Late peri-prosthetic femoral fracture as a major mode of failure in uncemented primary hip replacement

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Peri-prosthetic femoral fracture after total hip replacement (THR) is associated with a poor outcome and high mortality. However, little is known about its long-term incidence after uncemented THR.

We retrospectively reviewed a consecutive series of 326 patients (354 hips) who had received a CLS Spotorno replacement with an uncemented, straight, collarless tapered titanium stem between January 1985 and December 1989. The mean follow-up was 17 years (15 to 20). The occurrence of peri-prosthetic femoral fracture during follow-up was noted. Kaplan-Meier survival analysis was used to estimate the cumulative incidence of fracture.

At the last follow-up, 86 patients (89 hips) had died and eight patients (eight hips) had been lost to follow-up. A total of 14 fractures in 14 patients had occurred. In ten hips, the femoral component had to be revised and in four the fracture was treated by open reduction and internal fixation. The cumulative incidence of peri-prosthetic femoral fracture was 1.6% (95% confidence interval 0.7 to 3.8) at ten years and 4.5% (95% confidence interval 2.6 to 8.0) at 17 years after the primary THR. There was no association between the occurrence of fracture and gender or age at the time of the primary replacement.

Our findings indicate that peri-prosthetic femoral fracture is a significant mode of failure in the long term after the insertion of an uncemented CLS Spotorno stem. Revision rates for this fracture rise in the second decade. Further research is required to investigate the risk factors involved in the occurrence of late peri-prosthetic femoral fracture after the implantation of any uncemented stem, and to assess possible methods of prevention.

Peri-prosthetic femoral fracture after total hip replacement (THR) is associated with a poor clinical outcome and a high rate of post-operative complications. Besides considerable loss of function, it has a high mortality rate similar to that after fracture of the hip. The incidence of peri-prosthetic femoral fracture seems to be increasing worldwide, making it an important issue of health policy.

It is difficult to estimate the true incidence of this fracture because of the heterogeneous case mix and differing periods of follow-up, with reported incidence ranging from 0.1% to 2.3%. In a recent study a cumulative incidence of fracture of 3.5% was found at ten years after primary cemented THR, suggesting that it is more common than was previously thought.

Uncemented femoral implants of modern design show encouraging survival in the long term, with an excellent clinical outcome and persisting osseo-integration even in young patients. However, there have been few studies which have examined the incidence of peri-prosthetic femoral fracture after the implantation of uncemented stems, and to our knowledge, there have been no long-term studies.

Our primary aim therefore was to investigate the cumulative incidence of peri-prosthetic femoral fracture after the insertion of one type of uncemented femoral stem commonly used for THR using long-term survivorship analysis.

Patients and Methods

We retrospectively reviewed a consecutive series of 326 patients (354 hips) who had undergone THR using an uncemented, straight, collarless tapered titanium stem (CLS Spotorno; Zimmer Inc., Warsaw, Indiana) between January 1985 and December 1989 to determine the occurrence of peri-prosthetic femoral fracture during the follow-up period. There were 178 hips in 166 men and 176 hips in 160 women with a mean age of 57 years (13 to 81). The mean body mass index was 27 kg/m^2 (19 to 40). The left hip was involved in 175 patients and the right in 179.
The indications for using this implant were the absence of severe deformity of the femoral canal and adequate bone stock for uncemented fixation using the index of Singh, Nagrath and Maini,31 as described by Spotorno et al.32 We used either a modified Watson-Jones33 or the transgluteal lateral approach according to Bauer et al14 with the patient in the supine position. The surgical techniques and survival rates for this implant have been described previously.23,25 The mean follow-up was 17 years (15 to 20). During this period, 86 patients (89 hips) died and eight patients (eight hips) were lost to follow-up, of whom four had moved abroad. At the time of the most recent review, 35 stems had been revised for isolated failure of the femoral component. Details of the diagnoses leading to THR are given in Table I.

The patients were followed up at three and six months, at one year and yearly thereafter. Data were retrieved from a permanent continuous electronic database. Clinical and radiological data of all the patients with a peri-prosthetic femoral fracture were obtained directly from the medical records at our hospital or were acquired when revision surgery was performed elsewhere. The alignment of the stem in the coronal plane was determined on anteroposterior (AP) radiographs of the hip by measuring the angle formed between the long axis of the prosthesis and the long axis of the femur.35 We also further evaluated the intramedullary position of the tip of the stem in the coronal and the sagittal planes on AP and lateral radiographs. Filling of the femoral canal, measured as the ratio of the width of the stem to the width of the medullary canal was determined at 3 cm below the lesser trochanter on the initial post-operative AP radiograph.36 Subsidence of the stem was defined as distal migration of at least 5 mm of the distance between the proximal shoulder of the femoral component and the greater trochanter when the initial post-operative radiographs were compared with those taken at the follow-up by an author (MRS).

The fractures were classified by two independent experienced orthopaedic surgeons (MC, PRA) according to the Vancouver classification,37 which is reproducible and reliable.38 Vancouver type-A fractures are located at the lesser trochanter (AL) and at the greater trochanter (AG). Type-B fractures are located around or just below a well-fixed stem (B1), around or just below a loose stem with adequate bone stock (B2), around or just below a loose stem with poor proximal bone stock (B3). Type-C fractures are located well below the stem. We included all types of fracture in the study. Minor trauma was defined as a fall to the floor at the same level on which the patient had been standing or sitting. Major trauma included traffic accidents and any other high-energy trauma. Spontaneous fractures were defined as those which occurred without a fall or obvious trauma.

All the patients gave informed consent to participate in the study, which was approved by our institutional review board, and carried out in accordance with the Declaration of Helsinki, as revised in 2000.39,40

**Statistical analysis.** The Kaplan-Meier method using re-operation for a peri-prosthetic femoral fracture as the endpoint was used to calculate the cumulative incidence of fracture after primary THR, assessed with 95% confidence intervals (CI). The patients were censored at death, at revision of the stem for reasons unrelated to their fracture or at final follow-up, whichever came first. Differences in the cumulative incidence between different groups of patients were tested for statistical significance using the two-sided log-rank test. Continuous variables were compared using a two-sided Student t-test. We considered a p-value ≤ 0.05 to be significant. Data were recorded and analysed using SPSS version 17.0 (SPSS Inc., Chicago, Illinois) and Graphpad Prism version 5.0 (Graphpad Software, San Diego, California) software.

**Results**

During the follow-up period, 14 peri-prosthetic femoral fractures occurred in 14 patients (Fig. 1). There were seven men with a mean age of 52.4 years (47 to 59) and seven women with a mean age of 60.3 years (47 to 70). The mean time from primary THR to fracture was 11.8 years (3.4 to 17.2) for male patients and 11.6 years (3.4 to 18.2) for female patients, respectively; Student’s t-test, p = 0.94.

| Table I. Details of the diagnosis in the 354 hips |
|----------------------|----------------------|
| Diagnosis            | Hips (%)             |
| Osteoarthritis       | 188 (53.1)           |
| Congenital hip dysplasia | 85 (24.0)         |
| Avascular necrosis   | 39 (11.0)            |
| Post-traumatic osteoarthritis | 21 (5.9)      |
| Rheumatoid arthritis | 6 (1.7)              |
| Neck fracture         | 6 (1.7)              |
| Others               | 9 (2.5)              |
| Previous osteotomies | 57 (16.1)            |
There was also no significant difference in the mean age at the time of THR between patients with a subsequent fracture and those without (56.4 years (47 to 70) versus 56.1 years (13 to 81), respectively; Student’s t-test, p = 0.93).

In ten patients the fracture was caused by minor trauma, and in three by major trauma. In one patient it occurred spontaneously on turning while standing on the affected limb. In all cases, the peri-prosthetic femoral fracture was the only injury sustained. At the last follow-up before fracture, the stem was considered to be stable in all the patients and there were no planned stem revisions. No patient with this fracture reported any problems related to the hip before the fracture. The mean interval between last review and fracture was 3.1 years (0.5 to 11.3).

Of the stems with a peri-prosthetic femoral fracture, four had a varus alignment of > 2°. None had varus alignment of > 5° or valgus alignment of > 2°. The intramedullary position of the tip of the stem was central in eight hips, lateral in two, anterolateral in one, posterolateral in one hip and posterior in one. In the remaining hip we could not accurately determine the position of the tip in the sagittal plane because of an inadequate lateral radiograph.

There was no significant difference in the mean filling of the canal for hips with and without a fracture (81.0% (69.6% to 100.0%) vs 83.3% (52.2% to 100.0%), respectively; Student’s t-test, p = 0.37). Of the hips evaluated radiologically at a minimum of 15 years, one hip had > 2 mm of subsidence of the stem. In this case, the stem showed early subsidence, which stabilised at 12 months after operation without further clinical or radiological signs of loosening at follow-up. In the patients who sustained a peri-prosthetic femoral fracture, subsidence had not been found at the last follow-up before the fracture occurred.

**Discussion**

As stated in the introduction, the true incidence of peri-prosthetic femoral fracture after THR may have been under-reported. We found a cumulative incidence of 4.5% (95% CI 2.6 to 8) at 17 years after primary uncemented THR. The rate of fracture was low until the eighth post-operative year.
and showed a continuous rise thereafter into the second decade (Fig. 3). These findings suggest that peri-prosthetic femoral fracture becomes an increasingly relevant mode of failure in the long term. In our present series, we found that there were two main modes of failure around uncemented tapered stems, which were aseptic loosening and peri-prosthetic femoral fracture, which had a similar cumulative incidence at 17 years after primary THR (Fig. 4).

The lower incidence of peri-prosthetic femoral fracture in previous studies may have been due to failure to use survivorship analysis to evaluate the fracture rate over time which extended to a maximum of 15 years in these reports, and failure to include all types of fracture. Additionally it is possible that not all the information was included in registry reports, as surgeons may have considered some femoral fractures to be unrelated to the implant. In many follow-up studies, revision of the stem is applied as the endpoint but not re-operation related to peri-prosthetic femoral fracture when the stem is well fixed. In our study, we chose a consecutive series of primary THRs with one type of femoral component, thereby avoiding any confounding due to differences in the design, and analysed the incidence of fracture using the Kaplan-Meier method of estimating survival.

Recent studies have contributed to a better understanding of the aetiology and risk factors for peri-prosthetic femoral fractures. The Swedish Hip Registry has identified minor trauma as a major risk factor, accounting for approximately 75% of late peri-prosthetic femoral fractures, a finding reflected in our study. Furthermore, aseptic loosening has been shown to be an important risk factor for this fracture after cemented THR. Although two hips showed significant osteopenia of the proximal femur at the time of fracture, in our study using uncemented stems we did not find pre-fracture evidence of loosening of the femoral component at the last follow-up examinations. At the last clinical and radiological evaluation before peri-prosthetic femoral fracture, all the stems were considered to be well fixed. No patient reported any problems related to the hip before the fracture while those with late aseptic loosening often described the sudden onset of pain. The mean filling of the canal in hips with a peri-prosthetic femoral fracture was not significantly different from that in hips without a fracture. It has been reported previously with this stem that aseptic loosening rarely occurs when the stem is undersized. Therefore we assume that the ten stems found to be loose intra-operatively had traumatic loosening, although pre-fracture loosening after the last follow-up cannot be excluded completely. The importance of aseptic loosening as a predisposing factor for peri-prosthetic femoral fracture may differ between cemented and uncemented THR. Other generally accepted risk factors for these fractures are osteoporosis, osteolysis, and several pre-operative diagnoses, in particular rheumatoid arthritis and hip fracture as indication for the original THR. Other factors such as age, gender, the type of implant, and the method of fixation used show no consistency in the literature as risk factors. In our study, no significant difference in the incidence of peri-prosthetic femoral fracture in relation to gender or age at the time of primary THR was found. We could not find a relationship between the intramedullary position of the tip or alignment of the stem and the incidence of fracture. However, the primary weakness of
our study is its relatively low power to reveal relevant risk factors because of the small number of fractures and a relatively small series of 354 hips compared with various national registries.

Findings in our study suggest that minor trauma resulting from a fall plays the most important role in the pathogenesis of peri-prosthetic femoral fracture after uncemented THR. The same mechanism is known to account for approximately 90% of hip fractures in the elderly.\(^{54}\) As the risk of falling established in previous research varies from 28% to 70% per year among subjects aged 65 years and older,\(^{55-59}\) and the incidence of falls rise with increasing age,\(^ {60,61}\) we believe that this accounts for the rising incidence of peri-prosthetic femoral fracture in the second decade after primary THR.

The findings of our study may not apply to all types of cementless stem. The CLS Spotorno stem is designed to achieve press-fit fixation in the proximal femur, so it could be speculated that proximal stress concentration during a fall involving impact may be a pathogenic factor, especially in an ageing skeleton. Implant-related bone remodelling may also have some relevance. Further studies are necessary to decide whether the design of the implant has an influence on the incidence of fracture in the long term after the implantation of uncemented stems.

In conclusion, our findings indicate, besides aseptic loosening, peri-prosthetic femoral fracture is a major mode of failure in the long term after an uncemented THR. Rates of revision for this problem rise in the second decade. It is likely that longer periods of follow-up will show more fractures in the third decade. We believe that at this time there is insufficient evidence available to conclude whether or not cemented or cementless fixation makes a difference regarding the incidence of such fractures in the long term. Despite this important complication, the 17-year re-operation rate for all problems related to the femoral component is still low and the device remains in continued use for uncemented THR. Further evaluation should focus on the risk factors for these fractures after uncemented THR and the development of prevention strategies.

**References**


LATE PERI-PROSTHETIC FEMORAL FRACTURE AS A MAJOR MODE OF FAILURE IN UNCEMENTED PRIMARY HIP REPLACEMENT


