OPEN ACCESS

Acta Orthopaedica 2022; 93: 413–416

Stress fractures of the femoral neck in adults: an observational study on epidemiology, treatment, and reoperations from the Swedish Fracture Register

Acta Orthopaedica

Jonas SUNDKVIST [1], Michael MÖLLER [2], Cecilia ROGMARK [3], Olof WOLF [4], and Sebastian MUKKA [1]

[1] Department of Surgical and Perioperative Sciences (Orthopedics), Umeå University; [2] Institute of Clinical Sciences, Sahlgrenska Academy, Gothenburg University, Gothenburg; [3] Department of Orthopaedics, Lund University, Skåne University Hospital, Malmö; [4] Department of Surgical Sciences, Orthopaedics, Uppsala University, Uppsala, Sweden
Correspondence: Jonas.sundkvist@umu.se
Submitted 2022-01-02. Accepted 2022-03-05.

Background and purpose — Stress fractures of the femoral neck (sFNFs) are uncommon injuries. Studies on sFNFs are rare. We describe the demographics, classification, treatment, reoperation rates, and mortality in a cohort of sFNF patients from the Swedish Fracture Register (SFR).

Patients and methods — We included 146 patients ≥ 18 years of age with an sFNF registered in the SFR between 2011 and 2020. The cohort was linked with the Swedish Arthroplasty Register and reviewed using medical records and radiographs. We assessed the presence of disorders of bone remodeling, duration of symptoms, fracture classification, treatment, reoperations, and mortality.

Results — The mean age was 58 years (21–96), 75% were women and the median duration of symptoms was 23 days (1–266). 40% of patients had disorders of bone remodeling. 54% were undisplaced (uFNF), 30% displaced (dFNF), and 16% basicervical (bFNF). 14% of patients < 60 years were treated nonoperatively, by internal fixation (IF) in 77% and by arthroplasty in 10%. Patients ≥ 60 years were treated nonoperatively in 10%, IF in 40%, and arthroplasty in 49%. Nonoperative treatment was reserved for uFNFs or bFNFs, resulting in 35% receiving late surgery. The overall secondary or late surgery rate was 19%. Mortality was 2% at 90 days and increased to 3% at 1 year.

Interpretation — sFNF has a biphasic age distribution. One-third of patients presented with a displaced FNF and those managed nonoperatively for an undisplaced sFNF were at risk of late surgery. The mortality rates for patients with these injuries was low.

Stress fractures of the femoral neck (sFNFs) are rare injuries, and correct diagnosis is often delayed because early symptoms are easily missed (1). sFNFs account for approximately 1–2% of all femoral neck fractures and about 3–5% of all stress fractures (2-4). They have previously been reported among young active individuals, recreational runners, military recruits, and the elderly with moderate activity (5,6). Several classifications are in use: Garden, AO/OTA (7), or the system first introduced by Fullerton and Snowdy and later modified using MRI (8-10).

The role of bone remodeling disorders (e.g., chronic kidney failure, rheumatoid arthritis, sustained systemic cortisone treatment, and osteoporosis) in developing sFNFs is not well studied, although lower bone mineral density has been proposed to be a risk factor (11,12).

Plain radiographs can be inconclusive and further imaging with MRI is often needed to make a diagnosis (13). A late diagnosis, likely caused by both patient and doctor delays (1), can be detrimental as there is a greater risk of displacement requiring more extensive surgery (14).

There are few studies on the outcome of sFNFs in the adult population. Therefore, we describe the demographics, classification, treatment, reoperation rates and mortality of sFNFs in the Swedish Fracture Register (SFR).

Patients and methods

Study design and setting

This observational register study was based on data from the Swedish Fracture Register (SFR). The SFR, established in 2011, is a national quality register for managing fractures

DOI 10.2340/17453674.2022.2460

and treatment. Detailed data on patient and fracture characteristics, injury mechanism, and fracture treatment are recorded by the treating surgeon in each affiliated department through a pre-specified digital form. Only patients with a permanent unique personal identification number (PIN), given to all Swedish residents and fractures sustained in Sweden, are registered. Fractures in the SFR are mainly classified according to the AO/OTA classification system. The registration in the SFR of femoral fractures has been found to have high accuracy and validity (15). The coverage has increased gradually, from 40% in 2014 to all orthopedic departments (n = 54) in Sweden being engaged in 2021, i.e., 100% coverage. Compared with the National Patient Register, the completeness of femoral fractures in SFR in 2020 was 81%. The registration of FNFs in the SFR includes undisplaced or minimally displaced femoral neck fractures (uFNFs) (Garden 1–2, AO/OTA 31-B1), displaced femoral neck fractures (dFNFs) (Garden 3–4, AO/OTA 31-B3), and basicervical femoral neck fractures (bFNFs) (AO/OTA 31-B2). Information on peri-implant and periprosthetic fractures (unified classification system) and open fractures is available based on the Gustilo–Anderson classification. Besides information on high- and low-energy trauma, the register comprises data on stress and spontaneous/pathological fractures. Treatment is registered as nonoperative or operative. Operative treatment is further specified as fracture fixation, including types of osteosynthesis (screws or pins, sliding hip device (SHD), long and short intramedullary nails (IMNs), anatomic plates), arthroplasty (hemi or total, cemented or cementless fixation) or other (i.e., excision arthroplasty). Secondary procedures are also recorded, consisting of implant removal, re-osteosynthesis, conversion to arthroplasty, or other (i.e., excision arthroplasty).

Patients and data collection

We included all patients with a femoral neck fracture (ICD S72.00/S72.01) registered as a stress fracture (ICD M84.3) in the SFR between 2011 and 2020. We used the unique PIN to collect data, including the review of medical records of all contributing departments to verify and ensure completeness of the data. To identify patients referred outside the treating hospital for secondary hip arthroplasty, a linkage with the Swedish Arthroplasty Register (SAR) was performed (16).

Patient data included age, sex, ASA classification, cognitive impairment (yes/no), initial treatment, reoperation, and date of death.

Disorders of bone remodeling were defined as chronic kidney failure, rheumatoid arthritis, sustained systemic cortisone treatment, and osteoporosis (17).

We included only patients registered as stress fractures and excluded those with another unspecified atraumatic genesis (M84.6), unclear medical history (e.g., cognitive impairment), or substance abuse. Those with metastatic tumors and incorrect registrations were also excluded.

Radiographic assessment

We used plain anteroposterior radiographs to verify the taxonomy according to the AO/OTA classification (7). The use of MRI for diagnosis was documented.

Outcome measurements

The primary outcome measure was secondary or late surgery. Secondary surgery was defined as secondary hip arthroplasty, excision arthroplasty, or re-osteosynthesis due to subsequent fractures around the implants and surgical debridement, antibiotics, and implant retention caused by deep postoperative infection. Late surgery was defined as any operation on the hip after initial nonoperative treatment. Minor reoperation was defined as implant removal or adjustment of pin/screw.

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

The study complied with the ethical principles of the Helsinki Declaration and was approved by the Swedish Ethical Review Authority (2020-05439, 2021-02560 and 2021-05971-02).

The datasets used in this study are not publicly available because of patient integrity but are available from the corresponding author upon reasonable request.

The study was funded by grants from the regional agreement on medical training and clinical research (ALF) between Västerbotten County Council and Umeå University and between Skane Region and Lund University.

This work was supported by the Department of Orthopaedics, Umeå University Hospital. The authors declare no potential conflicts of interest.

Results

Patients and descriptive data

We identified 170 patients (175 fractures): 21 patients were excluded, 3 had bilateral sFNF and only the 1st fracture was included. 146 patients (109 females) with a mean age of 58 years (SD 22, range 21–96) were included (Table 1). The median duration of symptoms before starting treatment was 23 days (1–267). The mean follow-up was 61 months (6–107). 90-day mortality was 2% (n = 3) and 1-year mortality 3% (n = 5).

Fracture classification

Of all sFNFs, 54% (n = 79) were Garden 1–2, 30% (n = 44) Garden 3–4, and 16% (n = 23) basicervical fractures at diagnosis. MRI was used for diagnosis in 39% (n = 56).

Triggering activity and predisposing factors

Triggering activity was walking in 47% (n = 68) of patients, running in 37% (n = 53) and other/unknown in 18% (n = 26). Disorders of bone remodeling were present in 40% (n = 59).

Table 1. Patient characteristics (N = 146). Values are count (%) unless otherwise specified

Mean age (range)	58 (21–96)
Women	109 (75)
ASA classification	
1–2	105 (72)
3–5	38 (26)
Missing	3 (2)
Metabolic bone disorder	59 (40)
Triggering activity	
Walking	68 (46)
Running	53 (37)
Heavy lifting	3 (2)
Treadmill	2 (1)
Gymnastics	1 (1)
Unknown	19 (13)

Table 2. Treatment choice for the 3 fracture subgroups and overall fractures stratified by patients < 60 years of age at injury and those ≥ 60 years and fracture class

	Undisplaced or minimally displaced sFNF		Displaced sFNF		Basicervical sFNF		All sFNF	
Treatment	< 60 n = 44	≥ 60 n = 35	< 60 n = 11	≥ 60 n = 33	< 60 n = 19	≥ 60 n = 4	< 60 n = 74	≥ 60 n = 72
Hip screws	27	19	3	5	2	1	32	25
Sliding hip device	9	1	1	0	15	2	25	3
Intramedullary nailing	0	1	0	0	0	0	0	1
Hemiarthroplasty	0	4	0	12	0	0	0	16
Total hip arthroplasty	0	4	7	15	0	0	7	19
Excision arthroplasty	0	0	0	1	0	0	0	1
Nonoperative	8	6	0	0	2	1	10	7

Treatment

Surgical treatment varied between age groups and type of FNF (Table 2). Hip arthroplasty dominated in patients ≥ 60 years compared with those < 60 years (49% vs. 9%). In contrast, internal fixation prevailed (77%) in the younger age group. Nonoperative treatment was similar in the 2 age groups: 14% in patients < 60 years and 10% in patients ≥ 60 years.

Secondary or late surgical treatment

28 patients (19%) had a secondary surgical treatment or late surgery. 9 of 86 (10%) patients treated with IF underwent a major reoperation. 5 of 86 (6%) patients treated with IF underwent conversion arthroplasty (3 patients with avascular necrosis, 1 fixation failure, and 1 non-union). 4 patients suffered a peri-implant femur fracture and were treated with intramedullary nails. Minor reoperation with implant removal due to pain around the hip was done in 12 patients. 1 patient, treated with arthroplasty, suffered a deep infection and was treated with surgical debridement and antibiotics.

Of the 17 patients treated nonoperatively, 6 had later surgery (3 with IF due to fracture displacement, 2 with IF due to hip pain, 1 with arthroplasty due to avascular necrosis).

Discussion

sFNFs, affecting young and old patients, are accompanied by low mortality rates. One-third of patients presented with a displaced sFNF and those treated nonoperatively for an undisplaced sFNF were at risk of late surgery.

To date, only a few studies have investigated sFNFs and they have mainly focused on the younger, more active population (e.g., recreational runners and military recruits) (12,18,19). Our findings, based on data from the SFR, indicate a biphasic distribution of fractures with a younger active population and an older population with possibly lower quality of bone or impaired bone repair mechanisms (2). To our knowledge, this study is the largest cohort of sFNFs, covering all adults with a description of post-treatment outcome.

The terminology relating to stress fractures of the femoral neck is unclear, where both insufficiency and fatigue fractures occur in the literature with no quantifiable distinction between them (2,6). Osteopenia in the elderly (but is also seen even in younger athletes) has been proposed to play a central role in the pathogenesis of this condition (2,6,20). Because the detailed pathophysiology of stress fractures is unknown and because current models are based on theory, there is no evidence that stress, fatigue, and insufficiency fractures are separate entities (21).

Half of the fractures in the ≥ 60-year age group presented as a displaced fracture (Garden 3–4, AO-OTA B3), which has not been previously reported in the literature. A plausible explanation for this finding is that early symptoms mimic those of osteoarthritis and likely lead to both patient and doctor delays.

We present a 3% 1-year mortality rate compared with the previously reported 20–25% in the adult population (3). Our cohort could reflect a vital subpopulation of active older adults with a declining bone stock more prone to sFNFs.

The diagnosis and treatment of sFNFs are based on assessment and classification using radiographs or MRI (8-10). The share of the femoral neck involved in the fracture is thought to guide the treatment. The recommendation is that involvement of ≥ 50% or a tension-sided fracture should undergo fixation. However, a study including a large series of MRI-diagnosed sFNFs in military recruits questioned the relevance of previous classifications (19). The authors proposed an MRI-based algorithm for managing sFNFs, where fixation was recommended for those with a visible compression-sided fracture line over 50% of the femoral neck width or hip effusion. Nonoperative therapy was recommended for those with a visible compression-sided fracture line below 50% and those with tension or compression-sided stress oedema without a visible fracture line (22). Those recommendations were based on a large series of 305 sFNFs in military recruits followed by repeated MRI. Regrettably, our study does not have detailed imaging data on those diagnosed by MRI.

Our rate of later operative treatment in patients treated nonoperatively highlights the potential benefit of early stabilization by IF to reduce the risk of fracture displacement and subsequent major surgery. We argue that the relatively minor surgical procedure to stabilize an undisplaced fracture with IF should be considered for sFNFs. However, further clinical trials in young and older age groups are needed to assess the competing treatments for sFNFs.

Our study has some limitations. The main weaknesses are the study design and limited sample size. At the time of the study, Swedish national guidelines on diagnosing and treating FNFs were not available. Therefore, data represents the current national treatment spectrum in the clinical setting. Additionally, clinical factors and treatment details could not be assessed from the medical records. We know that not all sFNFs are registered in the SFR because of a lack of coverage and completeness during the study period. However, this is largely counterbalanced by the study's strength in using the SFR to identify one of the largest cohorts of sFNFs presented to date, including the entire adult age spectrum, with details on fracture classification, treatment choice, and reoperations. We chose a highly selected cohort of patients, excluding all patients with other atraumatic ICD codes and those with uncertain or dubious anamnesis documented in the medical records. This approach ensures a highly reliable sFNF dataset.

In summary, pain in the groin or proximal thigh during and/or after physical activity in young and elderly individuals is a symptom worth the physician's attention. MRI should be considered as an advanced diagnostic tool in patients with normal radiographs of the hip. Early diagnosis is vital given that there was a risk of fracture displacement, as one-third of the patients presented with a displaced sFNF. Nonoperative treatment can be considered, although at great risk for late surgery due to complications.

JS collected data, performed the statistical analysis, and wrote the manuscript. OW and CR wrote and reviewed the manuscript. MM collected data and wrote and reviewed the manuscript. SM initiated the study, supervised JS, performed the statistical analysis, and wrote and reviewed the manuscript.

The authors are grateful to all the physicians and secretaries in the orthopedic departments in Sweden for their invaluable contributions to the management of the Swedish Fracture Register. Special thanks are offered to the valued colleagues around the country who assisted in the collection of data for the present study.

Acta thanks Lene Bergendal Solberg and J L C van Susante for help with peer review of this study.

1. **Neubauer T, Brand J, Lidder S, Krawany M.** Stress fractures of the femoral neck in runners: a review. Res Sports Med 2016; 24(3): 185-99. doi: 10.1080/15438627.2016.1191489.
2. **Egol K A, Koval K J, Kummer F, Frankel V H.** Stress fractures of the femoral neck. Clin Orthop Relat Res 1998; (348): 72-8.
3. **Sundkvist J, Brüggeman A, Sayed-Noor A, Möller M, Wolf O, Mukka S.** Epidemiology, classification, treatment, and mortality of adult femoral neck and basicervical fractures: an observational study of 40,049 fractures from the Swedish Fracture Register. J Orthop Surg Res 2021; 16: 561. doi: 10.1186/s13018-021-02701-1.
4. **Clement D B, Ammann W, Taunton J E, Lloyd-Smith R, Jesperson D, McKay H, et al.** Exercise-induced stress injuries to the femur. Int J Sports Med 1993; 14(6): 347-52. doi: 10.1055/s-2007-1021191.
5. **Edwards W B, Gillette J C, Thomas J M, Derrick T R.** Internal femoral forces and moments during running: implications for stress fracture development. Clin Biomech (Bristol, Avon) 2008; 23(10): 1269-78.
6. **Tountas A A.** Insufficiency stress fractures of the femoral neck in elderly women. Clin Orthop Relat Res 1993; (292): 202-9.
7. **AO/OTA Fracture and Dislocation Compendium—2018.** J Orthop Trauma 2018; 32(1 Suppl.). Available from: https://www2.aofoundation.org/AOFileServerSurgery/MyPortalFiles?FilePath=/Surgery/en/_docs/AOOTA%20Classification%20Compendium%202018.pdf (accessed December 6, 2021).
8. **Fullerton L R Jr, Snowdy H A.** Femoral neck stress fractures. Am J Sports Med 1988; 16(4): 365-77. doi: 10.1177/036354658801600411.
9. **Gillingham B L.** Fatigue fractures of the femoral neck in athletes. J Am Acad Orthop Surg 1997; 5(6): 293-302. doi: 10.5435/00124635-199711000-00001.
10. **Provencher M T, Baldwin A J, Gorman J D, Gould M T, Shin A Y.** Atypical tensile sided femoral neck stress fractures: the value of magnetic resonance imaging. Am J Sports Med 2004; 32(6): 1528-34. doi: 10.1177/0363546503262195.
11. **Muldoon M P, Padgett D E, Sweet D E, Deuster P A, Mack G R.** Femoral neck stress fractures and metabolic bone disease. J Orthop Trauma 2001; 15(3): 181-5. doi: 10.1097/00005131-200103000-00006.
12. **Robertson G A, Wood A M.** Femoral neck stress fractures in sport: a current concepts review. Sports Med Int Open 2017; 1(2): E58-E68. doi: 10.1055/s-0043-103946.
13. **Biz C, Berizzi A, Crimì A, Marcato C, Trovarelli G, Ruggieri P.** Management and treatment of femoral neck stress fractures in recreational runners: a report of four cases and review of the literature. Acta Biomed 2017; 88(4S): 96-106. doi: 10.23750/abm.v88i4-S.6800.
14. **Pihlajamäki H K, Ruohola J P, Kiuru M J, Visuri T I**. Displaced femoral neck fatigue fractures in military recruits. J Bone Joint Surg Am 2006; 88(9): 1989-97). doi: 10.2106/JBJS.E.00505.
15. **Knutsson S B, Wennergren D, Bojan A, Ekelund J, Möller M.** Femoral fracture classification in the Swedish Fracture Register: a validity study. BMC Musculoskelet Disord 2019; 20(1): 197. doi: 10.1186/s12891-019-2579-z.
16. **Kärrholm J, Mohaddes M, Odin D, Vinblad J, Rogmark C, Rolfson O.** Swedish Hip Arthroplasty Register. Annual report 2017 (in Swedish); 2018. https://registercentrum.blob.core.windows.net/shpr/r/Arsrapport_2018_Hoftprotes_ENG_26mars_Final-rJepCXNsLI.pdf (accessed December 6, 2021).
17. **Feng X, McDonald J M.** Disorders of bone remodeling. Annu Rev Pathol 2011; 6: 121-45. doi: 10.1146/annurev-pathol-011110-130203.
18. **Kolaczko J G, McMellen C J, Magister S J, Wetzel R J.** Comparison of time to healing and major complications after surgical fixation of nondisplaced femoral neck stress fractures: a systematic review. Injury 2021; 52(4): 647-52. doi: 10.1016/j.injury.2021.02.046.
19. **Steele C E, Cochran G, Renninger C, Deafenbaugh B, Kuhn K M.** Femoral neck stress fractures: MRI risk factors for progression. J Bone Joint Surg Am 2018; 100(17): 1496-1502. doi: 10.2106/JBJS.17.01593.
20. **Arendt E A.** Stress fractures and the female athlete. Clin Orthop Relat Res 2000; (372): 131-8. doi: 10.1097/00003086-200003000-00015.
21. **Warden S J, Burr D B, Brukner P D.** Stress fractures: pathophysiology, epidemiology, and risk factors. Curr Osteoporos Rep 2006; 4(3): 103-9. doi: 10.1007/s11914-996-0029-y.
22. **Bernstein E M, Kelsey T J, Cochran G K, Deafenbaugh B K, Kuhn K M.** Femoral neck stress fractures: an updated review. J Am Acad Orthop Surg 2022; 30(7): 302-11. doi: 10.5435/JAAOS-D-21-00398.