■ HIP

Periprosthetic femoral fracture following primary hip arthroplasty

SHOULD THE CHOICE OF FEMORAL COMPONENT DESIGN AND FIXATION METHOD VARY ACCORDING TO THE SEX AND AGE OF THE PATIENT?

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Aims

Periprosthetic femoral fracture is a severe complication following hip arthroplasty, influenced by the design of the femoral component and the method of fixation. The aim of this study was to investigate the influence of sex and age on the risk of reoperation for periprosthetic femoral fracture.

Methods

We analyzed 204,041 primary hip arthroplasties from the Norwegian Arthroplasty Register and the Norwegian Hip Fracture Register (1 January 2005 to 31 December 2025). Femoral components were categorized as cemented composite beam (CB), cemented polished taper-slip (PTS), uncemented collarless (UCC-), and uncemented collared (UCC+). Cox regression analysis was used to compare the risk (adjusted hazard rate ratio (aHRR)) of reoperation for periprosthetic femoral fracture stratified by sex and age.

Results

In males, PTS and UCC- had a nine-times higher risk of reoperation for periprosthetic femoral fracture than CB. For UCC+, the risk was four times higher than CB. The risk of reoperation for periprosthetic femoral fracture was increased in males aged > 65 years for UCC-; for UCC+ the risk was increased in males aged > 75 years, whereas PTS had higher risk for periprosthetic femoral fracture at all ages, compared with CB. In females, the risk of reoperation for periprosthetic femoral fracture was increased in those aged > 70 years for PTS and UCC+ compared with CB, whereas for UCC- the risk of periprosthetic femoral fracture was higher in those aged > 60 years, compared with CB.

Conclusion

Our findings suggest that CB should be the preferred choice of femoral component, at least for males aged > 75 years and females aged > 70 years. UCC+ components were the best uncemented option, while the use of PTS components was associated with a high risk of periprosthetic femoral fracture among males of all ages.

Cite this article: ***Bone Joint J*** **2026;108-B(11):1325–1334.**

Introduction

Periprosthetic femoral fracture is a common indication for reoperation following total hip arthroplasty (THA) and hemiarthroplasty (HA), with an increasing incidence.[1,2] It is associated with increased morbidity and mortality, and decreased quality of life.[3,4] Osteoporosis, advanced age, and femoral neck fracture as the indication for the THA have all been associated with an increased risk of periprosthetic femoral fracture.[5] The lowest risk of reoperation for periprosthetic femoral fracture has been reported to be for THAs involving cemented composite beam (CB) femoral components,[2,6] and better results for uncemented collared components (UCC+) compared with cemented polished taper-slip (PTS) components and uncemented collarless components (UCC-).[2] We have previously reported a lowest risk of reoperation for periprosthetic femoral fracture and all-cause femoral component revision for CB compo-

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doi:10.1302/0301-620X.108B11.BJJ-2026-0178.R1 $2.00

Bone Joint J 2026;108-B(11):1325–1334.

Table I. Femoral component brands, manufacturer and number of components included and their Orthopaedic Data Evaluation Panel (ODEP) rating, number of females, follow-up, and the design and method of fixation groups into which they were allocated.

Femoral component design	ODEP rating	Manufacturer	Arthroplasties, n	Female, %	Median follow-up, yrs (IQR)
Total			204,041		4.8 (1.8 to 9.1)
Cemented composite beam				70	2.9 (1.0 to 6.2)
Lubinus SPII	15 A*	Waldemar Link, Germany	32,158	70	2.9 (1.0 to 6.2)
Cemented polished taper-slip				70	4.1 (1.5 to 8.0)
Exeter	15 A*	Stryker, USA	55,236	69	5.0 (1.9 to 9.5)
C-Stem	15 A*	DePuy Synthes, USA	12,299	72	2.3 (0.9 to 4.4)
MS-30	15 A*	Zimmer Biomet, USA	6,713	72	2.9 (1.3 to 5.0)
Uncemented collarless				60	8.1 (3.4 to 12.1)
Corail collarless	15 A*	DePuy Synthes, USA	39,982	62	9.1 (5.1 to 12.9)
POLARSTEM	10 A*	Smith & Nephew, UK	5,268	51	2.1 (0.8 to 4.8)
Accolade 2	10 A	Stryker, USA	2,981	54	6.3 (4.0 to 9.1)
Uncemented collared				58	4.7 (2.2 to 8.2)
Corail collared	15 A*	DePuy Synthes, USA	49,376	58	4.2 (1.7 to 7.3)

nents; however, in that study we adjusted for (but did not stratify) sex and age, which has subsequently been reported to be of significance.[6,7]

Which component design and fixation method to select for hip arthroplasty, in order to protect against periprosthetic femoral fracture, remains controversial.[2,8] The aim of this study was to investigate how sex and age influence the risk of reoperation for postoperative periprosthetic femoral fracture for different femoral component designs and fixation methods. For comparison, we also assessed further femoral operations for any indication, including osteosynthesis, for different designs of femoral component and methods of fixation.

Methods

We explored data on primary cemented CB, cemented PTS, and UCC- and UCC+s from the THAs reported to the Norwegian Arthroplasty Register (NAR) and HAs reported to the Norwegian Hip Fracture Register (NHFR) between 1 January 2005 and 31 December 2025. The NAR has recorded detailed information about primary and revision THAs since 1987, and information on any reoperations such as osteosyntheses for periprosthetic femoral fracture since 2016.[1] The NHFR has recorded detailed information about HAs for hip fractures and all reoperations including revisions since 2005.[1]

Both registers collect data on patients' identity, the date of operation, the indication for arthroplasty or reoperation, laterality, the type of implant including the catalogue number, the method of fixation, and other surgery-related factors. Patient-related details including sex, age, and comorbidities (American Society of Anesthesiologists grade)[9] are also recorded.[1] The National Population Register provides information about death and emigration for all Norwegian citizens. The personal identification number of each citizen is used in combination with laterality to link the primary arthroplasties to any subsequent procedure and information about death or emigration.

A reoperation for periprosthetic femoral fracture in the NAR and NHFR is defined as any surgical procedure following arthroplasty including revision and/or osteosynthesis with plates, screws, and/or wires. A revision is defined as a reoperation including removal or exchange of any prosthetic component. The surgeon reports to the registers immediately after surgery, either electronically or on paper.

The NAR has 97% completeness of reporting primary THAs and 91% of reporting any revisions, whereas the NHFR has 92% completeness of reporting primary HAs and 88% of reporting reoperations. Both registers have 100% cover of Norwegian hospitals, and mortality.[1]

The femoral components were classified into four groups according to the design and method of fixation: CB, PTS, UCC-, and UCC+.[6] Only common (n > 2,000), contemporary (still in use and n > 100 in the last year of the study period), and well-documented components were included (Table I). A femoral component was considered well-documented if its Orthopaedic Data Evaluation Panel rating was ≥ 10 A.[10] The selection of cases and allocation to the four groups in males and females, respectively, is shown in Figure 1. A total of 204,041 cases with complete information of covariates were eligible for analyses: 150,080 from the NAR and 53,961 from the NHFR.

The assessment of the risk of reoperation for periprosthetic femoral fracture was performed in a stepwise manner. We stratified the patients first by sex, and then we stratified each sex into five-year age groups from the age of 60 to 90 years. Based on these findings, we then grouped both sexes into four groups (< 65 years, 65 to 74 years, 75 to 85 years, and > 85 years) for sufficient statistical power in the detailed assessment. These eight groups were subsequently investigated for the risk of reoperation for periprosthetic femoral fracture, and the risk of further femoral surgery for any indication including osteosynthesis, for the four designs of component and methods of fixation, in addition to each individual brand. Lastly, we assessed the sub-groups of robust patients (aged < 75 years, and ASA grade I or II, and arthroplasty due to osteoarthritis (OA)) and frail patients (aged > 75 years, ASA grade III or IV, and arthroplasty due to hip fracture) to assess the association between the design of the component and method of fixation and reoperation for periprosthetic femoral fracture in these 'in extremis' groups. Frailty is a state of reduced physiological reserve and increased vulnerability to stress, and may be graded using, for instance, the Clinical Frailty Scale,[11] which is not reported either in the the NAR or the NHFR. We therefore assessed it using an alter-

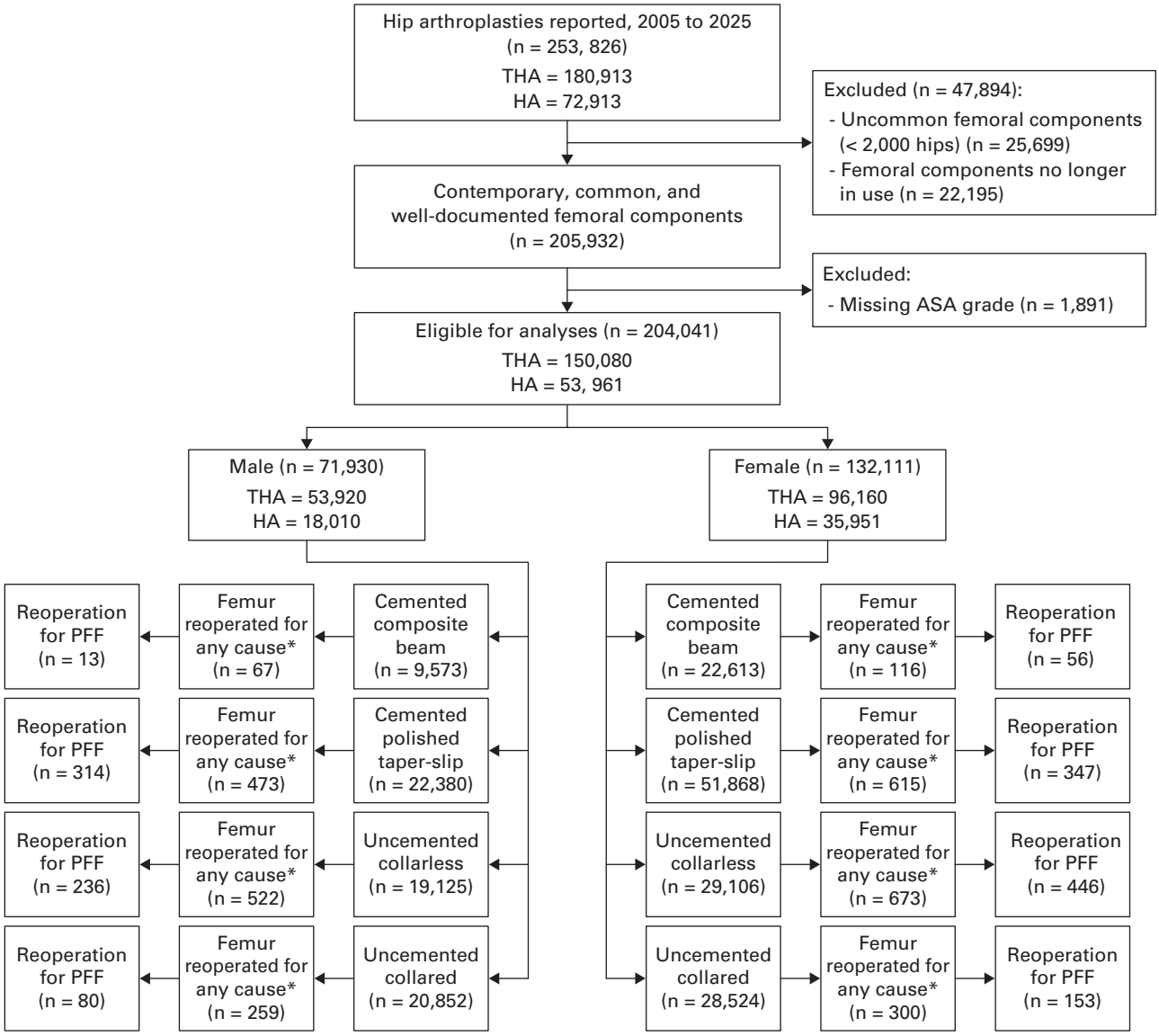


Fig. 1

Flowchart of inclusion and exclusion of hip arthroplasties from the Norwegian Arthroplasty Register (NAR) and the Norwegian Hip Fracture Register (NHFR), divided into the design of the femoral component and method of fixation groups, males and females, and with subsequent outcomes. *Including osteosyntheses. ASA, American Society of Anesthesiologists; HA, hemiarthroplasty; PFF, periprosthetic femoral fracture; THA, total hip arthroplasty.

native, composite definition of frail (aged > 75 years, ASA grade III or IV, and arthroplasty for hip fracture) and robust (aged < 75 years, ASA grade I or II, and arthroplasty for OA) patients.

Statistical analysis. In order to assess differences in risk of reoperation between the designs and methods of fixation, Cox regression models were applied. Survival curves were constructed using adjusted Cox regression models. The primary outcome was any reported reoperation for periprosthetic femoral fracture as defined above. Secondary outcomes were femoral reoperations for any indications including osteosynthesis. All patients were followed until their first reoperation for periprosthetic femoral fracture, reoperation for other indications, date of death or emigration, or until 31 December 2025.

Adjusted hazard rate ratios (aHRRs) were estimated as an expression of risk. In addition, competing risk analyses where other reoperations (including revision of the acetabular component or death) were considered as competing causes, were performed using the Fine & Gray model, estimating adjusted subdistribution hazard ratio (aSHR). The analyses were adjusted for sex, age, ASA grade, and indication for arthroplasty, when appropriate. Adjustments for the year of arthroplasty were also performed to account for change in reporting, changes in surgical strategy, and other factors over time.

The aHRRs and aSHR are presented with 95% CIs. When the value '1' was not within the borders of the 95% CI (for the aHRR and aSHR), we considered that there was a statisti-

Table II. The primary arthroplasties and reoperations for periprosthetic femoral fracture (PFF).

Risk factor	Male			Female		
	Arthroplasties, n	Reoperated for PFF, n	aHRR (95% CI)*	Arthroplasties, n	Reoperated for PFF, n	aHRR (95% CI)*
Age, yrs						
< 65	22,212	129	Reference	31,318	173	Reference
65 to 74	21,798	219	1.8 (1.4 to 2.3)	39,708	345	1.9 (1.6 to 2.3)
75 to 84	18,974	219	2.6 (2.0 to 3.3)	39,902	364	2.9 (2.4 to 3.6)
≥ 85	8,946	76	2.7 (2.0 to 3.8)	21,183	120	3.0 (2.3 to 3.9)
ASA grade						
I	9,651	53	Reference	14,299	110	Reference
II	35,462	325	1.7 (1.3 to 2.4)	76,161	608	1.2 (1.0 to 1.5)
III	24,472	247	2.3 (1.7 to 3.2)	38,580	269	1.4 (1.1 to 1.8)
IV	2,345	18	3.0 (1.7 to 5.3)	3,071	15	1.7 (1.0 to 3.0)
Indication for primary arthroplasty						
Osteoarthritis	41,460	366	Reference	75,949	628	Reference
Inflammatory hip disease	738	4	0.6 (0.2 to 1.5)	1,856	12	0.8 (0.4 to 1.3)
Acute hip fracture	20,342	189	1.6 (1.3 to 2.0)	40,011	231	1.1 (1.0 to 1.4)
Complications after a hip fracture	2,382	37	2.0 (1.4 to 2.7)	3,535	56	2.1 (1.6 to 2.7)
Complications after childhood hip disease	4,480	22	0.7 (0.5 to 1.1)	7,763	50	1.0 (0.4 to 2.5)
Osteonecrosis of the femoral head	1,946	20	1.5 (0.9 to 2.3)	2,389	21	1.4 (0.9 to 2.2)
Other diagnosis	582	5	1.2 (0.5 to 3.0)	608	4	0.9 (0.4 to 2.5)
Frailty of the patient						
Robust (< 75 yrs, ASA < 3, OA)	24,991	165	Reference	44,137	309	Reference
Intermediate frailty	35,787	388	2.1 (1.7 to 2.5)	67,679	605	2.0 (1.7 to 2.3)
Frail (> 75 yrs, ASA > 2, hip fracture)	11,152	90	3.5 (2.6 to 4.7)	20,295	88	2.3 (1.8 to 3.0)

*Adjusted for age, ASA grade, indication for primary arthroplasty, and year of primary surgery when appropriate.
AHRR, adjusted hazard rate ratio; ASA, American Society of Anesthesiologists.

cally significant difference between categories for that variable. We used SPSS v. 29.0 (IBM, USA) and RStudio v. 2025.05.1 + 513 (Posit, USA) software for the analyses. The study was performed in accordance with the STROBE statement and the guidelines for statistical analyses of arthroplasty register data.[12]

Results

We included 204,041 arthroplasties, 150,080 (74%) THAs registered in the NAR and 53,961 (26%) HAs registered in the NHFR (Figure 1). PTS was the most used design of femoral component, followed by UCC+ and UCC- (Table I and Figure 1). There were 71,930 males (35%) and 132,111 females (65%). For both males and females, the risk of sustaining a periprosthetic femoral fracture increased with age, increasing comorbidity, and when the indication for surgery was a fracture or a complication following a fracture (Table II). Patients treated with uncemented femoral components were younger and had less comorbidity (lower mean ASA grade) than those treated with cemented femoral components. Most patients with a hip fracture were treated with a cemented femoral component, whereas most of those who were treated with an uncemented component had OA (Table III).

Out of 204,041 primary hip arthroplasties, 1,645 (0.80%) required a later reoperation for a periprosthetic femoral fracture (0.89% in males and 0.76% in females). Males had a higher risk of reoperation for periprosthetic femoral fracture (aHRR 1.4 (95% CI 1.2 to 1.5)) compared with females. The risk of reoperation for periprosthetic femoral fracture for males and females in the four groups, and the individual brands, are shown in Table IV (femoral component groups) and Supplementary Table i (brands of femoral component). The results of all-cause femoral reoperation including osteosynthesis, are also shown. Applying a competing risk model only showed minor changes (Table IV). Survival curves are shown in Figures 2 and 3.

In males, the PTS and UCC- designs had a nine-times higher risk of reoperation for periprosthetic femoral fracture than the CB design. The corresponding risk for UCC+ was four times higher than for CB. Compared with Lubinus SPII, PTS, UCC-, and UCC+ brands had higher risk of reoperation for periprosthetic femoral fracture (Supplementary Table i). In females, CB was associated with a low risk of reoperation for periprosthetic femoral fracture compared with the other designs and methods of fixation. UCC- had a more than six-times higher risk of reoperation for periprosthetic femoral fracture compared with CB. The corresponding risk for PTS and UCC+ was two to three times higher than for CB. All PTS, UCC-, and UCC+ brands had a higher risk of reoperation for periprosthetic femoral fracture compared with the Lubinus SPII femoral component.

In males, based on five-year age intervals, the risk of reoperation for periprosthetic femoral fracture increased in those aged > 65 years for UCC- compared with CB, whereas for UCC+ the risk was increased at age > 75 years. PTS had a higher risk for periprosthetic femoral fracture at all ages, compared with CB (Supplementary Table ii and Figure 4). When grouped into four age groups, PTS and UCC- had an increased risk of reoperation for periprosthetic femoral fracture in males of all ages, whereas the risk was increased at age > 75 years for UCC+,

Table III. Characteristics of the patients and distribution of risk factors in the design and method of fixation groups, for males and females, respectively.

Variable	Cemented composite beam	Cemented polished taper-slip	Uncemented collarless	Uncemented collared
Males				
Median age, yrs (IQR)	73 (64 to 81)	77 (71 to 84)	65 (57 to 73)	67 (59 to 74)
Mean ASA grade (SD)	2.2 (0.7)	2.5 (0.7)	2.0 (0.7)	2.1 (0.7)
Indication, n (%)				
Osteoarthritis	3,629 (38)	8,660 (38)	13,310 (70)	15,861 (76)
Inflammatory hip disease	80 (1)	153 (1)	216 (1)	289 (1)
Acute hip fracture	5,035 (53)	11,581 (52)	1,947 (10)	1,779 (9)
Complications after hip fracture	382 (4)	717 (3)	821 (4)	462 (2)
Avascular necrosis of the femoral head	170 (2)	762 (3)	1,932 (10)	1,616 (8)
Complications of childhood hip disease	216 (2)	375 (2)	675 (4)	680 (3)
Other diagnosis	61 (1)	132 (1)	224 (1)	165 (1)
Type of arthroplasty (register), n (%)				
THA (NAR)	5,066 (53)	11,811 (53)	17,528 (92)	19,515 (94)
HHA (NHFR)	4,507 (47)	10,569 (47)	1,597 (8)	1,337 (6)
Females				
Median age, yrs (IQR)	78 (72 to 84)	78 (72 to 84)	66 (59 to 74)	67 (60 to 74)
Mean ASA (SD)	2.4 (0.6)	2.4 (0.7)	2.0 (0.6)	2.0 (0.6)
Indication, n (%)				
Osteoarthritis	11,189 (50)	23,754 (46)	19,781 (68)	21,225 (74)
Inflammatory hip disease	336 (1)	569 (1)	423 (1)	528 (2)
Acute hip fracture	9,334 (41)	23,486 (45)	3,837 (13)	3,354 (12)
Complications of a hip fracture	712 (3)	1,545 (3)	886 (3)	392 (1)
Avascular necrosis of the femoral head	491 (2)	1,456 (3)	3,450 (12)	2,366 (8)
Complications of childhood hip disease	447 (2)	849 (2)	556 (2)	537 (2)
Other diagnosis	104 (1)	209 (0)	173 (1)	122 (1)
Type of arthroplasty (register), n (%)				
THA (NAR)	14,254 (63)	30,378 (59)	25,831 (89)	25,697 (90)
HHA (NHFR)	8,359 (37)	21,490 (41)	3,275 (11)	2,827 (10)

ASA, American Society of Anesthesiologists; HHA, hip hemiarthroplasty; NAR, Norwegian Arthroplasty Register; NHFR, Norwegian Hip Fracture Register; THA, total hip arthroplasty.

compared with CB (Supplementary Tables iii and iv and Supplementary Figure a).

In females, based on five-year age intervals, the risk of reoperation for periprosthetic femoral fracture increased > 70 years for PTS and UCC+ compared with CB, whereas for UCC- the risk for periprosthetic femoral fracture was higher in those aged > 60 years (Supplementary Table ii and Figure 4). When grouped into four age-groups in females, UCC- had an increased risk of reoperation for periprosthetic femoral fracture in all ages, whereas the risk was increased in those aged > 65 years for PTS and UCC+, compared with CB (Supplementary Tables iii and iv and Supplementary Figure a).

Out of 204,041 primary hip arthroplasties, 3,025 (1.48%) required a femoral reoperation for any indication (1.84% in males and 1.30% in females). This risk was increased in males aged > 70 years for PTS and UCC-, and > 75 years for UCC+, compared with CB (Supplementary Tables ii to iv, Supplementary Figure b, Figure 4). For females, the corresponding risk was seen at > 65 years for UCC-, and > 70 years for PTS and UCC+

In robust males, UCC+ had a similar risk of reoperation for periprosthetic femoral fracture compared with CB, whereas PTS had an almost ten-times increased risk (Supplementary Table v). In frail males, all designs other than CB had a substantially increased risk of reoperation for periprosthetic femoral fracture, particularly pronounced for UCC-. In both robust and frail females, all other designs had a higher risk of reoperation than CB. In both frail males and females, the risk of periprosthetic femoral fracture was particularly high for uncemented femoral components (UCC- and UCC+).

Discussion

The main finding of this registry-based observational study on well-documented femoral components was that CB was associated with the lowest risk of reoperation for periprosthetic femoral fracture in both males and females, for most age groups, and in both robust and frail patients. UCC+ was the best alternative for males aged < 75 years, and for females aged < 70 years the best alternatives were PTS and UCC+. The risk of reoperation for a periprosthetic femoral fracture was considerably higher for PTS in males of all ages compared with CB.

These results are in line with several previous studies reporting that the CB design carries a low risk of periprosthetic femoral fracture,[2] and the use of an UCC+ design has shown better outcomes compared with UCC-.[6,13] Lamb et al[14] recently reported an association between the design of the component and the rate of major reoperations following primary THA. They showed that the cumulative incidence of periprosthetic femoral fracture was twice that of previous estimates, when both revision and reoperation for periprosthetic femoral fracture

Table IV. Risk of reoperation for periprosthetic femoral fracture (PFF), and risk of femoral reoperation for any indication, for the femoral component groups, stratified by sex.

Variable	Arthroplasties, n	Reoperated for PFF			Reoperated for any cause*		
		Total, n	aHRR (95% CI)†	aSHR (95% CI)‡	Total, n	aHRR (95% CI)†	aSHR (95% CI)‡
Males							
Total	71,930	643			1,321		
Femoral component design and fixation							
Cemented composite beam	9,573	13	Reference	Reference	67	Reference	Reference
Cemented polished taper-slip	22,380	314	9.4 (5.4 to 16.3)	9.3 (5.3 to 16.2)	473	2.6 (2.0 to 3.3)	2.6 (2.0 to 3.3)
Uncemented collarless	19,125	236	9.7 (5.5 to 17.1)	9.5 (5.4 to 16.7)	522	2.6 (2.0 to 3.4)	2.5 (1.8 to 3.3)
Uncemented collared	20,852	80	4.1 (2.2 to 7.3)	3.8 (2.1 to 6.9)	259	1.7 (1.3 to 2.3)	1.6 (1.2 to 2.2)
Females							
Total	132,111	1,002			1,704		
Cemented composite beam	22,613	56	Reference	Reference	116	Reference	Reference
Cemented polished taper-slip	51,868	347	2.5 (1.9 to 3.3)	2.5 (1.9 to 3.3)	615	2.1 (1.6 to 2.5)	2.0 (1.7 to 2.5)
Uncemented collarless	29,106	446	6.2 (4.7 to 8.3)	6.2 (4.7 to 8.3)	673	3.0 (2.5 to 3.7)	3.0 (2.5 to 3.7)
Uncemented collared	28,524	153	2.9 (2.1 to 3.9)	2.8 (2.1 to 3.9)	300	1.9 (1.6 to 2.4)	1.9 (1.5 to 2.3)

*Including osteosyntheses.
†Cox regression analysis, adjusted for age, ASA grade, indication for primary arthroplasty, and year of primary surgery.
‡Fine & Gray competing risk model, adjusted for age, ASA grade, indication for primary arthroplasty, and year of primary surgery.
aHRR, adjusted hazard rate ratio; ASA, American Society of Anesthesiologists; aSHR, adjusted subdistribution hazard ratio.

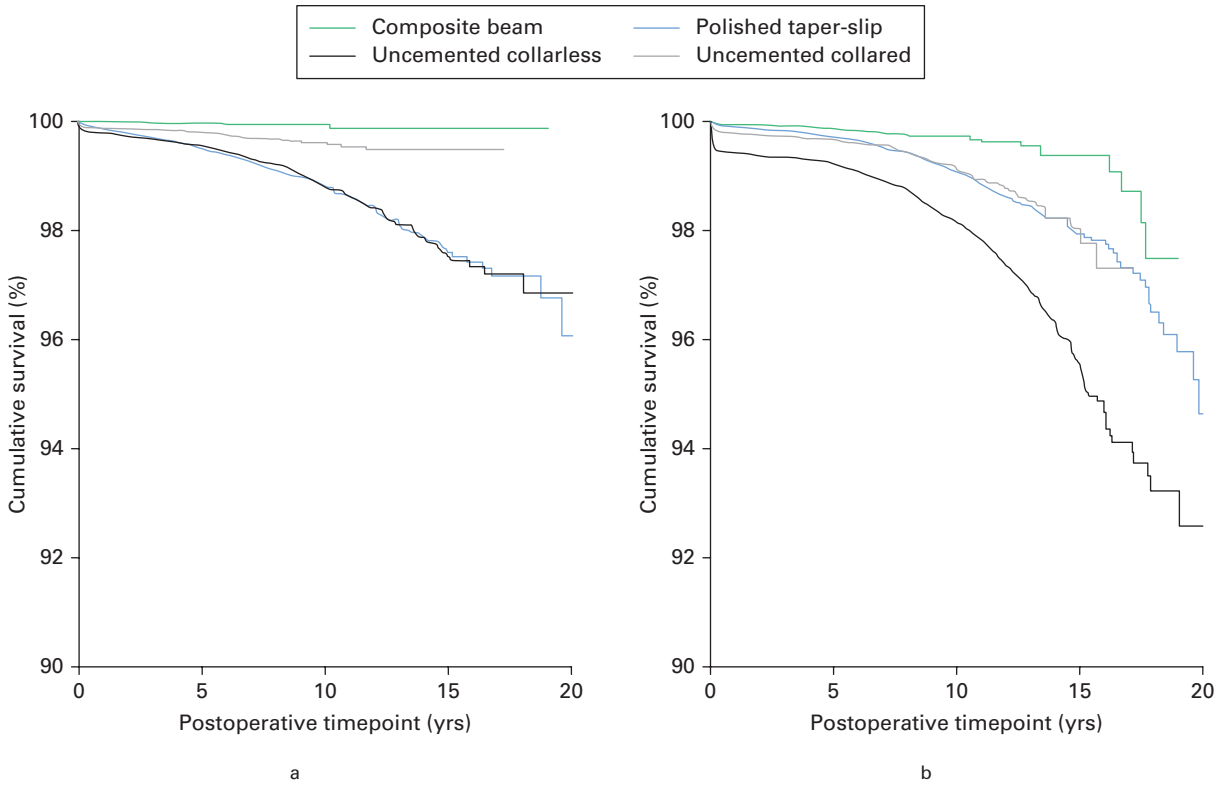


Fig. 2

Cox survival curves for reoperation for periprosthetic femoral fracture for the design of the femoral component and method of fixation groups, a) males and b) females, adjusted for age, American Society of Anesthesiologists grade, indication for arthroplasty, and year of initial surgery.

were included, making periprosthetic femoral fracture the most common indication for a major reoperation following THA.[14] In contrast to our study, Lamb et al[14] did not stratify for sex and age in the femoral component designs and fixation methods for periprosthetic femoral fracture reoperations specifically. They presented the cumulative incidence for several indications for major reoperations for males and females of different ages with curves for PTS (cobalt-chrome and stainless steel), UCC+, and

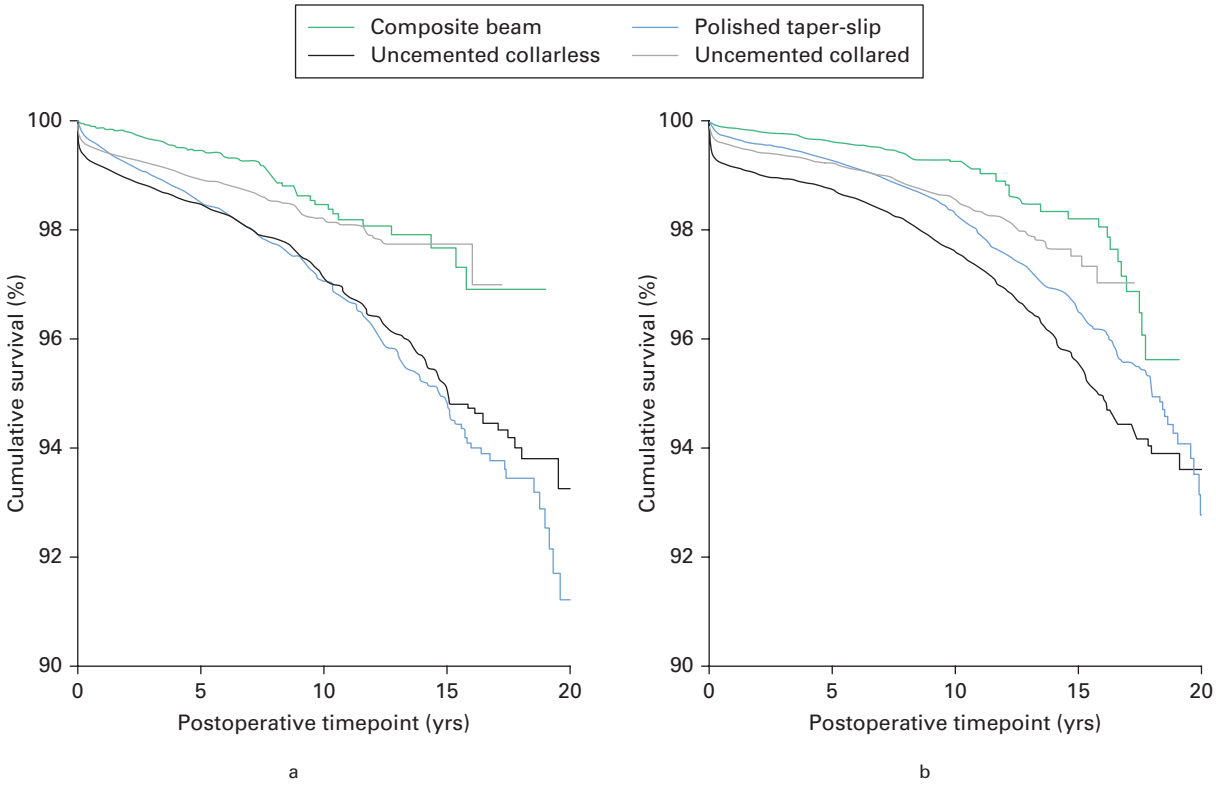


Fig. 3

Cox survival curves for femoral reoperations for any indication including osteosynthesis for the design of the femoral component and method of fixation groups, a) males and b) females, adjusted for age, American Society of Anesthesiologists grade, indication for arthroplasty, and year of intial surgery.

UCC-. They found, as we did, that the best ten-year cumulative incidences were for CB and UCC+. However, they found that the lowest cumulative incidences were for UCC+ in males aged > 68 years and PTS (stainless steel) in females of this age, in contrast to our findings. This was probably due to low numbers and the fact that CB was not included in the subanalyses on sex and age, which showed PTS, UCC-, and UCC+ as the dominating components in their study.

Some authors have reported a higher risk of periprosthetic femoral fracture among females compared with males.[15,16] We found that males had a higher risk of reoperation for periprosthetic femoral fracture than females, as has also been found by others.[8,17] The exact mechanism for this remains unclear, but it may be related to the generally higher body weight and muscle strength in males, causing increased mechanical load on the cement mantle or the surrounding bone.

CB designs had the lowest risk of reoperation for periprosthetic femoral fracture, in both males and females, which was most pronounced for the oldest age group, and at a younger age in females compared with males. Lamb et al[2] found similar results reporting that the lowest risk of periprosthetic femoral fracture after THA was associated with CB designs. Advanced age has previously been identified as a risk factor for periprosthetic femoral fracture.[15] Our findings suggest that CB should be the preferred choice at least for males aged > 75 years and females aged > 70 years. In younger age groups, CB still shows similar or better results regarding the risk of periprosthetic femoral fracture.

In males, PTS had an increased risk of reoperation for periprosthetic femoral fracture at all ages compared with CB. This was also previously reported by Lynch Wong et al,[8] who reported a five-times increased risk of periprosthetic femoral fracture associated with PTS, compared with UCC+ in males. The PTS design is intended to allow the component to subside into the cement mantle. However, traumatic events may lead to component-induced splitting of the mantle and surrounding bone.[8] Due to an increased body weight and the application of more axial and rotational forces, this complication might be more prevalent among males than in females.[8,14] We therefore believe that surgeons should exercise caution in the use of PTS in males of all age groups.

UCC- designs had a substantial risk of reoperation for periprosthetic femoral fracture, especially in old and frail patients, most pronounced in females, as also previously reported.[15,16] Kristensen et al[18] reported inferior results for uncemented HA among elderly and frail patients with a hip fracture. Hence, in our opinion, UCC- designs should not be used in these patients, neither in males nor females. If cementing is not an option, UCC+ shows similar or superior outcomes compared with UCC-, raising the question of whether UCC- components still have a place in hip arthroplasty, regardless of sex and age.

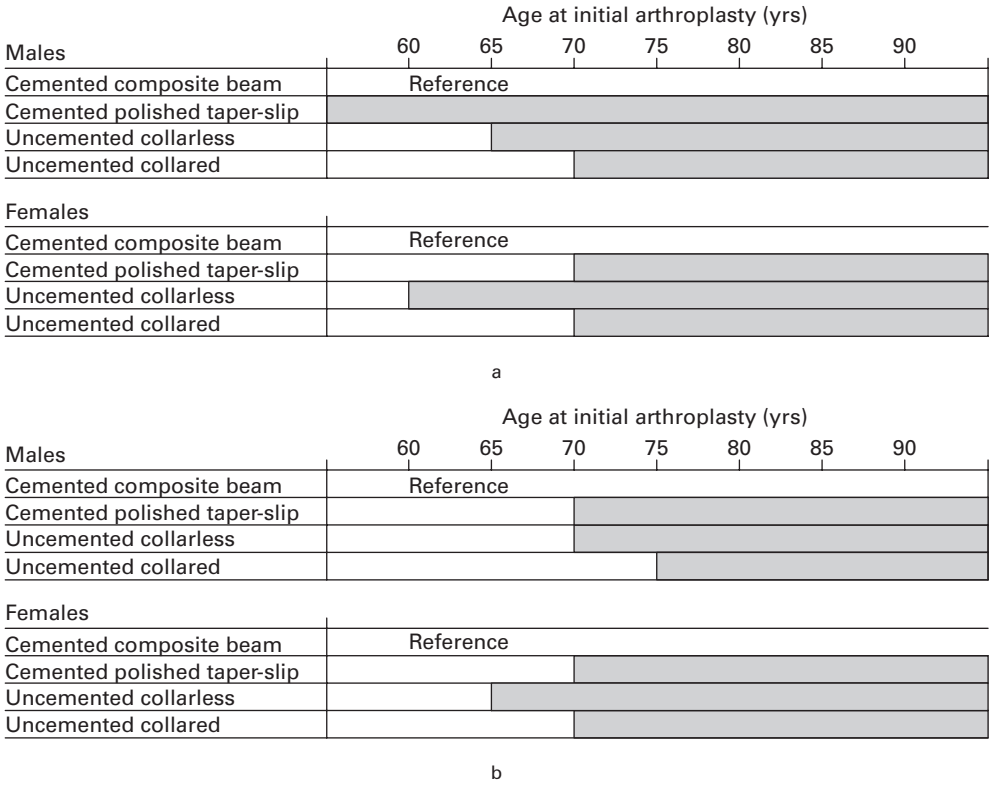


Fig. 4

Risk of reoperation for a) periprosthetic femoral fracture (PFF), and b) the risk of all cause femoral reoperation including osteosynthesis, for the design of the femoral component and method of fixation groups, based on the findings in Supplementary Table ii. The results show whether there was a significantly increased risk. Adjusted for American Society of Anesthesiologists grade, indication for primary arthroplasty, and year of primary operation.

UCC+ had higher risk of reoperation for periprosthetic femoral fracture in males aged > 75 years, in females aged > 70 years, and in frail patients. However, UCC+ performed well in males aged < 75 and females aged < 70 years, for both reoperation for periprosthetic femoral fracture and all-cause femoral reoperation. This indicates that UCC+ may be an option in males aged < 75 years and females aged < 70 years, as also has been previously reported.[8,13,14]

We had the benefit of detailed information about the patient- and surgery-related confounders, which will reduce the risk of selection bias and confounding.[12] However, there may still be some residual confounding. PTS and CB designs were more frequently used in older patients and females, whereas the use of uncemented components was associated with younger age, lower ASA grade, and males. The number of PTSs used was significantly higher compared with CB. Since 2018, orthopaedic surgeons in Norway have been advised to use cemented components for females aged > 75 years to reduce the incidence of periprosthetic femoral fracture.[16] As a result, there was an increase in use of cemented femoral components among the oldest females towards the end of the study period. This may have introduced selection bias and time-dependent confounding, since the choice of components for females has changed over time to designs which are more protective against periprosthetic femoral fracture. We addressed this by adjusting for the year of the initial surgery.

There may be under-reporting of reoperations, especially those which do not include revision, as reported by Lamb et al.[2,3] This effect will be accentuated since reoperations for periprosthetic femoral fracture were not reported in the NAR until 2016, in contrast to the NHFR. Patients with a cemented femoral component probably more often have a reoperation with osteosynthesis, in contrast to those with an uncemented component which is revised. The reoperations for periprosthetic femoral fracture before 2016 were not reported to the NAR, which represents a limitation of the study. We found an incidence of reoperation for periprosthetic femoral fracture of 0.8%, close to the figure of between 0.8% and 2.0% found when the true incidence of reoperation for periprosthetic femoral fracture has been validated.[3] If osteosyntheses are more often performed with one particular component, and are under-reported compared to revisions, then this may have influenced the results.[8] However, our assessments indicate that there was similar reporting of both reoperation and revision across the groups, and that any reporting bias was minor.

Considering the number of patients and hospitals, the quality and completeness of the data, the strict inclusion criteria, and the fact that we adjusted for several clinically important

risk factors in the analyses, we expect the selection bias and unknown confounding to be minor and the study to be without major systematic errors.

In conclusion, the use of cemented CB femoral components had the lowest risk of reoperation for periprosthetic femoral fracture and of all-cause femoral reoperation, including osteosynthesis, and should be the preferred choice for primary hip arthroplasty in males aged > 75 and females aged > 70 years. UCC+ components were the best alternative to cemented CB components, especially in males aged < 75 years and females aged < 70 years. Cemented PTS components had a considerably increased risk of reoperation for periprosthetic femoral fracture in males of all ages. UCC- should be used cautiously in males aged > 65 years and in females aged > 60 years. Uncemented femoral components should be avoided in frail patients, regardless of sex, to reduce the risk of periprosthetic femoral fracture.

Take home message

- Our findings suggest that composite beam should be the preferred choice for males aged > 75 years and females aged > 70 years.
- Uncemented collared components were the best uncemented option.
- Polished-tapered components were associated with a high risk of periprosthetic femoral fracture among males of all ages.

Supplementary material

Detailed results for the risk of periprosthetic femoral fracture and all-cause femoral reoperation stratified by sex, age groups, frailty, and implant brands.

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Funding statement:
The authors received no financial or material support for the research, authorship, and/or publication of this article.

ICMJE COI statement:
G. Hallan reports payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing or educational events from Ortomedic, Link Norway, and Heraeus Medical, all of which are unrelated to this study. J-E. Gjertsen reports payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing or educational events from DePuy Synthes, Smith & Nephew, and Heraeus Medical, all of which are unrelated to this study. O. Furnes reports consulting fees from Heraeus Medical and Ortomedic, both of which are unrelated to this study.

Data sharing:
The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

Acknowledgements:
The authors thank all Norwegian surgeons for conscientiously reporting total hip arthoplasties and hemiarthroplasties to the Norwegian Arthroplasty Register (NAR) and Norwegian Hip Fracture Register (NHFR), and the secretaries, IT analysts, and statisticians at the NAR and NHFR for quality insuring the data and preparing them for analyses.

Ethical review statement:
The study, including the registration and merging of data, was performed confidentially, with patient consent, according to Norwegian and EU data protection rules, and approved by the Regional Ethical Committee West (REK 2024-710016). The NAR and NHFR have licences from the Norwegian Data Protection Authority (reference numbers 03/00058 to 15/JT A (issued on 24 January 2017) and 2004/1658 to 2 SVE/- (issued on 3 January 2005)), respectively.

Open access funding:
The open access fee for this article was funded by the Norwegian Arthroplasty Register.

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This article was primary edited by J. Scott.