of the primary arthroplasty had been performed in 282 hips (4.4% of the original cohort) for reasons other than periprosthetic fracture (Table 1).

Table 1. Data for patients with and without periprosthetic femoral fractures

Variable	Periprosthetic femoral fracture		p Value
	Present	Absent	
Gender			p = 0.188
Male	38 (1.6%)	2323 (98.4%)	
Female	86 (2.1%)	4011 (97.9%)	
Implant type			p = 0.21
Charnley®	43 (1.6%)	2682 (98.4%)	
Exeter™	77 (2.2%)	3429 (97.8%)	
Other	4 (1.8%)	223 (98.2%)	
Age (years)			p < 0.001
< 50	6 (1.4%)	414 (98.6%)	
51–60	12 (1.2%)	967 (98.8%)	
61–70	23 (1.1%)	2102 (98.9%)	
71–80	44 (1.9%)	2247 (98.1%)	
> 80	39 (6.1%)	604 (93.9%)	

Twenty-four consultant surgeons performed or supervised the insertion of the primary prostheses during the study period, using either the anterolateral, lateral, or posterior approach. Second or third-generation cementing techniques were used throughout the study. The Charnley® (DePuy, Leeds, UK) and Exeter™ (Stryker Howmedica Osteonics, Berkshire, UK) prostheses were used in the majority (96.5%) of cases. Although the Charnley® prosthesis remained largely unchanged, substantial design modifications were made to the Exeter™ stem during the study period. The Exeter™ Mark I version with a matte finish was used from 1983 until 1986, after which the Exeter™ Mark II with a polished finish replaced it. The Exeter™ Universal system with a modular capability was introduced in 1988 and was used for the rest of the study period [25].

All patients sustaining periprosthetic femoral fractures in the same region were admitted via single emergency department to one orthopaedic trauma unit. Data regarding all trauma patients were prospectively entered in a regional trauma registry. The trauma database was queried to identify patients who had a primary cemented hip arthroplasty who subsequently were admitted to the trauma unit. These admissions were examined (REC, JTP, CMR) to identify patients with a periprosthetic fracture around their original implant, and were coded under various headings. Therefore, although we can be certain all locally inserted prostheses with a subsequent fracture were identified, it is not possible to quantify the total number of periprosthetic hip fractures during this period. In keeping with survival analysis methodology, we excluded all patients with prosthetic fractures who were not locally resident and those who had received their primary implant at another center. Patients with fractures occurring within 6 weeks of the primary surgery also were excluded, as these fractures were defined as a complication related to the initial surgery.

We (REC, PJW, CMR) retrospectively classified the fractures on conventional anteroposterior and lateral radiographs according to the Vancouver classification [13, 15]. This system is widely used, reproducible, reliable, and extensively investigated [3]. Vancouver Type A fractures are in the trochanteric region and often are clinically unrecognized, as the femoral shaft is stable and the patient often is still able to mobilize. For this reason, we excluded these fractures from our study because we believed our data were incomplete for these injuries. Type B fractures are located around the stem tip and are further subclassified into three subtypes. B1 fractures are those around a stable implant, whereas B2 fractures are around a loose implant. In B3 fractures there is loss of bone stock, and Type C fractures are located distal to the stem tip [2].

Gender and implant type were compared between groups using the chi square test. The Student t test was used

to compare the mean age at the primary surgery between patients sustaining a fracture and patients not sustaining a fracture (continuous parametric data). Life tables were constructed to calculate overall prevalence of fracture. Patients not reaching the end point of periprosthetic fracture were eliminated from additional analysis as loss to followup, revision of their primary implant, or death. Kaplan-Meier survival curves with confidence intervals were plotted and differences were tested for statistical significance using the log-rank test. We created inverted Kaplan-Meier curves to show cumulative prevalence of fracture in gender, implant type, and age. SPSS Version 13.0 (SPSS Inc, Chicago, IL) and Graphpad Prism® Version 4.0 (Graphpad Software, San Diego, CA) were used to record and analyze the collected data.

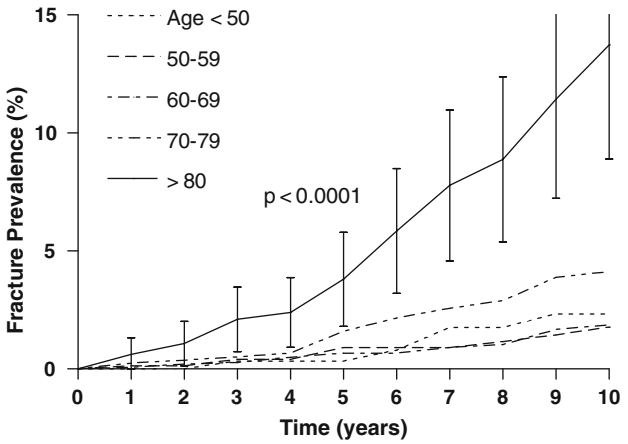

Fig. 1 An inverted Kaplan-Meier plot shows the increased rate of periprosthetic fractures in patients older than 80 years at the time of their primary arthroplasty.

Results

During this period, 124 periprosthetic fractures occurred in 124 patients after THA (Table 1), representing an overall prevalence of 2.3%. The fracture types classified according to the Vancouver system were Vancouver B1, 24 (19%); Vancouver B2, 64 (52%); Vancouver B3, 12 (10%); and Vancouver C, 24 (19%).

The mean time from the primary procedure to fracture was 6.3 years (standard deviation [SD] = 3.6 years). There were no differences in time between arthroplasty and fracture regarding gender ($p = 0.79$), age ($p = 0.79$), or implant ($p = 0.12$). Life table (Table 2) and Kaplan-Meier analysis (Fig. 1) show an increased prevalence of periprosthetic fractures between age groups ($p = 0.0001$). The mean age of patients at the primary surgery who subsequently sustained a fracture was greater than the mean age of patients without this complication (mean age, 73.5 years [SD = 12.8 years] versus 67 years [SD = 11.1 years]). Patients older than 70 years had an odds ratio of 2.9 (95% confidence interval [CI], 2.0–4.3) to sustain a fracture compared with the younger cohort. Patients 80 years or older at the time of the initial arthroplasty had an odds ratio of 4.4 (95% CI, 2.9–6.4) compared with patients younger than 80 years. Survival methodology did not show any difference in the incidence of fracture for gender (Log rank test, $p = 0.13$) or implant type (Log rank test, $p = 0.34$).

Table 2. Cumulative prevalence and 95% confidence intervals

Variable	Cumulative fracture prevalence (%, 95% CI)		
	1 year	5 years	10 years
Overall	0.1 (0–0.1)	0.8 (0.5–1.0)	3.5 (2.8–4.2)
Gender			
Male	0.05 (0–0.09)	1.3 (0.7–1.9)	3.2 (2.0–4.4)
Female	0.3 (0–0.4)	1.2 (0.8–1.6)	4.0 (3.0–5.0)
Implant type			
Charnley®	0 (0–0)	0.6 (0.3–0.9)	3.6 (2.4–4.8)
Exeter™	0.1 (0–0.2)	1.0 (0.6–1.4)	3.6 (3.6–4.6)
Age (years)			
< 50	0 (0–0)	0.3 (0–1.0)	2.3 (0.6–5.4)
51–60	0.1 (0–0.5)	0.9 (0.3–2.0)	1.8 (0.7–3.2)
61–70	0.1 (0–0.2)	0.7 (0.3–1.3)	1.9 (1.1–3.1))
71–80	0.2 (0–0.2)	1.7 (0.9–2.4)	4.1 (2.9–6.0)
> 80	0.6 (0–1.4)	2.4 (1.9–5.9)	13.7 (10.3–21.0)

Discussion

Periprosthetic fractures around a THA occur after a small percentage of procedures. It often requires complex and costly surgery and rehabilitation. Numerous studies have focused on the epidemiology of a series of patients with fractures, rather than providing survivorship analysis of the original arthroplasty cohort. The aim of our study was to use a unique linkage of hip arthroplasty demographic data, and subsequent trauma registry data, to perform a survivorship and epidemiologic study of periprosthetic hip fractures.

Because of limited clinical information available for each patient, our study examined the effect of only a limited number of potential risk factors. This is an important limitation of our study, as various other factors have been associated with an increased risk of fracture, most notably, the use of an uncemented primary arthroplasty, implantation in a hip with inflammatory arthropathy, changes in prosthetic design, and revision of the primary implant [6]. Therefore, our results cannot be used to advise patients undergoing revision procedures, uncemented arthroplasty, or arthroplasty using other prosthetic designs, or patients

who have inflammatory hip disease. Although these factors may alter the risk of later fracture in predominantly younger subgroups of the arthroplasty population, the majority of fractures in our study occurred in elderly patients. It seems likely the higher rate of fracture in these patients is attributable to intrinsic and extrinsic factors. Osteoporosis may predispose them to a fracture in the region of a femoral diaphysis, which is already at risk because of the stress riser produced by the prosthetic femoral stem. It also is likely these older patients are vulnerable to extrinsic factors such as increased falls and lower body mass index [24]. Our study cannot quantify the role played by femoral osteolysis in subsequent fracture as the arthroplasty database only collected basic demographic and procedure data. Additional investigation of this risk factor would require close radiographic followups of a cohort of patients who had hip arthroplasties. These limitations do not jeopardize our results as they relate to the clinical questions outside our primary and secondary research questions. They are outweighed by the positive findings that, to our knowledge, have not been reported.

Periprosthetic fractures are a rare complication of THA; in this study, only 3.5% of patients sustained fractures within 10 years of their primary implantation. The risk of fracture is influenced substantially by the age of the patient at the time of prosthetic implantation. The risk is low for an individual of normal life expectancy and who undergoes primary implantation before the age of 70 years. Patients older than 70 years have a 2.9 times greater risk of fracture than their younger peers, and those older than 80 years have a 4.4 times greater risk of fracture. There was no difference observed with different implants, and the type of fracture was not influenced by age, gender, or implant type.

This risk of fracture is greater than previously reported (Table 3), but may reflect an underlying older population and longer followup. However, it may reflect the underlying rate more accurately than previously reported by linking with a trauma registry covering the same population group. Our institution was the main provider of arthroplasty and trauma surgery during the study period. It is possible some earlier studies may have underreported the prevalence because some fractures may have been treated in trauma centers not linked to their primary arthroplasty center. The heterogeneous case mix in previous studies makes comparison of our results and published results difficult. Direct comparison also is difficult because previous studies have included perioperative and postrevision fractures. A summary of the existing literature published in 1999 [4] reported a crude prevalence of 1.3%, but with a range in reported prevalence from 0.1% to 2.1% (Table 3). Rates as much as 5.4% have been reported in association with uncemented prostheses [1, 13]. Most of these older studies did not use survivorship analysis to evaluate the rate of periprosthetic fracture with time. However, despite the examination of much larger patient populations and the use of more contemporary actuarial methods of analysis, there has been considerable variation in the reported prevalence of this complication [1, 5, 10, 17–20, 26], including those reported by the Scandinavian Registries (Table 3). The prevalence of fracture in our study is similar to that of a previous study reporting a higher fracture rate [17] and may be associated with the long followup in our study and survivorship methodology. Another reason for our higher reported prevalence may be that we included all Vancouver Type B and Type C fractures. The latter group was omitted from some previous studies. However, as only 18.8% of our fractures were of this type, this cannot fully account for the discrepancy. They are also intimately linked to primary arthroplasty, as the prosthesis may act as a stress riser, transmitting energy to the distal femur.

The risk of later fracture is similar to national reported statistics for deep infection, loosening, and dislocation after a primary cemented THA [10, 18, 23], and therefore we believe all of these patients should be counseled routinely about their age-specific risk of this complication. In particular, elderly patients (older than 70 years) should be

Table 3. Review of studies of prevalence of periprosthetic fracture after THA

Study	Total number of arthroplasties	Number of periprosthetic fractures	Fracture prevalence (%)
Lowenhielm et al. [17] (1989)	1442	14	2.50
Crockarell et al. [4] (1999)*	17,644	224	1.27
Berry [1] (1999)	23,980	262	1.10
Havelin et al. (Norwegian register) [10] (2000)	73,000	2847	3.90
Lucht (Danish register) [18] (2000)	18,222	117	0.64
Sarvilinna et al. (Finnish register) [20] (2003)	12,449	16	0.13
Lindahl et al. (Swedish register) [15] (2005)	Not stated	Not stated	0.40

* Summary of results reported before 1999.

warned of their risk of later fracture, as their risk of this complication exceeds their risk of the other major long-term complications of arthroplasty.

As the indications for THA continue expanding in an ageing population with a greater life expectancy, the prevalence of periprosthetic fractures will continue to increase. These fractures are a source of considerable morbidity in patients who are elderly, frail, have osteoporosis, and often are technically challenging to treat. Future studies should quantify the role played by subclinical osteolysis and whether newer bearing couples have an impact on subsequent fracture. Investigations using preoperative bone mineral density studies in a cohort of older patients who had primary THAs might help to ascertain whether those with lower bone mineral density are more at risk of this complication. If this is the case, it is possible either adjuvant medical treatment for osteoporosis [26], fall prevention, or the use of primary long-stemmed femoral implants might be feasible to reduce the risk of this complication.

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