Periprosthetic Femoral Fractures

Classification and Demographics of 1049 Periprosthetic Femoral Fractures from the Swedish National Hip Arthroplasty Register

Hans Lindahl, MD, Henrik Malchau, MD, PhD,
Peter Herberts, MD, PhD, and Göran Garellick, MD, PhD

Abstract: Postoperative femoral periprosthetic fracture is an uncommon complication of total hip arthroplasty surgery, but several centers worldwide have recently reported an increase in total numbers of such fractures. This severe complication is costly for society and results in high morbidity. Our analysis of 1049 periprosthetic fractures occurring in Sweden between 1979 and 2000 and recorded in the Swedish National Hip Arthroplasty Register focuses on patient- and implant-related factors, fracture classification, and fracture frequency. These were our 3 major findings: (1) a majority of the patients who sustained a late periprosthetic femoral fracture had a loose stem. (2) Implant-related factors are significantly associated with occurrence of a periprosthetic fracture. (3) Since the 1980s in Sweden, treatment results for periprosthetic fractures have been poor, with low long-term survivorship and a high frequency of complications. We have initiated further studies of this important problem. **Key words:** total hip arthroplasty surgery, Swedish National Hip Arthroplasty Register, femoral periprosthetic fracture, loose stem.
© 2005 Elsevier Inc. All rights reserved.

Postoperative periprosthetic femoral fracture is a severe complication of total hip arthroplasty (THA). Although uncommon, such a fracture presents a major challenge to the orthopedic surgeon. In many cases, the surgeon has to solve the problems of aseptic loosening, bone loss, and fracture in a single procedure.

The incidence of periprosthetic femoral fractures seems to be increasing [1,2] because of several factors: the population with a THA in place is growing. Total hip arthroplasty surgery is very successful, which has led to broadening of indications for THA, with more younger and more elderly patients now undergoing the procedure than in the 1980s. The average life expectancy is increasing; consequently, there are more elderly patients now than before the 1980s who have had a hip implant for many years, which increases the risk that their implant will loosen because of poor bone quality and/or periprosthetic bone loss. The use of THA in younger and more active patients means that the pool of young patients at risk of developing local osteolysis and at risk for high-energy trauma is growing. Furthermore, after 4 decades of THA

surgery, the number of patients with revised and rerevised hips has also risen; periprosthetic femoral fracture is more common after revision surgery.

We analyzed the correlation of periprosthetic femoral fracture after patients are discharged from the hospital after index or revision surgery and analyzed the correlation between risk of fracture and diagnosis, sex, comorbidity, implant type, fixation status, and time from index operation to fracture by examining periprosthetic femoral fractures, excluding perioperative fractures, reported to the Swedish National Hip Arthroplasty Register between 1979 and 2000. The register data for that period include 216 226 primary procedures, 36 366 reoperations, and 19 620 revisions.

Materials and Methods

The Swedish National Hip Arthroplasty Register was established on January 1, 1979 [3-5], and is an observational study in which data are collected prospectively. All orthopedic departments in Sweden participate. The cohorts are the total national number of THAs, including primary and revision procedures. The definition for implant failure is revision or removal of the implant. The registry consists of 3 different databases.

1. *Primary hip arthroplasty database*: From 1979 to 1991, the cumulative numbers of primary procedures were registered per year and per hospital, with information on the number and types of prostheses used. Since 1992, every primary procedure has been reported individually, with the patient identification number, age, sex, diagnosis, and identification of which hip was involved. The type of implant and the fixation method are described in detail.
2. *Reoperation hip arthroplasty database*: Complete copies of the medical records of all reoperated THAs (including all forms of surgical treatments after the index operation such as periprosthetic fractures) have been collected and computerized since 1979. Our analysis includes survival statistics in relation to patient and implant-related factors.
3. "*Environmental*" *database*: This database contains information about prophylactic measures against aseptic and septic loosening, called environmental factors. Yearly, all departments report details regarding surgical and cementing techniques [3-5].

Between 1979 and 2000, 1049 periprosthetic femoral fractures were reported to the register and 16 669 revisions were performed. We report here on 2 studies, from which we excluded perioperative fractures: a retrospective register analysis between 1979 and 1998 of 726 reported cases and a prospective nationwide register study between 1999 and 2000 of 323 periprosthetic fractures. The demographics and implant-related factors analyzed were the same for both studies.

The analyses are based on hospital records. No results of radiographic examinations are included in the register or in this report, because the study extends over 22 years and the x-rays for many cases are unavailable. The following variables were recorded: fracture after a primary procedure or after one or several revision procedures, age and sex, diagnosis at time of primary operation, type of implant, and time from the implant operation to fracture treatment. Patients whose primary implant was still in place at the time of fracture are referred to here as being part of the primary group. Those who underwent one or more revision surgeries before developing a fracture are referred to as being part of the revised group. We also attempted to estimate whether the implants were stable or loose (with or without bone loss) at the time of fracture. Stem fixation was categorized as either loose, unknown loose, or stable. *Loose* meant that the doctor and the patient were aware that the prosthesis was loose (ie, the patient was on a waiting list for a revision). *Unknown loose* meant that stem loosening was first detected when the patient fractured the femur. We gleaned information from the medical reports about the particular trauma that caused each fracture. Those fractures that occurred without a fall or substantial trauma were labeled *spontaneous*. Falls at the level at which the patients had been standing or sitting were labeled *minor trauma*. Traffic accidents and fall from different levels were labeled *major trauma*.

Fractures were classified on the basis of the radiologist's report and the surgeon's report and according to the Vancouver classification [6,7] system, which incorporates the factors of fracture site, implant stability, and bone stock stability. Type A fractures occurred proximally to the prosthesis. They were trochanteric, either greater (AG) or lesser (AL). Type B fractures occurred around the stem or just below it. Type B fractures were subdivided according to the stability of the component and/or bone loss. Type B1 included fractures in which the stem is solidly fixed, and type B2 included those in which the component was loose. If the stem was loose and there was severe bone loss, the fracture was classified as type B3. Type C fractures occurred below the stem tip.
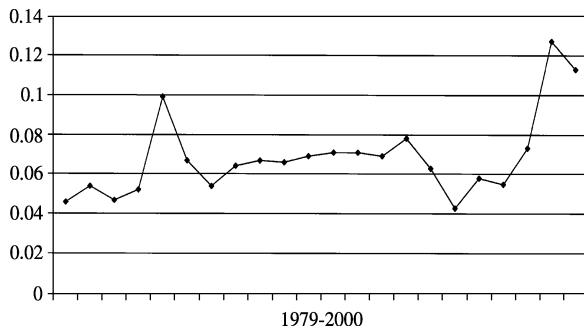
Fig. 1. The annual incidence of reported femoral periprosthetic fractures.

Through the register, it is possible to make demographic comparisons between the fracture group and the remaining THAs during the same period. Our analysis included only those fractures occurring after a primary procedure, because the revision cohort might include several confounding factors.

Fracture treatment, including revision and nonrevision, was described and then was recategorized using the Vancouver classification.

The register results are most often presented as survival analyses (Kaplan-Meier), with revision as an end point [8]. The fracture group was analyzed using this technique but with a complimentary failure definition [9], including reoperation due to refracture, nonunion, and other fracture-related problems. Those patients who died (Population Register of Sweden [10]) and those who underwent further surgery (National Hip Arthroplasty Register) were included in the study group.

At the time we conducted our retrospective study, 407 (56%) patients who underwent surgery between 1979 and 1998 were still alive. We sent them a questionnaire that included 5 questions: 2 about impaired walking capacity due to problems with the other hip or due to other medical conditions (leading to a reassignment of the patient to different Charnley categories [11]), 1 about whether the patient had undergone a second surgery, 1 about satisfaction with the treatment, and 1 about pain (none, mild, moderate, severe, or intolerable).

All statistical calculations were done on a personal computer using SPSS for Windows 2000 (version 11.0, SPSS, Chicago, Ill). Survivorship was analyzed with the Kaplan-Meier method. The 95% confidence limits (1.96 × SEM) are indicated on the survival curves shown in Fig. 3. The other statistical methods used are indicated below in the discussions of each calculation. Two-tailed tests were performed.

Results

Between 1997 and 2000, 688 cases of a late periprosthetic femoral fracture after a primary THA were reported, as were 361 cases of fractures after one or more revisions. The mean age of patients was 74 years (range, 20-79) without significant difference between the primary group and the revised group. The cases were almost equally distributed by sex, with slightly more women than men in the revised group and among the elderly patients. The annual incidence of fractures varied between 0.045% and 0.13% for all THAs performed in Sweden during the period under study, but there was an increasing incidence in 1999 to 2000, to approximately 0.1% (Fig. 1). The accumulated incidence was 0.4% for the primary group and 2.1% for the revised group. By December 31, 2002, 336 (32%) patients had died. All patients were traceable (through the Population Register of Sweden). Late femoral periprosthetic fracture is the third most common cause of reoperation, constituting 6% of these cases.

The main indication for THA in Sweden is osteoarthritis (OA), and in the fracture group, OA was the most common primary diagnosis. Patients with rheumatoid arthritis and patients who had a THA after a hip fracture were significantly more common ($P < .001$, χ^2 test) in the fracture group, compared with all patients with THAs (Table 1).

Eighty-two percent of the fractures were classified as Vancouver types B1 and B2 (Table 2). The B3 type is uncommon in Sweden, comprising only 4% of fractures. The main difference in classification between primaries and revisions is the proportion of B1 and B2 types ($P < .001$, χ^2 test). The B2 is more common in the primary group. Ten percent of the fractures were classified as type C. The frequencies of fractures classified as A, B3, and

Table 1. Primary Diagnosis in the Fracture Group vs the National Register

Diagnosis	Primary (*N* = 688)	Revised (*N* = 361)	National Register (*N* = 191351)
OA	69% (475)	72% (261)	76%
Hip fracture	17% (118)	10% (36)	11%
Rheumatoid arthritis	11% (73)	10% (37)	6%
Miscellaneous	3% (22)	8% (27)	7%

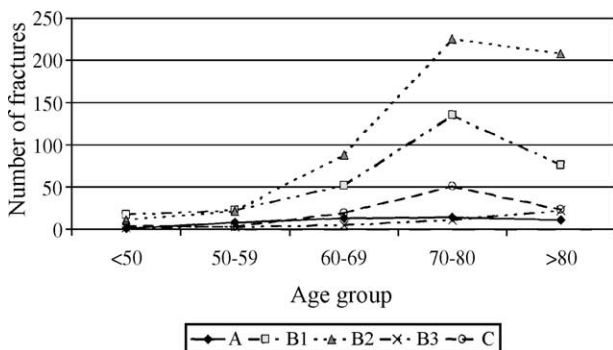**Table 2.** Fracture Classification According to the Vancouver System

Vancouver category	Primary group (N = 688)	Revised group (N = 361)	Total (N = 1049)
A	5% (32)	4% (15)	4% (47)
B1	21% (146)	44% (158)	29% (304)
B2	61% (417)	38% (138)	53% (555)
B3	4% (31)	3% (12)	4% (43)
C	9% (62)	11% (38)	10% (100)

Table 3. Type of Primary Implant

Implant	Fracture group, 1992-2000 (N = 146)	National register, 1992-2000 (N = 90 547)	Two-tailed P values, 1992-2000 (χ^2 test)
Charnley	42% (61)	23%	<.001
Exeter	26% (38)	13%	<.001
Lubinus	12% (17)	34%	<.001
Miscellaneous	20% (30)	30%	–

C were similar throughout the range of age groups. The proportion of B1 and B2 types increases with age (> 60 years). The B2 frequency continues to increase with higher age, whereas B1 frequency decreases among the oldest patients (Fig. 2).

The mean time interval from primary THA to fracture was 7.4 years (range, 1-262 months) and from revision to fracture was 3.9 years (range, 1-229 months). The time interval decreased with number of revisions (2 revisions, 3.8 years; 3 revisions or more, 2.3 years). The most frequent cause of fracture was a fall at the same level at which the patient had been sitting or standing: 75% in the primary group and 56% in the revised group. In the revised group, there were more "spontaneous" fractures (37%) than in the primary group (18%; $P < .001$, χ^2 test). The incidence of major trauma was 7% in both groups.

In the primary group, 30% of the stems were considered to be stable and had no obvious signs of loosening at the time of periprosthetic fracture. Twenty-three percent were "known loose" and 47% were "unknown loose." In the revised group, the corresponding incidences were 56%, 21%, and 23%, respectively.

The most commonly used prostheses in Sweden for a primary THA during this period were the

Charnley, the Lubinus, and the Exeter. A comparison of the total amount of primary THAs performed in Sweden and the fracture cohort revealed a significant increase of fractures with the Charnley ($P < .001$, χ^2 test) and with the Exeter ($P < .001$, χ^2 test) and significant decrease for the Lubinus ($P < .001$, χ^2 test) in the fracture group (Table 3). Before 1992, there were no individual registrations by implant and patient. Therefore, the statistical calculation revealed significant differences only for the last 9 years of the study (1992-2000).

An analysis in which the used index implant was correlated with the Vancouver classification revealed no significant differences, but there was a trend toward a high frequency of fractures of the Charnleys in the B2 category ($P = .08$, Fisher exact test). In these 2 comparisons, the revised group was excluded because of the possibility of confounding and non–implant-related factors. Only 9 of the 1049 cases involved uncemented prostheses and were not analyzed.

The type of treatment was classified as revision only, open reduction and internal fixation (ORIF) of the fracture, or revision combined with an ORIF, and then was further divided into the different Vancouver categories. Revision and revision with ORIF were performed in many of the A and C categories. The predominant treatment in category B1 was ORIF alone (Table 4). Table 5 shows the need for further surgery correlated with the type of treatment and Vancouver classification. The

Fig. 2. Numbers of fractures in different age groups and Vancouver categories.

Table 4. Treatment in the Different Vancouver Categories (A-C)

Method	A (N = 47)	B1 (N = 304)	B2 (N = 555)	B3 (N = 43)	C (N = 100)
Revision	26% (12)	13% (41)	35% (191)	70% (30)	6% (6)
Revision + ORIF	45% (21)	21% (63)	56% (312)	30% (13)	31% (31)
ORIF	29% (14)	66% (200)	9% (52)	0	63% (63)

Table 5. The Need for Further Surgery in Relation to Fracture Treatment and Vancouver Categories (A-C)

Method	A (N = 47)	B1 (N = 304)	B2 (N = 555)	B3 (N = 43)	C (N = 100)
Revision	6% (3)	3% (10)	5% (30)	5% (2)	3% (3)
Revision + ORIF	6% (3)	5% (16)	10% (55)	12% (5)	4% (4)
ORIF	9% (4)	24% (72)	4% (20)	0	18% (18)

highest need for revision due to failure was in group B1, treated with ORIF alone.

The peri- and postoperative complication rate (during the hospital stay) was high. Only major implant-related and major general medical complications were registered (Table 6). The total complication rate was 18%. By December 31, 2002, 245 (23%) patients had undergone re-operation for various reasons (Table 7). Of those, 109 (44.5%) underwent re-operation during the first 12 postoperative months. The mean hospital stay was 21 days (range, 1-300 days; median, 15 days). Thirteen patients died at the hospital after surgery, and 86 died during the first 12 months, resulting in a mortality of 9.4%.

The results of the survival analyses (Kaplan-Meier) are shown in Fig. 3. The overall 10-year survival rate for all THAs in Sweden between 1979 and 2002 was 90.5% ± 0.2% for revision as the end point [5] and 87.7% ± 0.2% for re-operation of any kind as the end point (Fig. 3A). Our results after treatment of periprosthetic fracture were much worse. With the extended failure definition, the early high frequency of

Table 6. Postoperative Complications

Type of complication	N = 1049
Copious bleeding	36
Early dislocation	34
Superficial wound infection	28
Death	13
Stroke	10
Gastrointestinal complications (ulcers, bleeding)	9
Deep venous thrombosis	8
Cardiac failure	7
Myocardial infarction	6
Pneumonia	5
Pulmonary embolism	5
Vascular injury	2
Sciatic injury	2
Perioperative asystole	3
Septicemia	1
Miscellaneous	16
Total	185 (18%)

Table 7. Late Complications Leading to Reoperation

Type of complication	N = 1049
Nonunion	59
Refracture	58
Aseptic loosening	51
Recurrent dislocation	40
Deep infection	24
ORIF failure	10
Miscellaneous	3
Total	245 (23%)

re-operations in the fracture group led to a low survivorship. The 10-year result for the entire fracture group was 69.9% ± 3.8% (Fig. 3B). Dividing that group into the primary and revised cohorts produced a 10-year survival rate of 73.2% ± 4.4% (Fig. 3C) and 64.9% ± 6.6%, respectively (Fig. 3D).

The self-administered questionnaire was sent to all living patients in the retrospective part (407/726 patients) of the study. The response rate was 93%. Thirty patients did not reply, owing to advanced age or mental capacity problems. Of those who responded, 287 (76%) were satisfied with the results of their fracture repair operation. Thirty percent reported at least one re-operation, which corresponded with register data. Thirty-nine percent had no pain, and 61% reported variable grades of pain.

Discussion

Several authors [1,2,12] have reported an increasing number of femoral periprosthetic fractures. However, because these fractures are uncommon, they are difficult to study; no individual surgeon or department deals with enough of them to produce a scientifically and statistically valid study sample. Therefore, we chose to conduct a nationwide observational study.

Although this study includes 1049 cases, it has some methodological flaws. The data were collected over a period of 22 years, which means that the treatment methods to some extent are historical. The Vancouver type A fracture (of the major or minor trochanter) and type C fracture (below the tip of the prosthesis) are probably underreported in the national register, as the surgeon could consider the fracture to be unrelated to the implant. Furthermore, we used the Vancouver classification but did not have access to radiographs for the study sample. Because of these factors, we focused more on epidemiological features, taking advantage of
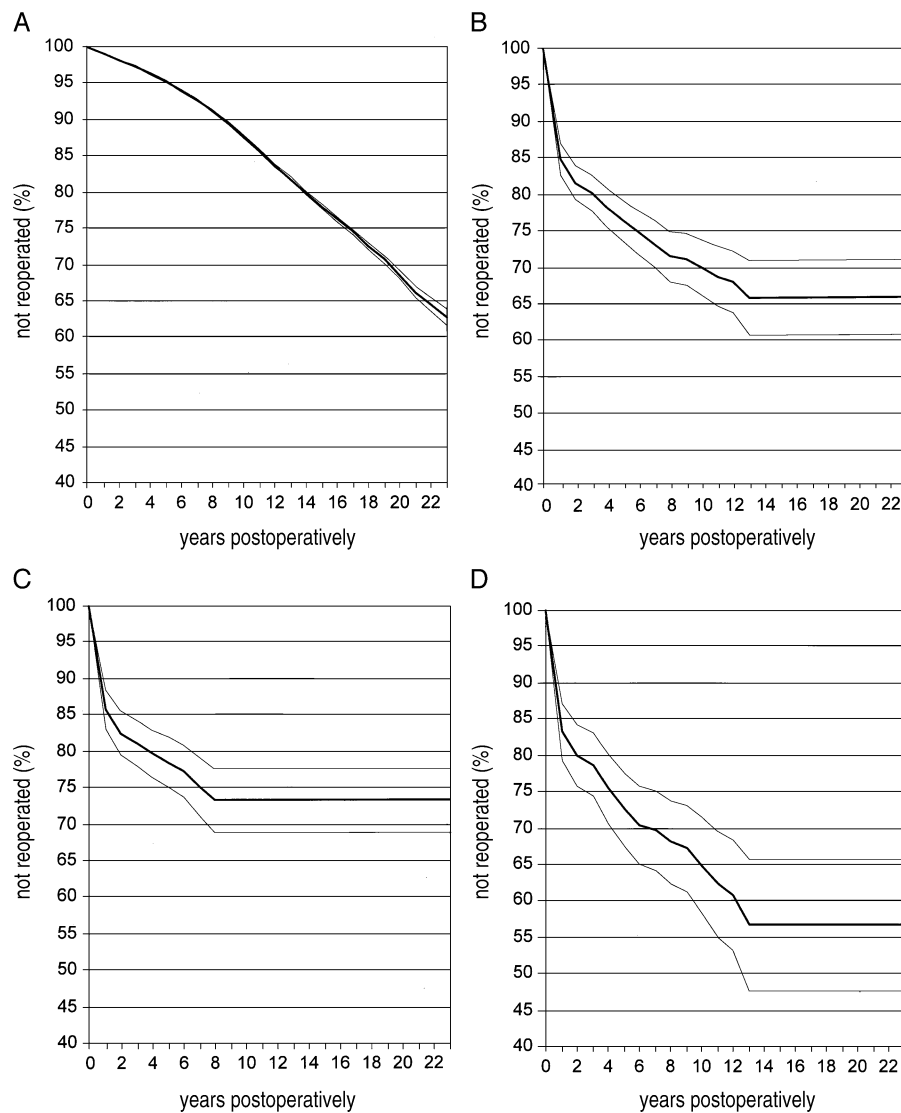
Fig. 3. A, Survival rate for all THAs in Sweden (1979-2002) that did not undergo re-operation of any kind. Ten-year survival rate: 87.7% ± 0.2%. B, Survival rate for operated periprosthetic femoral fracture with failure defined as re-operation. Ten-year survival rate for the total group: 69.9% ± 3.8%. C, Survival rate for operated periprosthetic femoral fractures in the primary group with failure defined as re-operation. Ten-year survival rate: 73.2% ± 4.4%. D, Survival rate for operated periprosthetic femoral fractures in the revised group with failure defined as re-operation. Ten-year survival rate: 64.9% ± 6.6%.

the high number of cases, rather than on treatment results or outcomes in individual cases. The obvious strength of this study is that all patients were traceable through the official Swedish population register, which meant that any re-operation could be found in the register's databases. This report should serve as a baseline for the ongoing prospective nationwide study in Sweden and other studies in the field.

Comparable incidence of postoperative periprosthetic femoral fractures is difficult to obtain because the cohort of patients with a THA is affected by

several confounding factors: (1) demographic profile or case mix, (2) length of the follow-up period, (3) the type of implant used, (4) the technique or fixation method used, (5) inconsistent inclusion of revision procedures, and (6) unrecorded cases. In addition, the local follow-up routines probably influence the fracture rate. A standardized follow-up routine that includes radiographic examination and the decision by surgeons to intervene early when there is impending loosening with or without bone loss probably could lower the fracture rate. The high frequency of "unknown

loosening" in our study indicates the need for such a routine. The high rate of (known) "loose" stems indicates that there are long waiting lists in Sweden, even for revision surgery.

Different authors have reported highly variable incidences and more often present incidence as accumulated than as annual. The Mayo Clinic [1] has reported an accumulated incidence of 0.6% in primary cemented THAs and 0.4% in primary uncemented THAs performed between 1969 and 1990. Löwenhielm et al [13] reported on a study of 1442 primary cemented THAs with an accumulated postoperative risk for late periprosthetic femoral fracture of a maximum of 2.5% at 11 years. The annual incidence ranged between 0% and 1.2%. In our study, the annual incidence was 0.07% for the first 18 years, increasing to 0.1% at the end of the study period. The accumulated incidence was 0.4% for the primary group and 2.1% for the revised group.

The mean age at time for index operation for all primary hip arthroplasty compared to mean age in the fracture group is presented in Table 8. We have no exact age data on all primary THA before 1987, so the material is between 1987 and 2000. There is a significant difference in mean age, except for patients with the primary prosthesis at time for fracture. This might mean that younger and likely more active patients have a higher risk for sustaining an implant-related fracture in the long run. Beals and Towers [14] reported that patients' mean age was 67 years at the time of periprosthetic fracture, whereas Ruiz et al [15] reported that the mean age was 77 years.

We retrospectively estimated the Vancouver classification for each case from the medical records, which included the radiologist's report as well as the surgeon's interpretation before and during surgery. Our finding that the B categories constitute approximately 80% of all fractures is in concordance with that of other studies [1,12,16]. There was a difference between the primary group and the revised group, with the B2 type being much more common than B1 among the primaries ($P < .001$, χ^2 test). The

cause of this is probably multifactorial: shorter time from surgery to fracture (7.4 vs 3.9 years) and factors related to the revision procedure itself, such as fenestration for cement extraction or accidental penetration and loss of bone stock as a result of stem loosening. A report from the Mayo Clinic on 97 periprosthetic fractures noted that 25% were B3 fractures, or the most severe fracture classification, which was not nearly as common in our study (4%). A reason for the rather low incidence of the B3 fractures reported in Sweden could be that revised patients are monitored with regular clinical and radiographic follow-up as recommended by the Swedish Orthopaedic Association 1991. Regular radiographic follow-up to look for massive bone loss typical of type B3 fractures is quite important. Tower and Beals [14] reported loosening in 22 of 93 cases but no cases with severe bone loss.

The most important finding in this study is that 70% of the stems (primary group) were considered to be loose when the patient sustained a fracture, whereas 47% were "unknown loose." Considering the poor overall results after fracture-repair surgery, the optimal approach is probably surgical intervention before the patient sustains a fracture. Obviously, revision procedures must be a high priority especially for patients with pronounced bone loss and loose implants. At present, follow-up routines vary a good deal from department to department and region to region in Sweden. Early component loosening with or without periprosthetic bone loss in cemented femoral stems (osteolysis) is initially a silent, progressive process. We know that stem-loosening is more symptomatic than cup-loosening. The only method currently available for detecting early bone loss is monitoring all THAs with periodic radiography and performing revision surgery at an early stage, but is it cost-effective? Lavernia [17] reported comparing prices and hospital stays for patients who sustained a periprosthetic fracture with those for patients monitored regularly who underwent revision when radiographs showed impending loosening and bone loss. Lavernia [17] reported cost-effectiveness for a standardized follow-up routine.

Another major finding of our study is the significant association between type of implant and risk for periprosthetic fracture. The Charnley flanged (Cobra design) and the Exeter (polished) prostheses are associated with a higher risk of periprosthetic fracture, and the Lubinus SPI and SPII are associated with a lower risk. The increased risk of femoral osteolysis when the Exeter matte was used has been well described, but no matte devices have been used in Sweden since the mid-

Table 8. Mean Age at Time for Index Operation (1987-2000)

Group of patients	N	Mean	SD	t Test
All primary THA patients	127744	69.72	10.63	
Total Fx patients	448	67.84	11.46	$P < .001$
Total Fx patients with primary prosthesis	351	69.16	10.91	NS
Total Fx patients revised	97	63.07	12.15	$P < 0.001$

1980s. Furthermore, in Sweden, the Lubinus stem implant has been used in 3 designs: the straight monobloc version (Lubinus IP), the anatomically shaped Lubinus SPI (monobloc), and the Lubinus SPII (curved and modular). The SPII design has been the most commonly used stem implant in Sweden since the late 1980s. In a study like ours, it is impossible to pinpoint a single cause for the different results with each type of prosthesis. However, there are some differences: (1) the Charnley and the Exeter are shorter than the Lubinus. (2) The Exeter and the Charnley are straight, whereas the Lubinus is anatomically shaped. (3) The Exeter is polished, whereas the Charnley and the Lubinus have almost the same surface. The so-called C2 problem [18] with the Charnley —the difficulty in positioning a straight stem and achieving an adequate cement mantle— has been well described. An inadequate cement mantle, with implant contact with the inner and distal femoral cortex, has been correlated with long-term loosening and femoral osteolysis [19,20]. Löwenhielm et al [13] also reported implant-related factors. The Lubinus prosthesis was associated more with distal fractures; the Charnley was associated more with proximal fractures. Those researchers concluded that the different designs of the 2 prostheses were to blame.

Results correlated with different surgical treatments, implants, and Vancouver classification should be interpreted cautiously because of our study's design. Some cases of type A fractures treated conservatively and some cases of diaphyseal fractures treated by traction were probably not recorded in the national register. Traction was an alternative treatment at least up to the mid-1980s. Nonsurgical approaches were inconsistently reported to the register. There were, however, some clear tendencies. Open reduction and internal fixation methods, such as fixation with only one plate and/or the use of one or several cerclage wires (including Partridge bands), resulted in a high frequency of revision procedures and should probably be abandoned [21-27]. The high revision percentage for B1 cases (stable stems) treated with ORIF alone is surprising. Most reports since the late 1980s [28-31] have suggested that the B1 fractures are the only type that could be successfully treated without revision and with an adequate ORIF method. The most probable reason for our opposite finding is an underestimation of stem loosening by the surgeon and/or radiologist. If, at preoperative planning, the surgeon considers the stem to be stable, he or she might decide to repair the fracture using a direct approach, without exposing the joint—and would

have no way to test the stem. Another confounding factor could be the design of the Exeter prosthesis, because surgeons using this stem often do not consider a subsided stem to be loose.

Since the mid-1990s, several studies have reported good midterm results by using cortical strut allografts; this technique is considered the contemporary method of choice, especially in North America. However, it is not so common in Europe, and there is no established bone bank in Scandinavia to provide such grafts. During the study period, this type of graft was uncommon, and even now it is seldom used. Its use could, of course, influence the overall results of surgery.

Our questionnaire results can be regarded as a validation of the register-based figures for further surgery. Thirty percent of the living patients who completed the questionnaire reported having undergone revision surgery. The high frequencies of dissatisfaction and pain they reported emphasize the poor results of the treatment employed.

The high rates for major complications, revision surgery, and early mortality add up to severe morbidity for these patients and a high price for society. Several authors [6,12,32-34] have written about the need for a standardized classification and an adequate treatment algorithm for late femoral periprosthetic fractures. Our results strongly support such a need. Two questions arise: because prevention could be the most effective approach, can we as orthopedic surgeons persuade health care decision makers to allocate resources for a standardized follow-up routine? Should technically demanding cases be handled by specialized units? Each surgeon at smaller hospitals treats very few patients with periprosthetic femoral fractures, and thus the level of skill each attains in treating them is questionable. There is definite need for further studies, preferably prospective multicenter trials.

References

1. Lewallen DG, Berry DJ. Periprosthetic fracture of the femur after total hip arthroplasty: treatment and results to date. Instr Course Lect 1998;47:243.
2. Berry DJ. Epidemiology: hip and knee. Clin Orthop 1999;30:183.
3. Herberts P, Malchau H. How outcome studies have changed total hip arthroplasty practices in Sweden. Clin Orthop 1997;344:40.
4. Herberts P, Malchau H. Long-term registration has improved the quality of hip replacement: a review of the Swedish THR Register comparing 160 000 cases. Acta Orthop Scand 2000;71:111.

5. Malchau H, Herberts P, Eisler T, et al. The Swedish Total Hip Replacement Register. J Bone Joint Surg Am 2002;84-A(Suppl 2):2.

6. Brady OH, Garbuz DS, Duncan CP. Classification of the hip. Clin Orthop 1999;30:215.

7. Brady OH, Garbuz DS, Masri BA, et al. The reliability and validity of the Vancouver classification of femoral fractures after hip replacement. J Arthroplasty 2000;15.

8. Kaplan E, Meier P. Nonparametric estimation from incomplete observation. J Am Stat Assoc 1958;53.

9. Garellick G, Malchau H, Herberts P. Survival of hip replacement. A comparison of a randomized trial and a registry. Clin Orthop 2000;375:157.

10. Official statistics of Sweden. Stockholm: National Central Bureau of Statistics; 2002.

11. Charnley J. Low friction arthroplasty of the hip: theory and practice. Berlin: Springer; 1979.

12. Schmidt AH, Kyle RF. Periprosthetic fractures of the femur. Orthop Clin North Am 2002;33:143.

13. Löwenhielm G, Hansson LI, Karrholm J. Fracture of the lower extremity after total hip replacement. Arch Orthop Trauma Surg 1989;108:141.

14. Beals RK, Tower SS. Periprosthetic fractures of the femur. An analysis of 93 fractures. Clin Orthop 1996; 327:238.

15. Ruiz AL, Thompson NW, Brown JG. Periprosthetic femoral fractures in Northern Ireland. Ulster Med J 2000;69:118.

16. Crockarell Jr JR, Berry DJ, Lewallen DG. Nonunion after periprosthetic femoral fracture associated with total hip arthroplasty. J Bone Joint Surg Am 1999; 81:1073.

17. Lavernia CJ. Cost-effectiveness of early surgical intervention in silent osteolysis. J Arthroplasty 1998;13:277.

18. Barrack RL, Mulroy Jr RD, Harris WH. Improved cementing techniques and femoral component loosening in young patients with hip arthroplasty. A 12-year radiographic review. J Bone Joint Surg Br 1992;74:385.

19. Garellick G, Malchau H, Regner H, et al. The Charnley versus the Spectron hip prosthesis: radiographic evaluation of a randomized prospective study of 2 different hip implants. J Arthroplasty 1999;14:414.

20. Chambers IR, Fender D, McCaskie AW, et al. Radiological features predictive of aseptic loosening in cemented Charnley femoral stems. J Bone Joint Surg Br 2001;83:383.

21. Ahuja S, Chatterji S. The Mennen femoral plate for fixation of periprosthetic femoral fractures following hip arthroplasty. Injury 2002;33:47.

22. Barfod G, Steen Jensen J, Hansen D, et al. Hemiarthroplasty of the hip followed by ipsilateral fracture of the femoral shaft. Injury 1986;17:104.

23. Otremski I, Nusam I, Glickman M, et al. Mennen paraskeletal plate fixation for fracture of the femoral shaft in association with ipsilateral hip arthroplasty. Injury 1998;29:421.

24. Petersen VS. Problems with the Mennen plate when used for femoral fractures associated with implants. A report of 5 patients. Int Orthop 1998;22:169.

25. Somers JF, Suy R, Stuyck J, et al. Conservative treatment of femoral shaft fractures in patients with total hip arthroplasty. J Arthroplasty 1998;13:162.

26. Venu KM, Koka R, Garikipati R, et al. Dall-Miles cable and plate fixation for the treatment of periprosthetic femoral fractures—analysis of results in 13 cases. Injury 2001;32:395.

27. Schutzer SF, Grady-Benson J, Jasty M, et al. Influence of intraoperative femoral fractures and cerclage wiring on bone ingrowth into canine porous-coated femoral components. J Arthroplasty 1995;10:823.

28. Abhaykumar S, Elliott DS. Percutaneous plate fixation for periprosthetic femoral fractures—a preliminary report. Injury 2000;31:627.

29. Courpied J, Watin-Augouard L, Postel M. Fractures du femur chez les sujets porteurs de prothèses totales de hanche ou de genou [Femoral fractures in subjects with total prostheses of the hip or knee]. Int Orthop 1987;11:109.

30. Serocki JH, Chandler RW, Dorr LD. Treatment of fractures about hip prostheses with compression plating. J Arthroplasty 1992;7:129.

31. Zenni Jr EJ, Pomeroy DL, Caudle RJ. Ogden plate and other fixations for fractures complicating femoral endoprostheses. Clin Orthop 1988;231:83.

32. Berry DJ. Management of periprosthetic fractures: the hip. J Arthroplasty 2002;17(Suppl 1):11.

33. Wilson D, Masri BA, Duncan CP. Periprosthetic fractures: an operative algorithm. Orthopedics 2001; 24:869.

34. Tower SS, Beals RK. Fractures of the femur after hip replacement: the Oregon experience. Orthop Clin North Am 1999;30:235.