

Rate of conversion to secondary arthroplasty after femoral neck fractures in 796 younger patients treated with internal fixation: a Swedish national register-based study



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Background and purpose — In younger patients with a femoral neck fracture (FNF), internal fixation is the recommended treatment regardless of displacement. Healing complications are often treated with arthroplasty. We determined the rate of conversion to arthroplasty up to 5 years after fixation of either undisplaced FNFs (uFNFs) or displaced FNFs (dFNFs).

Patients and methods — The study was based on prospectively collected data from the Swedish Fracture Register (SFR) and the Swedish Arthroplasty Register (SAR). FNFs in patients aged < 60 treated with parallel pins/screws or sliding hip screws (SHS) registered in SFR 2012–2018 were cross-referenced with conversions to arthroplasty registered in SAR until 2019. The cumulative conversion and mortality rates were determined by Kaplan–Meier analyses and patient- and surgery-dependent risk factors for conversion by Cox regression analyses.

Results — We included 407 uFNFs and 389 dFNFs (median age 52, 59% men). The 1-year conversion rate was 3% (95% CI 1–5) for uFNFs and 9% (CI 6–12) for dFNFs. Corresponding results at 5 years were 8% (CI 5–11) and 25% (CI 20–30). Besides a displaced fracture, age 50–59 was associated with an increased rate of conversion in uFNFs. This older group also had a higher mortality rate, compared with patients aged < 50. There was no sex difference for mortality.

Interpretation — Adults aged under 60 with uFNFs and dFNFs face an 8–25% risk, respectively, of conversion to arthroplasty within 5 years after internal fixation. This is new and pertinent information for surgeons as well as patients.

In younger individuals with femoral neck fractures (FNF), internal fixation (IF) is the recommended treatment alternative (1). Nevertheless, the risk of healing complications has to be acknowledged; osteonecrosis of the femoral head and non-union are the most common but the actual rate of conversion to arthroplasty is insufficiently described in younger patients. A population-based study on 796 individuals aged under 50 years found a conversion rate of 14%, but did not distinguish fracture displacement (2). A smaller case series (n = 122) presented a conversion rate of 22% for displaced FNFs (dFNF) (3). Besides the obvious need to give correct information on prognosis to younger patients, detailed knowledge on conversion rate is mandatory to underpin a sound treatment strategy. The debate focuses on where to draw the line between internal fixation and hip replacement as primary treatment of a dFNF. Different age limits are proposed, even as low as 45 years has been suggested (4). Traditions and surgical preferences vary internationally; the Scandinavian countries have had a higher age limit for primary arthroplasty as treatment for FNFs but have gradually shifted from 70 to approximately 60 years (5,6). Also, for undisplaced FNFs (uFNF), primary arthroplasty has recently been put forward as an alternative, at least in elderly patients (7,8). We designed a national register-based study to determine the rate of conversion to arthroplasty from IF due to uFNFs and dFNFs in patients under the age of 60. Furthermore, we descriptively analyzed mortality and the relationship between conversion rate and sex, age, trauma mechanism, and surgeon's experience.

Patients and methods

Study design

This longitudinal cohort study is based on 2 Swedish national registries with prospectively collected data: the Swedish Fracture Register (SFR) and the Swedish Arthroplasty Register (SAR). We followed the STROBE guidelines for reporting the study.

Setting

The SFR started in 2011 and during the study period (2012–2018) the coverage for hip fractures increased from 18% to 86% due to an increased number of hospitals reporting to the register (9,10). By 2021 all orthopedic departments in Sweden participated, i.e., coverage of 100%, in the register, which comprised 645,000 fractures at the end of 2021. The completeness of the register has been validated and in 2018 the completeness for femoral fractures was 55% (11,12). FNFs are classified in the SFR according to the 2007 AO/OTA classification as undisplaced subcapital (31-B1), transcervical/basicervical (31-B2), and displaced subcapital (31-B3) (13). The accuracy of the fracture classification in the SFR has been validated, and was found to be substantial (14). The injury, fracture classification, and treatment are registered by a physician through individual log-in on the SFR webpage.

SAR is the national quality register for hip and knee replacement surgery in Sweden. SAR has a coverage of 100% for all departments performing hip replacement surgery, both public and private. For the years of the current study, the completeness was approximately 98% for total hip arthroplasty (THA), 96% for hemiarthroplasties (HA), and 92% regarding revisions of both THA and HA (15). By regular co-processing with the population register (the Swedish Tax Agency) any date of death is noted in both register databases.

Participants

Data for all patients aged 18 to 59 years registered with a hip fracture (defined by the ICD codes S72.00, S72.10 and S72.20) in SFR from 2012 to 2018 was extracted and cross-referenced with available data from SAR for each individual from the date of the index fracture until December 31, 2019. The unique individual personal number of each Swedish citizen ensures a reliable match between registers and subsequent surgeries and/or death. Only the 1st registered hip fracture was included in the study; contralateral and subsequent ipsilateral fractures and duplicate registrations were excluded. The uFNFs (AO/OTA 31-B1, Garden 1–2) and dFNFs (AO/OTA 31-B3, Garden 3–4) were further examined for eligibility; other fracture types were excluded (13). We identified all available FNFs in the SFR, but the data search did not include any concurrent fractures. As they are specified in the reporting procedure, and identified by their ICD-10 diagnose codes (M84.4, M84.8, M84.3), pathological, spontaneous, and stress fractures were excluded from the analysis together with peri-

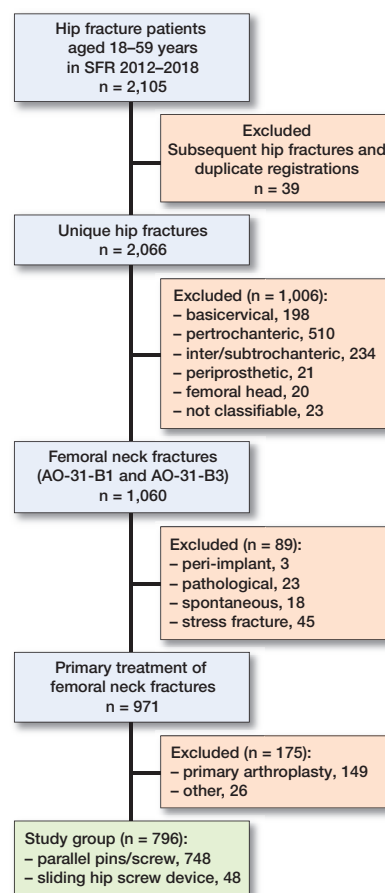


Figure 1. Flowchart of inclusion.

implant fractures. Based on the primary treatment, fractures treated with IF (parallel pins/screws or sliding hip screw devices [SHS]) were identified, and we excluded patients treated with primary arthroplasty, intramedullary nail, other types of plate fixation, or non-surgically from further analysis on conversion rate (Figure 1).

Study variables

We analyzed basic demographic and epidemiological variables (i.e., sex, age, and trauma mechanism) and data on the primary fracture treatment from SFR (i.e., type of IF used and surgeon's experience defined as performed by either a resident or a specialist), together with the rate of conversion to hip arthroplasty registered in SAR and mortality. Trauma mechanism was defined according to the definition used in SFR: low-energy trauma is same-level falls and high-energy trauma is caused by truly high level of energy, such as traffic accidents or falls from a height. Length of follow-up was defined as time from injury date to date of death or end of study period on December 31, 2019.

Study outcomes

The main aim was to determine rates of conversion to arthroplasty after IF of uFNFs and dFNFs at 1, 2, and 5 years. Fur-

Table 1. Patient characteristics. Values are count (%) unless otherwise specified

Characteristics	uFNF	dFNF	Total
	AO-31-B1 n = 407	AO-31-B3 n = 389	
Median age (IQR)	53 (48–57)	52 (45–56)	52 (46–57)
Age < 50	133	159	292 (37)
Age 50–59	274	230	504 (63)
Sex distribution (p = 0.008)			
Men	222 (55)	248 (64)	470 (59)
Women	185 (46)	141 (36)	326 (41)
Trauma mechanism (p = 0.005)			
High-energy trauma	44 (11)	72 (19)	116 (15)
Low-energy trauma	321 (79)	293 (75)	614 (77)
Missing	43 (11)	25 (6)	66 (8)
Primary treatment (p = 0.5)			
Parallel pins/screws	385 (95)	363 (93)	748 (94)
Sliding hip screw	22 (5)	26 (7)	48 (6)
Surgeon's experience (p = 0.003)			
Resident surgeon	139 (34)	95 (24)	234 (29)
Specialist surgeon	254 (62)	278 (71)	532 (67)
Missing	14 (3)	16 (4)	30 (4)
Mean follow-up, years, (SD)	3.5 (1.7)	3.5 (1.7)	3.5 (1.7)

uFNF: undisplaced femoral neck fracture.

dFNF: displaced femoral neck fracture.

thermore, analyses were performed on mortality and associations between conversion to arthroplasty and sex, age, trauma mechanism, and surgeon's experience in the study group.

Statistics

Observations were grouped according to fracture classification (i.e., uFNF or dFNF), sex, and age < 50 or 50–59. Data on continuous variables were assessed for normality and presented as mean or median, depending on normal distribution. We analyzed associations between categorical variables using a chi-square test. Kaplan–Meier analysis was used to determine the rate of conversion to secondary arthroplasty as cumulative reoperation rate (CRR) with 95% confidence interval (CI) at 1, 2, and 5 years after the injury and to estimate mortality rates. We used a Cox proportional hazards regression model to determine hazard ratios (HR) between risk factors for secondary arthroplasty, where female sex, age 50–59, high-energy trauma mechanism, and resident surgeon previously have been described to have increased risk of reoperation and were assumed to be associated with a higher HR (4,16–18). Participants with missing data for a variable were excluded from analysis of that specific variable. Analysis of data was performed in IBM SPSS version 26 (IBM Corp, Armonk, NY, USA) and R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

Ethics, data sharing, funding, and potential conflicts of interests

The study was conducted in accordance with the Helsinki Declaration and was approved by the Swedish national ethi-

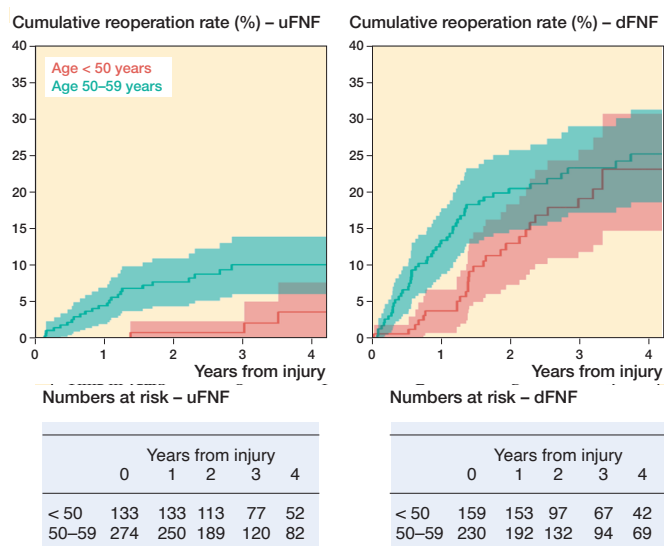


Figure 2. Cumulative reoperation rate with 95% confidence intervals presented by age classification and fracture type. uFNF: undisplaced femoral neck fracture. dFNF: displaced femoral neck fracture.

cal review board (Etikprövningsnämnden: Dnr 2019-05024). Data was pseudonymized before extraction from the registries and subsequent analysis. The data supporting the findings of this study is available upon reasonable request to the corresponding author. The study was supported by grants from the Research and Development Council of Region Skåne and a grant from the Swedish Research Council funding for clinical research in medicine. The authors declare no conflicts of interest related to the study.

Results

2105 hip fractures were identified in the SFR. After exclusion, 407 uFNFs and 389 dFNFs treated with internal fixation with parallel pins/screws or SHS were analyzed (Figure 1).

Patients were aged 20 to 59 years at the time of the fracture, 59% of the fractures occurred in men, and 77% were due to low-energy trauma. Fractures due to high-energy trauma were more prevalent in dFNFs compared with uFNFs. The distribution of parallel pins/screws and SHS was similar in uFNFs and dFNFs. Specialists performed 2/3 of all operations due to FNFs (Table 1).

108 of the 796 participants underwent a conversion to arthroplasty, 28 after IF of uFNFs, and 80 after dFNFs. There were 2 conversions to HA, all others to THA. In an implant survival analysis, the conversion rates after 1, 2, and 5 years for dFNFs were 9% (95% CI 6–12), 17% (CI 13–21), and 25% (CI 20–30), which were higher than for uFNFs, which demonstrated 3% (CI 1–5), 5% (CI 3–8), and 8% (CI 5–11) (Table 2, see Supplementary data).

Table 3. Cox proportional hazard ratios and 95% confidence intervals for conversion to arthroplasty

	HR (CI)	p-value
Undisplaced femoral neck fracture		
Female sex	1.2 (0.5–2.7)	0.7
Age (50–59)	5.2 (1.4–20)	0.02
High-energy trauma	2.9 (0.8–11)	0.1
Resident surgeon	1.5 (0.6–3.3)	0.4
Displaced femoral neck fracture		
Female sex	1.5 (0.9–2.4)	0.1
Age (50–59)	0.8 (0.5–1.3)	0.3
High-energy trauma	1.1 (0.6–2.0)	0.7
Resident surgeon	1.7 (1.0–2.8)	0.06

HR (CI): hazard ratio with 95% confidence interval.

Age 50–59 was associated with an increased rate of conversion to arthroplasty for uFNFs but not for dFNFs (Figure 2). When analyzing risk factors for conversion, age 50–59 had an HR of 5.2 (CI 1.4–20) compared with age < 50 years in the uFNF groups. No other risk factors could be identified (Table 3).

The exclusion of 149 patients treated with primary arthroplasty theoretically reduced the number of FNFs at risk of conversion to arthroplasty (Figure 1). Median age (IQR) for patients treated with primary arthroplasty was 56 (54–58). 9% were aged < 50, 56% were women, and 89% low-energy trauma (n = 14, 84 and 133 respectively).

The mortality rates were similar between uFNFs and dFNFs and between men and women (Figures 3 and 4). At 1 year, 20 individuals had died and at 5 years, 62. The 1- and 5-year cumulative mortality rate of individuals aged 50–59 at the time of the fracture was 4% (CI 2–6) and 16% (CI 11–20) compared with 0% and 5% (CI 2–7) for those aged < 50 (Table 4, see Supplementary data).

Discussion

A considerable proportion of young and middle-aged individuals with an FNF can expect a conversion to hip arthroplasty within 5 years post-fracture, 1 in 4 for displaced fractures and 1 in 12 for undisplaced fractures.

Our rates of conversion to arthroplasty were comparable to previous reports on younger patients (2,3). Stockton et al. (2) considered their conversion rate to be high and called for improvement in the treatment of FNFs in younger patients. Our results for uFNFs are in close proximity, but we regard the conversion rate to be acceptable and believe it confirms IF as the gold standard for uFNFs in this age group. For patients with dFNFs on the other hand, outcome after IF is poorer. In our 50–59-year group, there is an immediate and steady increase in the rate of conversion during the entire follow-up, showing a readiness of the surgeons to perform secondary surgery. Surgeons may feel at ease, as other patients in the same

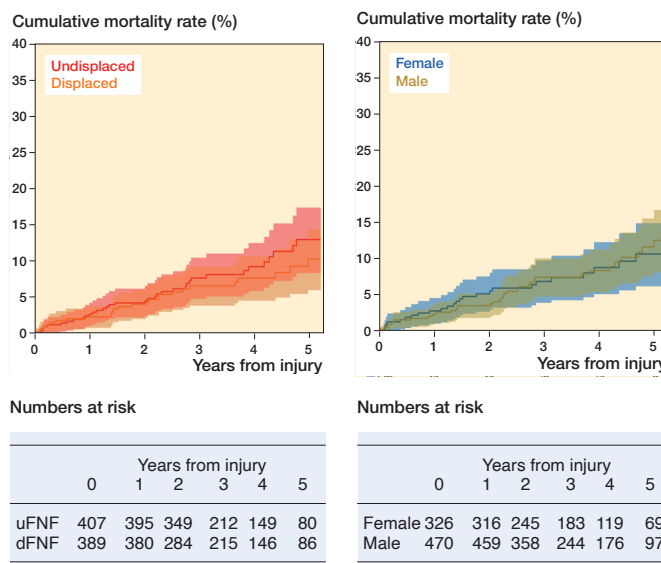


Figure 3. Cumulative mortality rate with 95% confidence intervals presented by fracture type.

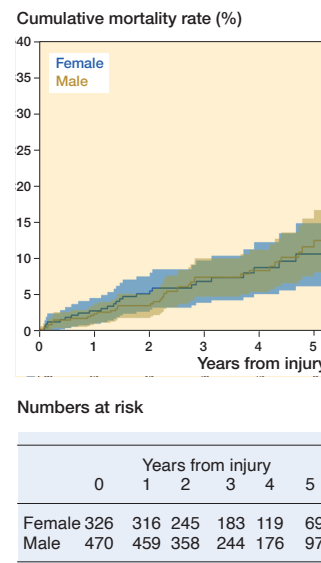


Figure 4. Cumulative mortality rate with 95% confidence intervals presented by sex.

age span with symptomatic osteoarthritis are routinely given a hip replacement nowadays, as we know better the good long-term prognosis for the arthroplasty. Remarkably, the youngest group with dFNF also ended up with a 23% conversion rate at 5 years, albeit their rate was modest during the earliest years, maybe reflecting a more guarded attitude towards arthroplasty in this age group. On the other hand, when 3 of 4 with dFNFs still had their native hip at 5 years, the result in terms of conversion to arthroplasty can be said to be acceptable or even good. Future endeavors should focus on improving the clinical pathway for this group of young patients, for whom this fracture is still unsolved (19).

In elderly patients, the degree of displacement of the FNF, including both posterior and anterior tilt, and fracture comminution, have been found to predict failure of IF (20–22). Our results confirm that displacement according to Garden is a risk factor for failure leading to conversion arthroplasty in younger patients also. Nevertheless, our conversion rate is much lower than in geriatric patients treated with internal fixation of their dFNFs, where major secondary surgery can be expected in approximately 40% (23,24).

Should we lower the age limit for primary arthroplasty? The rationale for treating younger patients with internal fixation, even if their fracture is displaced, is the theoretical benefits of preserving the femoral head and a fear of multiple revisions of an arthroplasty during a long remaining life span. But if we consider long-term results from RCTs on patients aged over 60, those initially treated with IF never reached superior functional results compared with those treated with arthroplasty (22,25). When considering risk of revision of the primary arthroplasty, one should bear in mind that conversion arthroplasties are associated with inferior outcome compared with

primary arthroplasties for FNFs (26,27). Ideally, those with an inherently higher risk of fixation failure should be identified preoperatively and selected for primary arthroplasty. Otherwise, a focus on realistic expectations and readiness for swift conversion arthroplasty when needed would also be acceptable in the future, given that most young patients' fractures actually do heal.

Notably, there was no difference between men and women regarding mortality, although elderly males with hip fractures have a higher risk of dying (28), and younger women have been reported to have more comorbidities (29). The 5-year mortality of 16% for those 50–59 years old is noteworthy, and the 1-year mortality of 4% was 10-fold higher compared with the mean mortality rate for the same ages in the general Swedish population during the years of the study (30,31). They may in this aspect resemble the elderly, which could speak in favor of a primary arthroplasty rather than internal fixation in those of advanced biological age and an expected shorter survival. This is supported by an analysis of cost-effectiveness where the lowest age proposed for THA as primary treatment of FNFs was 45 years in patients with multiple comorbidities whereas it was 54 for healthy patients (4).

Limitations

That some individuals in the older age span with dFNF were initially selected for primary arthroplasty may affect the conversion rates reported in our study. Assuming that these patients were identified as at particularly high risk of fixation failure, our estimates of the conversion rates are potentially underestimated by this selection bias.

The number of parallel implants varies internationally. In line with Scandinavian tradition, 2 pins or screws are used almost exclusively in this cohort. There is little support in the literature that adding extra screws will reduce the risk of re-dislocation or non-union (16). That only 6% received an SHS hindered us from testing the suggestion made by the FAITH study (32), i.e., that SHS could have some benefits in those with displaced fractures.

We lack data on whether an open reduction has been performed, but the Swedish tradition is to rely on closed reduction only. Also, the literature has so far not been able to show any clear benefits of open reduction (33,34).

Indices depicting comorbidities and biological age/frailty would have been desirable variables to analyze, but unfortunately the registers do not include these potentially important risk factors for conversion to arthroplasty. Those selected for primary arthroplasty in our material may represent such a subgroup of frailer individuals.

Strengths

Our study is the largest to date analyzing conversion rate after IF due to uFNFs and dFNFs. We believe our result to have good external validity as it reflects everyday practice in non-selected patients and surgeons. We consider conversion to arthroplasty

as a marker of a major hip complication. Naturally, other outcomes are valuable and patient-reported outcome is always preferable. Any kind of reoperation could be relevant to report, but in Sweden valgus osteotomy, core decompression, or vascular grafts are very seldom utilized. Implant removal is a common reoperation, but the severity of the underlying situation is difficult to grade. It can span from routine procedures with no or little discomfort experienced by the patients to major complications such as deep infection or fracture collapse. We also chose our outcome due to the SAR's high completeness and national coverage, leading to a reliable result.

Conclusion

After IF in patients aged < 60, the rate of conversion to arthroplasty for dFNFs was significantly higher than for uFNFs during the entire follow-up. At 5 years, 25% and 8%, respectively, had undergone a conversion to hip arthroplasty.

In dFNFs, the conversion rates were similar in all ages. For uFNFs the conversion rates in patients aged 50–59 were significantly higher than for younger patients. No other risk factors for conversion to arthroplasty could be identified in our material. Mortality rates were markedly higher for patients aged 50–59 but did not differ between men and women or between uFNFs and dFNFs.

In perspective, both surgeons and patients should be aware of the risk of conversion to arthroplasty at the time of initial treatment. A clinical implication would be a long-term follow-up scheme and readiness for swift conversion when needed.

All authors were involved in the study design and approved the final manuscript. SSR initiated the study, curated data, performed statistical analysis, wrote, and reviewed the manuscript. JL critically reviewed the manuscript. BV contributed expert knowledge, wrote, and reviewed the manuscript. MM contributed expert knowledge and critically reviewed the manuscript. CR initiated the study, supervised SSR, wrote, and reviewed the manuscript.

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Supplementary data

Table 2a. Cumulative reoperation rate with 95% confidence intervals presented by fracture type

Fracture type Time, years	No. at risk	Cumulative events	CRR (95% CI)
Undisplaced femoral neck fracture (n = 407)			
1	383	12	3.0 (1.3–4.6)
2	302	21	5.4 (3.1–7.7)
3	197	25	6.9 (4.2–9.5)
4	134	27	8.0 (4.9–11)
5	73	27	8.0 (4.9–11)
Displaced femoral neck fracture (n = 389)			
1	345	35	9.2 (6.2–12)
2	229	63	17 (13–21)
3	161	73	22 (17–26)
4	111	78	24 (19–29)
5	64	79	25 (20–30)

CRR: cumulative reoperation rate.

Table 4. Cumulative mortality rate with 95% confidence intervals by age classification

Age group Time, years	No. at risk	Cumulative events	CMR (95% CI)
< 50 years (n = 292)			
1	292	0	0 (0–0)
2	228	4	1.5 (0.0–3.0)
3	165	9	3.8 (1.3–6.2)
4	108	10	4.5 (1.7–7.3)
5	60	10	4.5 (1.7–7.3)
50–59 years (n = 504)			
1	483	20	4.0 (2.3–5.7)
2	375	28	5.7 (3.6–7.7)
3	262	40	9.1 (6.3–12)
4	187	44	11 (7.6–14)
5	106	52	16 (11–20)

CMR: cumulative mortality rate.

Table 2b. Cumulative reoperation rate with 95% confidence intervals presented by age classification and fracture type

Age group Fracture type Time, years	No. at risk	Cumulative events	CRR (95% CI)
< 50 years			
Undisplaced femoral neck fracture (n = 133)			
1	133	0	0 (0–0)
2	113	1	0.8 (0.0–2.4)
3	77	1	0.8 (0.0–2.4)
4	52	3	3.6 (0.0–7.7)
5	32	3	3.6 (0.0–7.7)
Displaced femoral neck fracture (n = 159)			
1	153	6	3.8 (0.8–6.7)
2	97	19	13 (7.3–18)
3	67	25	19 (12–26)
4	42	28	23 (15–31)
5	20	28	23 (15–31)
50–59 years			
Undisplaced femoral neck fracture (n = 274)			
1	250	12	4.5 (2.0–6.9)
2	189	20	7.7 (4.4–11)
3	120	24	10 (6.1–14)
4	82	24	10 (6.1–14)
5	41	24	10 (6.1–14)
Displaced femoral neck fracture (n = 230)			
1	192	29	13 (8.5–17)
2	132	44	21 (15–26)
3	94	48	23 (17–29)
4	69	50	25 (19–31)
5	44	51	26 (20–33)

CRR: cumulative reoperation rate.