Functional outcome of femoral periprosthetic fracture and revision hip arthroplasty

A matched-pair study from the New Zealand Registry

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Background and purpose The number of periprosthetic fractures following total hip arthroplasty (THA) is increasing. There is, however, limited data on the functional outcome following these injuries. We analyzed functional outcome for revision THA following periprosthetic fracture, and compared this to the outcome of elective revision THA performed for aseptic loosening.

Methods 232 patients undergoing revision THA for femoral fracture were identified from the New Zealand National Registry. Functional outcome was measured using the Oxford 12 hip score (OHS). A reference group of 232 patients undergoing elective revision THA was selected and matched for age and sex.

Results Outcome was worse following revision THA for periprosthetic fracture than in reference patients (mean OHS: 29 vs. 24, $p = 0.006$). A higher 6-month mortality rate was seen in periprosthetic fracture patients (7.3% vs. 0.9%, $p < 0.001$), along with a higher likelihood of re-revision (7.3% vs. 2.6%, $p = 0.06$).

Interpretation This large comparative series of periprosthetic fractures following THA shows that patients with periprosthetic fracture have poorer functional outcome and higher death rates than patients undergoing revision THA for aseptic loosening.

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Periprosthetic fractures present a difficult clinical problem. Estimates of the incidence of postoperative fracture following primary total hip arthroplasty (THA) range from 0.1% to 2.1% (Berry 1999), and with rising numbers of patients in the population living with hip prostheses in situ, there is evidence that the prevalence is increasing (Sarvilinna et al. 2004). Recent work aimed at optimizing the treatment of such injuries has led to wide adoption of the Vancouver classification of periprosthetic femoral fractures (Duncan and Masri 1995), together with treatment protocols based on this system (Duwelius et al. 2004, Parvizi et al. 2004). The prognosis is frequently less favorable than in elective revision THA, but there is a paucity of data to confirm this general clinical impression. The objective of this matched-pair study was to analyze functional outcome, death rate, and re-operation rate for revision THA following periprosthetic fracture, and to compare these against the outcomes of elective revision THA for aseptic loosening of the femoral component. This has relevance for preoperative patient consent, expectations regarding functional outcome, and prognosis.

Methods

Data covering the period January 1, 1999 to October 31, 2004 were obtained from the New Zealand Arthroplasty Registry, involving all patients who had undergone revision THA during this time with the “reason for revision” recorded as “fractured femur”. Patients undergoing open reduction and internal fixation without exchange of any prosthetic component were excluded. Femur fractures

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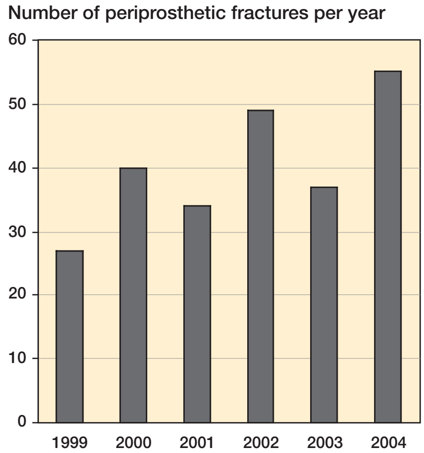

Figure 1. Number of revisions for periprosthetic fracture per year.

that had occurred during primary THA or within 2 weeks of surgery were also excluded, as was 1 patient with bilateral fractures. A reference group was selected from the registry data for patients who had undergone revision THA with the reason listed as "loosening femoral component". Reference patients were matched for sex and age to index (fracture) patients. As the New Zealand Registry has only been recording ASA scores since January 2005, these could not be used as matching criteria. It is worth noting that since records started, the mean ASA score for patients undergoing revision for periprosthetic fracture and for aseptic loosening has been identical at 2.3.

In the New Zealand Registry, self-assessed patient outcome is recorded prospectively using the Oxford 12 hip score (OHS). Questionnaires are sent by post 6 months after the procedure that has been recorded. The OHS is an instrument for assessment of functional outcome and has been validated in several studies (Dawson et al. 1996, McMurray et al. 1999, Field et al. 2005). Few patients score more than 50 points (Field et al. 2005) and the New Zealand Registry arbitrarily divides scores into "excellent" (12–18), "good" (19–26), "fair" (27–36), and "poor" (37–60).

232 procedures for periprosthetic fracture of the femur (232 patients) were identified from the registry data. This included 12 patients with femoral fracture who underwent surgery with exchange of one or more components (head, cup liner, and/or cup) other than the stem. The number of surgical procedures for periprosthetic fracture in THA requiring revision of one or more components during the observation period is depicted in Figure 1. A reference group of 232 procedures on 232 patients who underwent elective THA revision was selected and matched for analysis (Table 1). 17 of the 232 patients included in the study (7%) died within 6 months of surgery; 123 of the 215 surviving patients responded to the OHS questionnaire at 6 months (57%). The OHS response rate of the reference group was 76%.

Statistics

Side, previous revision, deaths within 6 months, type of bone graft, approach, acetabulum revision, and grade of primary surgeon (consultant or registrar) were analyzed with respect to periprosthetic fractures using the McNemar change test with a continuity correction (to allow for the matched nature of the data). This test produces p-values, and the exact approach presented by Liddell (1983) was used to build 95% confidence intervals. Differences in operating times and OHS between the two groups were investigated using paired t-tests. Cox proportional-hazards regressions were performed

Table 1. Patient demographics

	Periprosthetic fractures (232 hips, 232 patients)	Reference group (232 hips, 232 patients)
Females	103 (44%)	103 (44%)
Males	129 (56%)	129 (56%)
Average age	73 years	73 years
Mean time between index and revision surgery	10 years	11 years
6-month OHS response rate	57% (123/215)	76% (175/230)

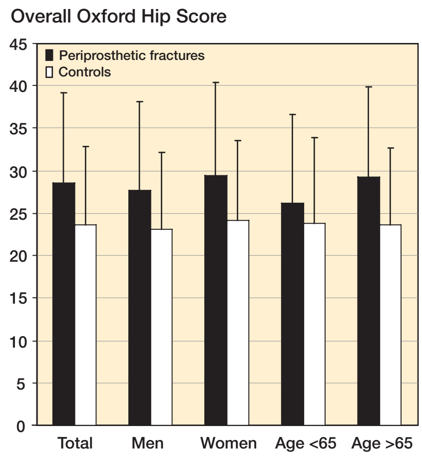

Figure 2. Overall Oxford hip score (OHS) and outcome according to age and sex. Error bars represent ± SD.

to compare outcomes such as survivorship and revision rates with reference to length of follow-up. We stratified by match to allow for the paired nature of our data, and fitted these models onto the time-constant covariates: match (whether the case was a match), age, and gender. The exponentiated coefficients of the fitted models can be interpreted as multiplicative effects on the hazard (Fox 2002). For example, holding the other covariates (age, sex) constant, being a match reduces the likelihood of death by a factor of 0.52, or by 48%. We used the R statistical package (version 2.6; R Foundation, Vienna, Austria).

Results

Functional outcome following surgery was worse in patients undergoing revision for fractured femur than in reference patients (OHS score: 29 points vs. 24 points, $p = 0.006$) (Figure 2). This 5-point difference in scores between fracture and reference groups covers a full functional grade using the system outlined above, representing both a clinically significant and a statistically significant difference. Functional outcome after fracture was also poorer when males and females were analyzed separately. On the other hand, no statistically significant difference in outcome scores was found if patients were under the age of 65 years (53 patients, 26 points vs. 24 points, $p = 0.6$). In contrast, a highly statistically significant difference between fracture and reference patients was found in patients who were 65 years or older (29 points vs. 24 points, $p = 0.005$).

No statistically significant differences were found between the two groups in terms of operative time (165 min vs. 156 min, $p = 0.1$), grade of surgeon, side, the use of autogenous or synthetic bone graft, and operative approach (Table 2). A posterior approach was used in 52% of index patients and 54% of reference patients, and a lateral approach in 29% and 26%, respectively. The remaining approaches were trochanteric osteotomy or anterior.

A higher mortality rate was seen in fracture patients during the follow-up period (17% vs. 11%, $p = 0.06$), and a larger number of periprosthetic fracture patients died within 6 months of their surgery (7.3% vs. 0.9%, $p < 0.001$). A higher rate of re-revision was seen in the fracture group (7.3 vs. 2.6%), although the difference was not statistically significant ($p = 0.06$). The most common cause of re-revision in this group was dislocation (7 patients), followed by re-fracture (3), loosening of the acetabulum (2) or stem (2), infection, implant failure, and pain (1 each). Periprosthetic fracture patients were less likely to receive a cemented implant than reference patients (18% vs. 33% $p < 0.001$), and they were more likely to have bone graft used during their procedures (22% vs. 6.9%, $p < 0.001$).

No statistically significant differences in surgeon experience were seen between the index and reference groups, with 61 periprosthetic patients being operated on by consultants who averaged 15 or more revision procedures for any reason per year, as opposed to 65 reference patients ($p = 0.7$). Similarly, 41 periprosthetic patients had their procedures performed by consultants averaging less than 5 revisions per year, as opposed to 32 reference patients ($p = 0.3$). Statistically significant differences were seen in the 6-month death rates of patients operated on by more experienced surgeons or at larger institutions (5.6% vs. 19%, $p = 0.04$, and 3.5% vs. 20%, $p = 0.03$). Differences in OHS and re-revision rates were not statistically significant ($p > 0.05$) (Table 3).

Table 2. Comparisons of baseline and outcome variables between periprosthetic fracture group and reference group. Point estimate is how much more likely the characteristic or outcome is for cases with periprosthetic fractures relative to the reference group

	Periprosthetic fractures (n = 232)	Reference group (n = 232)	P-value	Point estimate (95% CI)
Surgical characteristics				
Previous revision	27 (11.6%)	32 (13.8%)	0.6	0.8 (0.5–1.5)
Bone graft (femoral)				
Total	50 (21.6%)	16 (6.9%)	< 0.001	4.7 (2.2–11)
Allograft	40 (17.2%)	14 (6.0%)	< 0.001	4.3 (1.9–11)
Autograft	6 (2.6%)	2 (0.8%)	0.2	5.0 (0.6–23)
Synthetic	4 (1.7)	0 (0.0%)	n/a	n/a
Acetabulum revised	118 (51%)	155 (67%)	< 0.001	0.52 (0.4–0.8)
Cemented stem	42 (18%)	77 (33%)	< 0.001	0.43 (0.3–0.7)
Outcomes				
Mean follow-up period (years)	3.2	3.6		
Subsequent re-revision	17 (7.3%)	6 (2.6%)	0.06	0.52 [a] (0.27–1.0)
Overall deaths	40 (17%)	25 (11%)	0.06	0.06 [a] (0.004–1.1)
Deaths at < 6 months	17 (7.3%)	2 (0.9%)	< 0.001	17 (2.7–710)

[a] Exponentiated coefficient of the variable “match” in the associated Cox regression analysis (see Methods).

Table 3. Comparisons of outcome variables (periprosthetic fracture patients only)

	No. of hips	Mean OHS	Re-revision rate (n)	Death rate at < 6 months (n)
Total	232	29	17 (7.3%)	17 (7.3%)
Surgeons with				
> 15 revisions/year [a]	61	28	4 (7%)	4 (7%)
< 5 revisions/year	41	29	3 (7%)	7 (17%)
P-value		0.8	0.9	0.1
Surgeons with				
> 5 fracture revisions [b]	66	26	5 (8%)	3 (5%)
< 2 fracture revisions	43	30	3 (7%)	8 (19%)
P-value		0.2	0.9	0.04
Largest 5 centers [c]	85	31	8 (9%)	3 (4%)
Smallest 15 centers	35	28	3 (9%)	7 (20%)
P-value		0.3	0.9	0.03

[a] Mean number of revisions performed for all causes.
[b] Total number of revisions performed for periprosthetic fracture.
[c] Measured by patient volume.

Discussion

To our knowledge, this study represents the largest comparative series of revisions for periprosthetic fractures in THA (with functional outcome data) yet reported. Our findings of periprosthetic fracture patients having poorer functional outcome and higher death rates than patients undergoing revision THA for aseptic loosening confirm the findings of previous studies with smaller sample sizes (Beals and Tower 1996, Springer et al. 2003).

The New Zealand Arthroplasty registry was set up in 1999. Registry data on hip arthroplasties are collected prospectively, and the compliance rate among public hospitals exceeds 98% (Rothwell 2003). As this study is registry-based, there are limitations to the conclusions that can be drawn from the data, due to the lack of information on aspects such as the type or severity of the fracture. In a series at a representative New Zealand hospital, most patients (80%) undergoing revision were type B2 or B3 fractures, with the remainder being type A fractures (Young et al. 2007). This is consistent with other series reported in the literature (Sarvilinna et al. 2004, Duwelius et al. 2004). In addition, the comparative degree of adequacy of bone stock prior to revision surgery between the two groups is unknown. It is possible that the periprosthetic fracture group had more severe loss of bone, thus predisposing those patients to fracture, and this would affect their outcomes when compared to the reference group.

Most patients with periprosthetic fractures in the registry data (170/234, 73%) were revised to an uncemented revision prosthesis. Springer et al. (2003) reviewed 116 patients who underwent revision for type B2 or B3 periprosthetic fractures, and found the best results in those treated with uncemented extensively porous-coated stems, in comparison to proximally coated or cemented implants. The design of such stems enables the surgeon to gain stable distal fixation, thus bridging the fracture site (Lewallen and Berry 1998). The majority of the uncemented revision stems in the registry data (46/170, 86%) were of the extensively coated type. A further 3% (5/170) of the uncemented revision femoral components used distal interlocking screws, which have been advocated in the treatment of periprosthetic fractures (Clift 2000), although complications including screw breakage are common (Eingartner et al. 1997).

The use of femoral allograft was higher in the periprosthetic fracture group. The ability of allograft struts to provide structural support with reduced stress shielding, and also to augment femoral bone stock, confers obvious advantages in the treatment of periprosthetic fractures (Brady et al. 1999, Duwelius et al. 2004). Another explanation for the greater use of allografts is the possible use of femoral impaction grafting, which has been advocated in the treatment of periprosthetic fractures (Tsiridis et al. 2004). This involves cementing a revision stem into the neocortex created by the impacted graft, and bridging the fracture with a long revision stem. While the registry does not specifically record data on the use of this technique, only 8 of 234 procedures (3%) used both femoral allograft and a cemented femoral component, suggesting that impaction grafting to treat periprosthetic fractures is uncommon in New Zealand.

The difference in functional outcome scores between revisions for periprosthetic fracture and revision for aseptic loosening can be explained by the complexity of these injuries, and by the high complication rate that has been noted previously (Beals and Tower 1996, Lindahl et al. 2006). Patients in the periprosthetic fracture group were exposed to two major traumatic episodes, the fracture and subsequent revision procedure, and this may explain the larger difference in outcomes seen in older patients.

The New Zealand Registry sends out Oxford hip score questionnaires at 6 months postoperatively, and this represents early follow-up only. However, in a smaller comparative New Zealand series (Young et al. 2007) similar scores were obtained at longer term follow-up, which suggests that much of the functional recovery has been completed by this time, and other papers have suggested that the OHS at 6 months is representative of later scores (Field et al. 2005).

A lower mortality rate was seen in patients who had been operated on by more experienced surgeons and at larger centers (Table 3). This finding must be interpreted with caution in a registry-based study, as factors affecting mortality such as blood loss, delay to surgery, and co- morbidities are not recorded. Larger centers are also more likely to have a higher availability of sub-specialist surgeons and intensivist-led postoperative facilities, which may also have a positive effect on survivorship.

There was a lower response rate for the OHS at 6 months in the fracture group than in the reference group (57% vs. 76%) and this may have affected the results of the study. When respondents and non-respondents were analyzed separately, however, no significant differences were seen with regard to age, sex, operative time, or risk of subsequent re-revision. Cognitive impairment is a known risk factor for falls, which is the leading cause of periprosthetic fracture (Young et al. 2007). There may have been a higher rate of cognitive impairment in the fracture patients, thus limiting their ability to complete a self-assessment questionnaire such as the OHS and leading to a lower response rate. A recent comparison of outcome measures in hip surgery noted both a higher complication rate and worse scores in initial non-respondents (Ostendorf et al. 2004), suggesting that the true difference in outcomes may actually be greater.

In conclusion, revision surgery in the management of THA patients with periprosthetic fractures is demanding. In comparison to elective revision THA, poorer functional outcomes can be expected. The involvement of surgeons with special interest in trauma and revision arthroplasty in the management of these injuries is recommended.

Contributions of authors

SWY: main researcher and author. CGW: statistical analysis. RPP: supervision.

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