The risk of peri-prosthetic fracture after primary and revision total hip and knee replacement

R. M. D. Meek,
T. Norwood,
R. Smith,
I. J. Brenkel,
C. R. Howie

From the Scottish Arthroplasty Project, Edinburgh, United Kingdom

Peri-prosthetic fracture after joint replacement in the lower limb is associated with significant morbidity. The primary aim of this study was to investigate the incidence of peri-prosthetic fracture after total hip replacement (THR) and total knee replacement (TKR) over a ten-year period using a population-based linked dataset.

Between 1 April 1997 and 31 March 2008, 52 136 primary THRs, 8726 revision THRs, 44 511 primary TKRs, and 3222 revision TKRs were performed. Five years post-operatively, the rate of fracture was 0.9% after primary THR, 4.2% after revision THR, 0.6% after primary TKR and 1.7% after revision TKR. Comparison of survival analysis for all primary and revision arthroplasties showed peri-prosthetic fractures were more likely in females, patients aged > 70 and after revision arthroplasty.

Female patients aged $\geq$ 70 should be warned of a significantly increased risk of peri-prosthetic fracture after hip or knee replacement. The use of adjuvant medical treatment to reduce the effect of peri-prosthetic osteoporosis may be a direction of research for these patients.

■ R. M. D. Meek, FRCS (Tr & Orth), MD, Orthopaedic Surgeon
Orthopaedic Department
Southern General Hospital, 1345 Govan Road, Glasgow G51 4TF, UK.

■ T. Norwood, BSc, Senior Information Analyst
■ R. Smith, PhD, Information Analyst
Information Services Division, NHS National Services Scotland, Gyle Square, 1 South Gyle Crescent, Edinburgh EH12 9EB, UK.

■ I. J. Brenkel, FRCS, Orthopaedic Surgeon
Queen Margaret Hospital, Whitefield Road, Dunfermline KY12 0SU, UK.

■ C. R. Howie, FRCS, Orthopaedic Surgeon
Edinburgh New Road Infirmary, 51 Little France Crescent, Edinburgh EH16 4SA, UK

Correspondence should be sent to Mr R. M. D. Meek; e-mail: rmdmeek@doctors.org.uk

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The management of peri-prosthetic fracture after total hip replacement (THR) and total knee replacement (TKR) is technically demanding and may require a variety of surgical options. There is increased morbidity[1] and dysfunction[2] after fracture compared with primary hip and knee replacements and as the number of primary and revision replacements, especially of the knee,[3] increases, so will the numbers of peri-prosthetic fractures. It is important to quantify these in order to plan appropriate facilities for their management.

There has been much work on the classification and management of femoral peri-prosthetic hip fractures[4,5] but less is known about their incidence. In the largest series, Berry[6] reported a peri-prosthetic fracture rate of 1% (238 of 23 980) after primary THR and 4% (252 of 6349) after revision procedure. Peri-prosthetic fractures around the knee are traditionally classified by location.[7,8] Their incidence is even less well known, with reports ranging from 0.3% to 2.5% after primary TKR and 1.6% to 38% after revision procedures.[9-13] In Berry's series the incidence of peri-prosthetic fractures after TKR was 2%.[6]

The risk factors for peri-prosthetic fracture include poor bone stock, age, chronic use of corticosteroids, inflammatory arthropathy, stress risers – whether iatrogenic or due to local osteolysis, previous surgery, excessively stiff joints and various neurological conditions.[6,9,11,14-22] The aim of our study was to investigate the population-based incidence of peri-prosthetic fractures after THR and TKR over a ten-year period, using a comprehensive, linked administrative database and to confirm any age and gender bias.

Patients and Methods

The Scottish national database holds information on all hospital arthroplasty operations performed from 1982 onwards, along with associated complications and information on admissions and deaths. All clinical data are extracted from the Scottish Morbidity Records for Inpatients and Day Cases (SMR01). This results in all subsequent re-admissions anywhere being electronically linked with the original operation. The records are validated and held centrally. Arthroplasty records are further checked by sending details of post-operative patients back to individual surgeons quarterly, asking them to confirm the type of replacement, diagnosis and laterality. All patients > 15 years who underwent elective THR and TKR between April 1997 and March 2008 were included in this study. Accordingly, 60 862 THRs (52 136 primary, 8726 revision) and 47 733 TKRs (44 511 primary and 3222 revision) were reviewed to

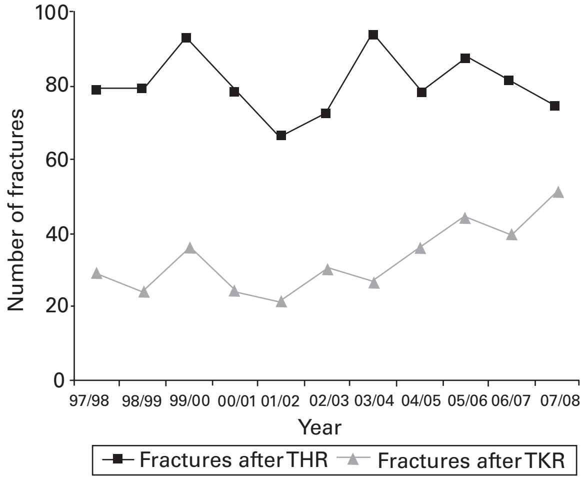

Fig. 1a

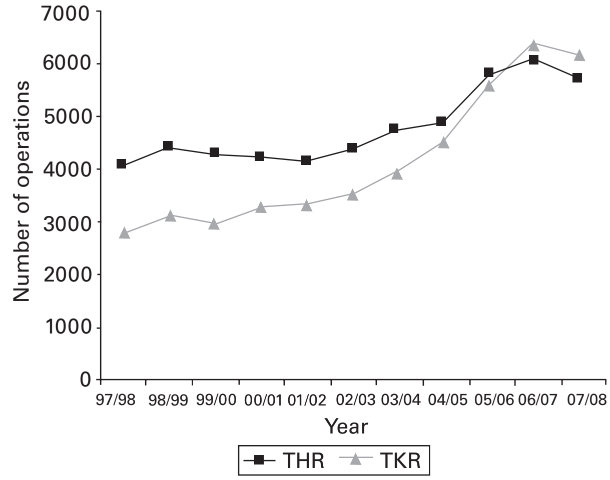

Fig. 1b

Graphs showing a) the number of peri-prosthetic fractures after total hip replacement (THR) and total knee replacement (TKR) and b) the number of THRs and TKRs performed between 1997 and 1998 and 2007 and 2008.

Table I. Summary of the peri-prosthetic fracture rates at five and ten years and the mean age of patients

			Fractures (%)		Mean age	
	Number of operations	Number of fractures	Five years	Ten years	At operation	At fracture
Primary THR*						
Male	19 923	137	*0.6*	*1.2*	66.3	69.2
Female	32 213	371	*1.1*	*2.1*	72.6	75.7
Total	52 136	508	*0.9*	*1.7*	70.9	73.9
Revision THR						
Male	3580	122	*3.5*	*5.6*	70.2	72.0
Female	5146	238	*4.6*	*6.6*	73.7	75.8
Total	8726	360	*4.2*	*6.2*	72.5	74.5
Primary TKR†						
Male	18 706	64	*0.3*	*0.6*	68.0	70.6
Female	25 805	199	*0.7*	*1.7*	71.8	75.5
Total	44 511	263	*0.6*	*1.3*	70.9	74.3
Revision TKR						
Male	1600	11	*0.7*	*1.0*	68.6	71.3
Female	1622	39	*2.6*	*3.5*	72.6	74.1
Total	3222	50	*1.7*	*2.2*	71.7	73.4

* THR, total hip replacement
† TKR, total knee replacement

determine those who were re-admitted with a peri-prosthetic fracture. Fractures at the time of primary implantation were excluded.

The definitions of THR and TKR were according to OPCS Classifications of Operations 4th revision codes.[23] Peri-prosthetic fractures were systematically derived from the database as the first fracture following THR or TKR. They were identified using International Classification of Diseases Version 10 (ICD 10)[24] codes M966, M841 (for pelvic/thigh or unspecified location), S722 to S729 (for hips) and S821 to S729 (for knees). Fractures of the neck of the femur (S720) and pertrochanteric fractures (S2721) were excluded.

The peri-prosthetic fractures were identified by applying a ten-year review of all fractures to determine if the patient had a prior THR or TKR. Replacements where the patient was admitted as an emergency (4715 of 108 595, 4%) were included. Peri-prosthetic fractures with fracture code M841, nonunion of fracture (93 of 1181, 8%), were included although it cannot be guaranteed that all nonunions relate to hip or knee joints. In both cases, inclusion of these cases made little difference to the overall results (Table I).

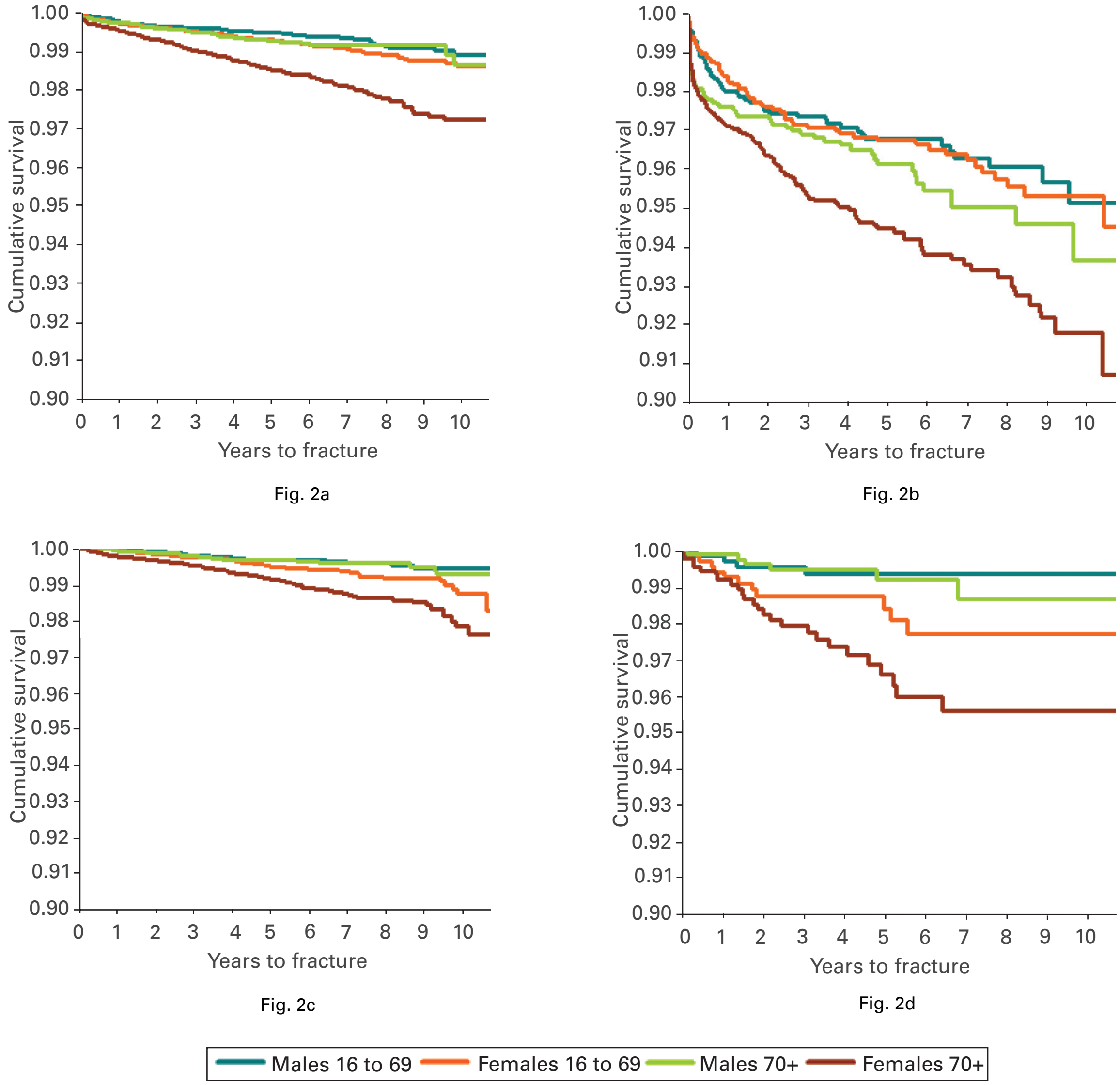

Fig. 2

Graphs showing survivorship of hip and knee replacements comparing age and gender, after a) primary hip b) revision hip, c) primary knee and d) revision knee procedures.

Statistical analysis. We used Kaplan-Meier survival analysis to censor patients who reached the end of the study period without a fracture or who had died. The relationship between peri-prosthetic fracture and risk factors was examined with the use of *t*-tests (continuous variables) and chi-squared tests (categorical variables). Differences in survival functions, from arthroplasty to peri-prosthetic fracture, for potentially influencing factors were tested using the log-rank (Mantel-Cox) chi-squared statistic. Cox's regression was used to assess the multivariate effect of age, gender and primary *vs* secondary replacements on the risk of peri-prosthetic fracture. All data analysis was conducted using SPSS software (version 17; SPSS Inc., Chicago, Illinois). A p-value of < 0.05 was considered statistically significant.

Results

The number of peri-prosthetic fractures following primary THR and TKR during the study period is shown in Figure 1. The number of fractures after TKR more than doubled from 21 per year in 2001 to 51 in 2007, while the incidence of fracture following THR remained stable at around 80 per year. A similar trend is observed in the annual number of operations during this period. The number of TKRs more than doubled from 3000 to over 6000 per year. A smaller increase was observed for THR with the number of operations per year increasing from 4200 to around 6000 in 2007 to 2008.

The number of primary and revision procedures during the study period and the subsequent peri-prosthetic fracture rate are summarised in Table I. At five years the inci-

Table II. Cox proportional-hazards regression (95% confidence intervals (CI)) for time to fracture

	Hazard ratio	p-value
THR*		
Age group	1.6 (95% CI 1.4 to 1.9)	< 0.001
Gender	1.5 (95% CI 1.3 to 1.7)	< 0.001
Primary or revision	4.4 (95% CI 3.8 to 5.1)	< 0.001
TKR*		
Age group	1.6 (95% CI 1.3 to 2.1)	< 0.001
Gender	2.3 (95% CI 1.8 to 3.1)	< 0.001
Primary revision	3.0 (95% CI 2.2 to 4.1)	< 0.001

* THR, total hip replacement

† TKR, total knee replacement

dence of fracture was 0.9% for primary THR and 4.2% for revision THR. By ten years the fracture rate had increased to 1.7% for primary THR and 6.2% for revision procedures. The incidence of fracture was 0.6% for primary TKR and 1.7% for revision procedure at five years and 1.3% and 2.2% respectively at ten years.

Women had higher fracture rates across all types of operation; their mean age at operation and fracture was also higher than men for all procedures (Table I). The difference between the mean age of men and women at operation and fracture was significant at the 5% level for all procedures except revision TKRs (age at fracture; primary THR $p < 0.001$, revision THR $p = 0.009$, primary TKR $p = 0.014$, revision TKR $p = 0.231$. Age at operation; primary THR $p < 0.001$, revision THR $p = 0.004$, primary TKR $p = 0.002$, revision TKR $p = 0.458$).

Kaplan-Meier survivorship curves for peri-prosthetic fracture comparing the effect of gender and age at time of operation for all types of operation are shown in Figure 2. A higher fracture rate was observed in THR than TKR for primary and revision procedures. Revision replacements had a higher fracture rate than primaries for hips and knees (log-rank; hips $p < 0.001$ and knees $p < 0.001$). For each procedure, increased age and female gender were associated with a higher risk of fracture. The univariate log-rank test for differences in survivorship of age and gender found them to have significantly different survival curves for THR and TKR operations at the 5% level. The effects noted in the Kaplan-Meier curves were confirmed using Cox's regression. The effect that age, gender and operation type have on the risk of peri-prosthetic fracture after THR and TKR is summarised in Table II. For hips and knees, age (16 to 69 and ≥ 70 years), gender and whether primary or revision all contribute significantly to the prediction of time to fracture. Patients who undergo revision THR are 4.4 times more likely to fracture than primary THR and patients aged ≥ 70 years are 1.5 times more likely than those aged between 16 and 69 to have a fracture after THR, while female patients are 2.9 times more likely to suffer a fracture after THR than males. Patients who undergo revision TKR are 3.0 times more likely to fracture than those undergoing primary TKR. Patients aged ≥ 70 years are 1.6 times more likely to have a fracture after TKR than younger patients and female patients are 2.3 times more likely to suffer a fracture after TKR than males.

Discussion

The increasing volume of peri-prosthetic fractures has been recognised for over a decade.[25] In this study, 508 (1.7%) primary hip and 263 (1.3%) primary knee patients sustained a fracture within ten years of their operation. The risk of fracture is significantly influenced by the gender and age of the patient at the time of operation. The risk is higher for female patients, those aged ≥ 70 years and and those who underwent a revision procedure.

As expected, the pattern of peri-prosthetic hip fracture from this national population-based audit is in keeping with the few reports in the literature.[6,26] The linear shape of the survival curves indicates little change in the likelihood of having a peri-prosthetic fracture over time, at least in the first ten years. However, it should be noted that the overall number of peri-prosthetic fractures after TKR is increasing along with the number of TKRs performed annually.[3] This allows us to predict, with some confidence, the future numbers of peri-prosthetic fractures for the planning of service provision.

The lower incidence of fracture after primary TKR compared with THR may explain the lack of validated classification systems to guide appropriate treatment. The Rorabeck and Taylor[7] and Felix et al[8] classifications are based principally on anatomical site and stability of the implant. In comparison, peri-prosthetic femoral fractures of the hip are classified with the Vancouver system, which is based on the site of the fracture, amount of available proximal bone stock and stability of the stem.[4,27] The correct classification of these fractures is important, as it helps to guide treatment. The scarcity of peri-prosthetic knee fractures may make formation of a treatment algorithm difficult. However, a recent review of classification system for peri-prosthetic fractures after TKR takes into account the status of the prosthesis, quality of distal bone stock and the reducibility of the fracture (Type I (A and B), II and III), using a system similar to the Vancouver classification.[28]

Whether this will aid the development of successful management algorithms awaits analysis.

It is established practice to warn all patients of significant risks. The relative risks for patients undergoing revision replacement surgery and the relationship to their gender and age can be given. Also, we report the incidence of peri-prosthetic fracture after THR and TKR at ten years is over 1.7% for all female patients. These should be routinely warned of the greater chance of peri-prosthetic fracture. There is mounting evidence of the role of adjuvant medical treatment, particularly bisphosphonates, to prevent loss of peri-prosthetic bone density on a prolonged basis after THR and TKR.[29-31] The outcome following treatment of peri-prosthetic fractures is related directly to the degree of bone loss[24,29,32-34] and it is unclear whether bisphosphonate treatment would lead to a significant improvement in peri-prosthetic fracture load or results of treatment. We would caution against the use of such drug therapy until the risks and benefits are established.

A weakness of this study is that it does not record patients who are re-admitted to a private hospital or leave Scotland. Although their numbers are small it should be an aim to inter-link national databases and compel private hospitals to participate in national registries. Another weakness is that the treatment of the peri-prosthetic fracture is also not recorded. In some aspects this is not a problem, as the data were collected over a ten-year period, which means that the methods of treatment used initially are to some extent historical. There are many surgical options, including revision of the prosthesis or fixation of the fracture while leaving the prosthesis in place, which have changed over time and preclude specific analysis. It is known that surgical outcome is related to volume, and surgeons are advised to undertake a minimum number of operations per year to maintain competence.[35] This analysis permits the prediction of the future incidence of peri-prosthetic fractures, thereby allowing planning for the number of surgeons and centres to provide such care.

The significant overall incidence of peri-prosthetic fracture lends support for the long-term follow-up of patients who have undergone THR and TKR, as advocated by the American Associations of Orthopaedic Surgeons[36] and British Orthopaedic Association.[37] It is known that loosening is not always symptomatic and the only reliable currently available method for detecting early bone loss is periodic radiography. It has also been established that timely revision prior to substantial bone loss is cost effective, as the cost of timely intervention was half that of the management of a peri-prosthetic fracture.[38] Also revision replacement after a peri-prosthetic fracture has a higher mortality, similar to that for hip fractures.[39]

This population-based study quantifies an increased incidence of lower limb peri-prosthetic fracture in elderly female patients, presumably related to bone stock and quality. At-risk patients must be advised accordingly. Also, it should be established if adjuvant medical treatment would benefit these patients, by instituting a national randomised study of bone protection in female patients.

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