Three Hundred and Twenty-one Periprosthetic Femoral Fractures

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Three Hundred and Twenty-one Periprosthetic Femoral Fractures

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Background: The purpose of this study was to determine the demographics, incidence, and results of treatment of periprosthetic fractures in a nationwide observational study.

Methods: In the years 1999 and 2000, 321 periprosthetic fractures were reported to the Swedish National Hip Arthroplasty Register. All of the associated hospital records were collected. At the time of follow-up, the Harris hip score, a health-related quality-of-life measure (the EuroQol-5D [EQ-5D] index), and patient satisfaction were used as outcome measurements. A radiologist performed the radiographic evaluation.

Results: Ninety-one patients, with a mean age of 73.8 years, sustained a fracture after one or several revision procedures, and 230 patients, with a mean age of 77.9 years, sustained a fracture after a primary total hip replacement. Minor trauma, including a fall to the floor, and a spontaneous fracture were the main etiologies for the injuries. A high number of patients had a loose stem at the time of the fracture (66% in the primary replacement group and 51% in the revision group). Eighty-eight percent of the fractures were classified as Vancouver type B; however, there was difficulty with preoperative categorization of the fractures radiographically. There was a high failure rate resulting in a low short to mid-term prosthetic survival rate. The sixty-six-month survival rate for the entire fracture group, with reoperation as the end point, was 74.8% ± 5.0%. One factor associated with fracture risk was implant design.

Conclusions: On the basis of these findings, we believe that high-risk patients should have routine radiographic follow-up. Such a routine could identify a loose implant and make intervention possible before a fracture occurred. Furthermore, we recommend an exploration of the joint to test the stability of the implant in patients with a Vancouver type-B fracture in which the stability of the stem is uncertain.

Level of Evidence: Prognostic Level II. See Instructions to Authors for a complete description of levels of evidence.

Total hip replacement is a common, successful operation with few complications. However, periprosthetic femoral fracture is a severe complication, which may occur years after the operation. Treatment of such fractures is technically demanding, with a high frequency of complications and reoperations[1].

The incidence of periprosthetic femoral fractures seems to be increasing because of several factors. First of all, good results from total hip replacement have led to a broadening of the indications for the procedure. Second, the population with a total hip replacement in place is growing. Finally, after four decades in which total hip replacements have been performed, a large number of patients have had revision arthroplasties, and periprosthetic femoral fracture is more common after revision surgery[2,3]. We performed a prospective nationwide study of periprosthetic femoral fractures reported to the Swedish National Hip Arthroplasty Register[4,5], which included 242,393 primary procedures, 28,045 reoperations, and 22,840 revisions at the end of the study (December 31, 2004). Periprosthetic fractures were excluded. This study gave us a unique opportunity to analyze this uncommon complication. Our purpose was to evaluate the demographics, incidence, treatment, and outcome of periprosthetic femoral fractures in order to identify risk factors associated with the fractures and their treatment.

Materials and Methods

The Swedish National Hip Arthroplasty Register began on January 1, 1979, and all orthopaedic departments in Sweden participate. The registry consists of three different databases. The first is the primary hip arthroplasty database, which contains information on every primary procedure since 1992, reported individually. The second is the reoperation database, which includes information relating to all reoperations following total hip arthroplasty. The third is the environmental and technique database, which contains details regarding the operation, including prophylaxis against infection and surgical techniques.

TABLE I Vancouver[8] Classification of Fractures Based on Surgeons' Findings*

Vancouver Category	Primary-Replacement Group (N = 230)†	Revision Group (N = 91)†	Total (N = 321)†
A	3% (6)	2% (2)	2% (8)
B_1	24% (56)	37% (34)	28% (90)
B_2	53% (123)	38% (35)	49% (158)
B_3	10% (24)	11% (10)	11% (34)
C	9% (21)	11% (10)	10% (31)

*The first author (H.L.) classified the fractures on the basis of both the surgeons' preoperative interpretation of the radiographs and the operative report. †The values are given as the percentage of hips with the number of hips in parentheses.

All hospital records on the study patients were collected. The follow-up was done at each local hospital. A standardized follow-up protocol was used: all patients completed a questionnaire containing eleven items, including Charnley's functional categories (A, B, and C)[6], a pain visual analogue scale (0 to 100, with 0 indicating no pain and 100 indicating unbearable pain), a satisfaction visual analogue scale (0 to 100, with 0 indicating satisfied and 100 indicating dissatisfied), and a generic measurement tool (the EuroQol-5D [EQ-5D]). The Charnley category provides a correction for comorbidity. The EQ-5D is a global health index with a weighted total value for health (range, –0.594 to 1.0). The examiner determined the Harris hip score, and a radiographic examination was performed. Mortality records were obtained from the Population Register in Sweden.

The patients with a primary implant in place at the time of the fracture were referred to as the "primary replacement group." The patients who had undergone a revision arthroplasty one or several times prior to the fracture were referred to as the "revision group." The stability of the stem was categorized as loose, unknown loose, or stable. The definition of loose was that the physician and the patient were aware that the prosthesis was loose (that is, the patient was on a waiting list for a revision). If the loose stem was first detected when the patient presented with the fracture, it was defined as unknown loose.

Spontaneous fractures were defined as those that occurred without a fall or any obvious trauma. Minor trauma was defined as a fall to the floor. Major trauma included a traffic accident and a fall down a flight of stairs.

The fractures were classified according to the Vancouver system[7,8], which incorporates the site of the fracture, the stability of the implant, and the quality of the surrounding bone stock. Type-A fractures involve either the greater (A_G) or lesser (A_L) trochanter. Type-B fractures occur around the stem or just distal to it. Type-C fractures occur distal to the tip of the stem. Type-B_1 fractures are associated with a solidly fixed stem, and type-B_2 fractures are associated with a loose stem. If the stem is loose and there is severe bone loss, the fracture is classified as type B_3. The B_3 group was further classified according to the Paprosky classification of femoral deficiency[9,10].

The first author (H.L.) classified the fractures on the basis of both the surgeons' preoperative interpretation of the radiographs and the operative report. Subsequently, the radiographs were examined and classified by the study radiologist (H.R.). Interobserver analysis of the grading was performed by comparing the classifications based on the findings of the treating orthopaedic surgeons with those assigned by the study radiologist. Intraobserver analysis was done by comparing two sets of observations made, with a two-month interval between them, by the study radiologist, who evaluated fifty radiographs. The stem was defined as radiographically loose if there was a continuous radiolucency at the cement/stem-bone interface on either the anteroposterior or the lateral radiograph, debonding of the implant from the cement, or a cement fracture. Clinical loosening was defined as obvious motion on manual manipulation during surgery.

The fracture treatment was described and categorized. Failure was defined as any repeat surgery.

Statistical Analysis

All statistical calculations were done on a personal computer with use of SPSS for Windows 2000 (version 11.0; SPSS, Chicago, Illinois). Kaplan-Meier survival analyses[11] were performed, with the 95% confidence limits (1.96 × standard mean error) indicated on the survival curves. Other statistical methods included the t test, chi-square test, and Fisher exact test. Two-tailed tests were performed, and $p < 0.05$ was considered to be the threshold for significance.

Results

During the period from 1999 to 2000, 321 periprosthetic femoral fractures were reported to the registry. Late femoral periprosthetic fracture was the third most frequently reported cause for reoperations (responsible for 9.5% of the reoperations), after aseptic loosening (responsible for 2036 [60.1%] of the reoperations) and recurrent dislocation (responsible for 445 [13.1%] of the reoperations). Ninety-one fractures occurred after a revision procedure and 230, after a primary total hip replacement. At the time of follow-up, sixty-six of the patients had died, thirty-three were unable to answer the questionnaire because of dementia, one had emigrated, one was homeless, and three refused to return for follow-up. That left 217 patients (68%) who were able to answer the questionnaire.

TABLE II Vancouver[8] Classification of Fractures Based on Surgeons' Findings* Compared with Classification by Study Radiologist (H.R.)

Surgeons' Findings (N = 321)†	Study Radiologist's Findings (N = 307)†
A = 8	**A = 4,** B_1 = 1, B_2 = 2
B_1 = 90	A = 1, **B_1 = 31,** B_2 = 22, B_3 = 8, C = 23
B_2 = 158	B_1 = 29, **B_2 = 99,** B_3 = 18, C = 6
B_3 = 34	B_1 = 2, B_2 = 15, **B_3 = 15,** C = 1
C = 31	B_1 = 4, B_2 = 6, **C = 20**

*The first author (H.L.) classified the fractures on the basis of both the surgeons' preoperative interpretation of the radiographs and the operative report. †The values are given as the number of hips.

At the time of follow-up, fracture radiographs were available for 307 patients (96%) and postoperative radiographs were available for 295 patients (92%). The missing radiographs had either been destroyed or the patient had died postoperatively. A total of 281 patients (88%) had radiographic follow-up after the initial postoperative radiographic examination. The remainder had either died (twenty-eight patients) or were not able to take part in the radiographic examination (twelve patients). The mean follow-up time, with failure defined as a reoperation, was five years (range, 3.8 to six years).

The annual incidence of periprosthetic hip fracture was 0.13% in 1999 and 0.11% in 2000. The cumulative incidence of periprosthetic hip fracture from 1979 until 2000 was 0.4% following the primary total hip replacements and 2.1% following the revision total hip replacements.

Forty-eight percent (154) of the patients with a fracture were male, and 52% (167) were female. The mean age was 77.9 years in the primary replacement group and 73.8 years in the revision group.

An index diagnosis of hip fracture (i.e., before implantation of the hip prosthesis) was significantly more common than an index diagnosis of osteoarthritis or inflammatory arthritis in the fracture group ($p < 0.001$). The cause of the fracture was classified as spontaneous, minor trauma, or major trauma, and the majority of the fractures (81% in the primary replacement group and 70% in the revision group) were due to minor trauma. Spontaneous fractures were significantly ($p < 0.05$) more common in the revision group.

In the primary replacement group, 34% (seventy-eight) of the stems were considered to be stable, with no obvious signs of loosening. The remaining 66% (152) were loose and, among these, 47% (108 of 230) were unknown loose (first recognized as loose at the time of presentation of the fracture). In the revision group, 49% (forty-five) of the stems were stable, 51% (forty-six) were loose, and 27% (twenty-five) were unknown loose. There was a significant difference between the primary and the revision group with regard to the stability of the stems ($p = 0.005$).

During the period from 1992 to 2000, the prostheses most commonly used for primary total hip replacements in Sweden were the Lubinus (Waldemar Link, Hamburg, Germany), Charnley (DePuy Orthopaedics, Warsaw, Indiana), and Exeter (Stryker, Kalamazoo, Michigan) prostheses. One of these three implants was used in 76% of the patients in the fracture cohort. Only three patients were treated with an uncemented prosthesis. Significantly more Charnley ($p < 0.001$) and Exeter ($p < 0.001$) prostheses and significantly fewer Lubinus prostheses ($p < 0.001$) were used in the fracture group than in the patients without fractures. There were no notable differences among the three prosthetic groups (Charnley, Exeter, and Lubinus) with regard to the mean age at the time of the fracture, gender, or the time between the index operation and the primary diagnosis.

The Vancouver classifications of the fractures, based on the orthopaedic surgeons' findings, are presented in Table I. The estimated probability of agreement between these grades and the classifications assigned by the study radiologist (H.R.) was 76%, and, as seen in Table II, the disagreement was greatest with regard to the Vancouver type-B fractures. The surgeon's grade of B_1 was in agreement with the study radiologist's classification only 34% of the time (in thirty-one cases). The radiologist graded the remainder of those fractures (classified as B_1 by the surgeon) as A, B_2 or B_3 (stem loose at the time of fracture), or C. The intraobserver reliability analysis showed very good agreement (94%) between the radiologist's classifications done two months apart.

The operative techniques used for the various Vancouver categories of fractures are shown in Table III. The majority (144 [75%]) of the revisions were performed with a cemented long-stem implant. Forty-nine patients (25%) were treated

TABLE III Treatment of Fractures in Different Vancouver Categories[8]*

Method of Treatment	A (N = 8)	B_1 (N = 90)	B_2 (N = 158)	B_3 (N = 34)	C (N = 31)
Revision	25% (2)	10% (9)	31% (49)	68% (23)	6% (2)
Revision and open reduction and internal fixation	50% (4)	6% (5)	54% (86)	29% (10)	10% (3)
Open reduction and internal fixation	25% (2)	82% (74)	12% (19)	0	74% (23)
Other†	0	2% (2)	3% (4)	3% (1)	10% (3)

* The values are given as the percentage of hips with the number in parentheses. †Other = removal of the prosthesis, retrograde nailing, or nonoperative treatment with traction only.

TABLE IV Need for Additional Surgery in Relation to Fracture Treatment and Vancouver Categories[8]*

Method	A (N = 8)	B_1 (N = 90)	B_2 (N = 158)	B_3 (N = 34)	C (N = 31)
Revision	0	3 of 9 (33%)	5 of 49 (10%)	3 of 23 (13%)	0
Revision and open reduction and internal fixation	0	1 of 5 (20%)	20 of 86 (23%)	2 of 10 (20%)	1 of 3 (33%)
Open reduction and internal fixation	0	22 of 74 (30%)	6 of 19 (32%)	0	6 of 23 (26%)

*The denominators are from Table III.

with a long, distally fixed, uncemented prosthesis. The mode of fixation at the revision was based on the surgeon's preference. In general, cement was preferred at rural and central hospitals, and most of the uncemented implants were used at university hospitals. There was no significant difference, with the numbers available, in the reoperation rate following use of the cemented stems and that following use of the uncemented stems ($p = 0.26$).

The bone deficiency associated with the thirty-four type-B_3 fractures was classified according to the system described by Paprosky et al.[9,10]. No fracture was found to be associated with the more severe Paprosky types (III or IV) of bone deficiency, the majority (twenty-six) were associated with Paprosky type-II deficiency, and eight were associated with Paprosky type-I deficiency. Thirty-three of the thirty-four type-B_3 fractures were treated with revision, and one was treated with resection arthroplasty. Impacted cancellous allograft was used in fifteen patients, and a long, distally fixed uncemented prosthesis was used in twelve.

Six patients died within one week postoperatively and another thirty-six died during the first twelve months after the operation, resulting in a first-year mortality rate of 13.1%. Forty-five (14%) of the patients sustained a postoperative complication prior to discharge. The most frequent complications were dislocation (eight patients), wound infection (five), prolonged bleeding (four), and urinary tract infection (four).

By December 31, 2004, seventy-one (22%) of the original 321 patients had been operated on again, and fifty-four (17%) had the reoperation during the first twelve postoperative months. The main reasons for a reoperation were nonunion (33%), refracture (24%), and stem loosening (13%).

The need for additional surgery following treatment of the fracture was analyzed with respect to the initial surgical treatment and the Vancouver classification (Table IV). The reasons for a reoperation following open reduction and internal fixation of Vancouver type-B_1 fractures were nonunion and fracture of the plate (twelve), stem loosening (three), refracture (three), deep infection (two), and recurrent disloca-

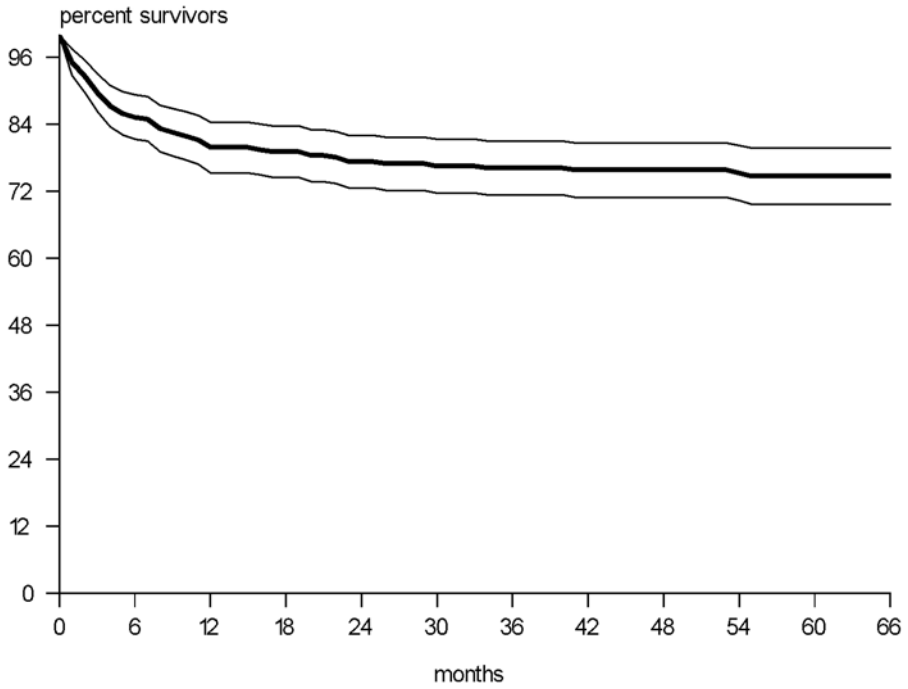

Fig. 1

Survival curve, with 95% confidence interval, for the total group of operatively treated periprosthetic femoral fractures, with failure defined as a reoperation. The 5.5-year survival rate is 74.8% ± 5.0%.

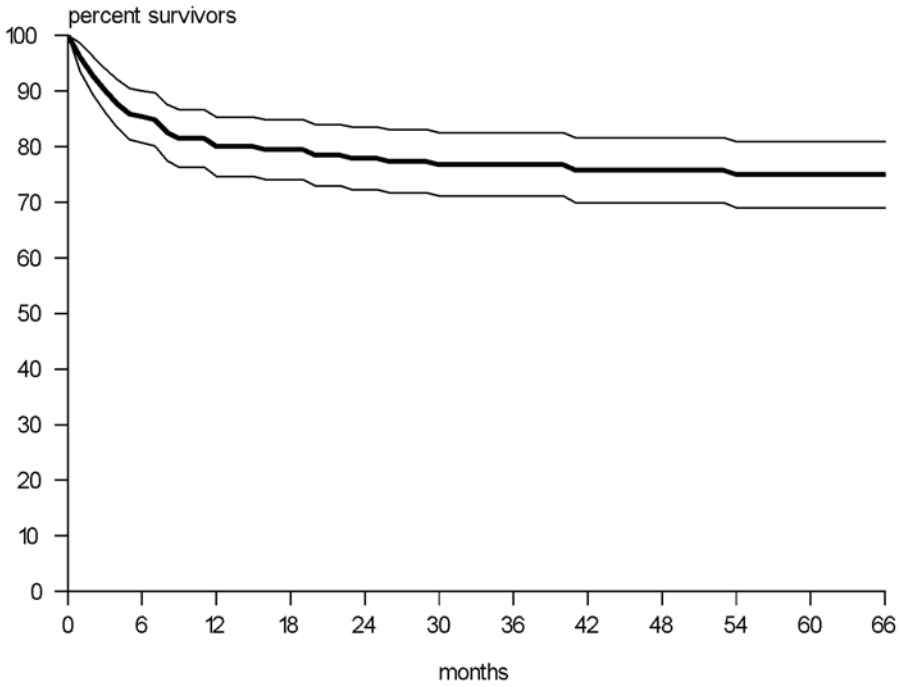

Fig. 2

Survival curve, with 95% confidence interval, for the operatively treated periprosthetic femoral fractures that occurred following a primary replacement, with failure defined as a reoperation. The 5.5-year survival rate is 74.9% ± 6.0%.

tion (two). Of the remaining type-B_1 fractures treated with open reduction and internal fixation, 23% (twelve) had no signs of fracture-healing on radiographs and 13% (seven) had callus formation but a visible fracture line.

The results of the Kaplan-Meier survival analyses are shown in Figures 1, 2, and 3. The high frequency of reoperations in the fracture group resulted in a low rate of short to mid-term prosthetic survival.

The mean Harris hip score after the operation was 67 points for the patients with Charnley category-A or B function and 59 points for those with Charnley category-C function. The mean value on the visual analogue scale for pain was 23, and the mean value on the visual analogue scale for overall satisfaction was 27. The mean EQ-5D index was 0.59, which indicates that the health-related quality of life was poor.

Discussion

This study is an example of how a nationwide observational study can be used for an analysis of an uncommon complication. Several authors[2,12] have reported an increase in the total number of late periprosthetic femoral fractures. Highly varying rates of such fractures have been reported in the literature[12-14]. The findings in this study are in accordance with those in a report from the Mayo clinic[15], in which the cumulative incidence of fractures was 0.6% after 17,579 primary total hip replacements with cement and 2.8% after 3265 revision procedures with cement.

The mean age of the patients at the time of the primary operation in the fracture group was significantly ($p < 0.001$) younger than that in the entire group of patients treated with total hip replacement. This may mean that younger, more active patients have a higher risk of loosening and thus of sustaining a periprosthetic femoral fracture.

An important observation in this study was that many of the stems in the patients who sustained the fracture after a primary replacement were considered to be loose at the time of the fracture. Bethea et al.[16] and Beals and Tower[17] also noted that many patients had a loose implant at the time of fracture. The lower prevalence of loose implants in the revision group compared with that in the primary replacement group in our study probably indicates that patients with a revision arthroplasty are more frequently monitored.

A major finding in this study was the association between the type of implant and the risk of periprosthetic fracture. The Charnley (cobra-flange-design) and the Exeter (polished) prostheses were associated with higher rates of periprosthetic fracture, and the Lubinus (SPII) was associated with a lower rate. Our findings suggest that the implant design plays a major role in fracture risk. The Charnley and Exeter stems are straight and shorter than the anatomically shaped Lubinus stem. The difficulty in positioning a straight stem and achieving an adequate cement mantle has been well described in reports on the Charnley prosthesis[18,19]. An inadequate cement mantle, with contact between the implant and the inner femoral cortex, has been correlated with long-term loosening and femoral osteolysis. Löwenhielm et al. reported that the de-

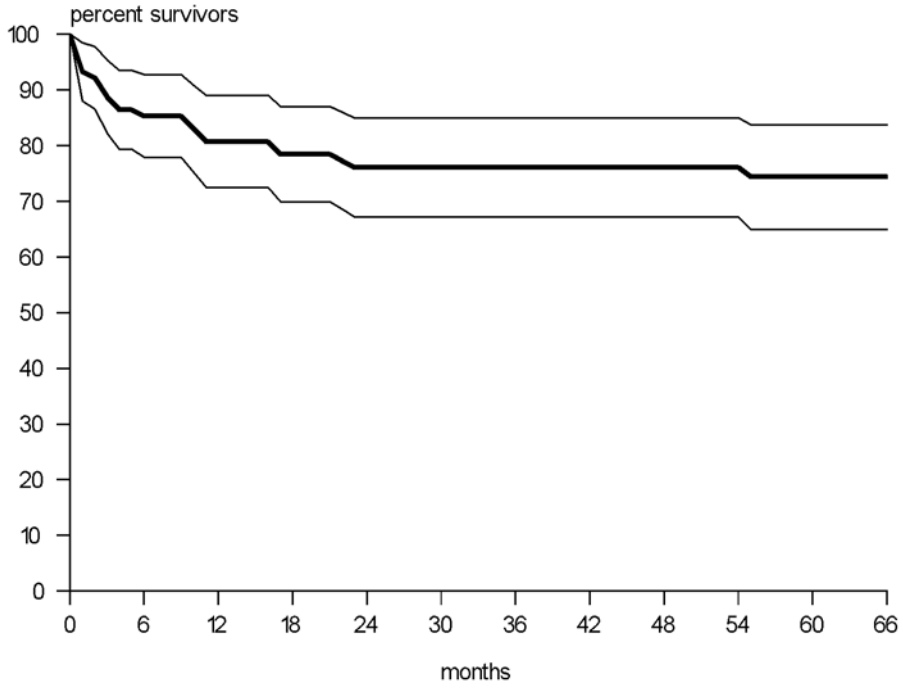

Fig. 3

Survival curve, with 95% confidence interval, for the operatively treated periprosthetic femoral fractures that occurred following a revision, with failure defined as a reoperation. The 5.5-year survival rate is 74.4% ± 6.7%.

sign of the prosthesis was related to either a proximal or a distal fracture[20].

A review of the current literature suggests that the Vancouver type-B_1 fracture is the only type that can be successfully operated on without a stem revision—i.e., that can be treated with an adequate open reduction and internal fixation[12,15,21-24].

There have been several reports on the use of conventional plates or cable-grip plates; some have demonstrated good results[25-28], and some have shown high failure rates[26,29]. In recent years, good mid-term results have been reported following the use of cortical onlay strut allografts[30-34]. Use of a cortical allograft is uncommon in Sweden, and only two cases in this study were treated with onlay grafts. We found a high frequency of repeat surgery after treatment of Vancouver type-B_1, B_2, and C fractures with open reduction and internal fixation alone. The high failure rate is likely due to an underdiagnosis of loose implants, resulting in inadequate treatment. Furthermore, typically only one plate was used for open reduction and internal fixation in Sweden. Biomechanical studies have shown superior stability when two orthogonal plates or a combination of a plate and a structural onlay allograft[35-39] is used. When a plate is used, proximal unicortical screws provide the best strength of fixation[40,41].

We found a clear difference between the assignment of the Vancouver type-B classification by the author who based it on the findings of the surgeons and that by the experienced radiologist who graded the fractures on the radiographs alone. A reason for this difference could be the suboptimal quality of the radiographs of the acute fractures and the lack of comparison with previous radiographs. When Brady et al. validated the Vancouver classification system[8], they excluded cases with poor-quality radiographs. The underestimation of the frequency of loose implants shown in our study probably explains the higher failure rates observed in patients with B_1 and C fracture patterns.

The use of allograft bone in the treatment of periprosthetic fractures has been well described[42], and it seems to be effective, with a low rate of complications, for Paprosky type-I or II bone loss. The use of a fully coated long uncemented stem in patients with minor or moderate bone defects has been described in the literature[43], but this treatment has not been widely used in Sweden. There was no notable difference in reoperation rates between the patients treated with a cemented stem and those treated with an uncemented stem in our study. However, when used for the treatment of type-B_2 and B_3 fractures, uncemented stems were associated with a lower reoperation rate. Berry reported fracture-healing in all of his eight patients in whom a type-B_3 fracture was treated with a fluted tapered modular femoral implant[44]. Kolstad reported good results following use of the long distally fixed Wagner prosthesis (Centerpulse, Winterthur, Switzerland)[45]. However, he reported a high frequency of recurrent dislocations.

Prefracture Harris hip scores were not available for the patients in our series, but the postoperative scores were low in all Charnley categories. The health-related quality of life, reported in this study as the EQ-5D index, was clearly inferior

compared with that for patients evaluated one year after a primary total hip replacement, as presented in the 2005 annual report from the Swedish National Hip Arthroplasty Register.

The high rates of major complications, reoperations, early mortality, and poor clinical outcomes indicate substantial morbidity for patients with a periprosthetic fracture and consequently high costs for society. Several authors[7,12,21,22] have identified the need for a standardized classification and an adequate treatment algorithm for late femoral periprosthetic fractures. The results of this registry analysis strongly support such a need.

In conclusion, it seems that classifying a periprosthetic femoral fracture in the Vancouver B category is difficult and inconsistent. Surgical exploration of the joint is therefore recommended for all patients with a Vancouver B fracture pattern assessed radiographically. If there is doubt regarding the fixation status of the stem, revision of the femoral implant and open reduction and internal fixation of the fracture are recommended.

We also concluded that implant-related factors are associated with periprosthetic fractures. These factors should be considered when the surgeon is selecting an implant for a primary total hip replacement. Periprosthetic fractures are rather uncommon complications, and it is therefore difficult for the individual surgeon to obtain adequate training to address them. We therefore propose centralization of these technically demanding cases in a few experienced centers to optimize treatment. ■

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