Cumulative incidence and treatment of non-simultaneous bilateral femoral neck fractures in a cohort of one thousand two hundred and fifty patients

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Abstract

Purpose: In the Netherlands, over 20,000 patients sustain a hip fracture yearly. A first hip fracture is a risk factor for a second, contralateral fracture. Data on similarity of the treatment of bilateral femoral neck fractures are only scarcely available. The objectives of this study were to determine the cumulative incidence of non-simultaneous bilateral femoral neck fractures and to describe the patient characteristics and treatment characteristics of these patients.

Methods: A database of 1,250 consecutive patients with a femoral neck fracture was available. Patients with a previous contralateral femoral neck fracture were identified by 27 reviewing radiographs and patient files. Patient characteristics, previous fractures, hip fracture type and details on treatment were collected from the patient files.

Results: One hundred nine patients (9 %, 95 % confidence interval 7–10 %) had sustained a non-simultaneous bilateral femoral neck fracture. The median age at the first fracture was 81 years; the median interval between the fractures was 25 months. Overall, 73 % was treated similarly for both fractures in terms of non-operative treatment, internal fixation or arthroplasty. In patients with identical Garden classification (30 %), treatment similarity was 88 %.

Conclusions: The cumulative incidence of non-simultaneous bilateral femoral neck fractures was 9 %. Most patients with identical fracture types were treated similarly. The relatively high risk of sustaining a second femoral neck fracture supports the importance of secondary prevention, especially in patients with a prior wrist or vertebral fracture.

Introduction

Hip fractures are a global public health problem. In the Netherlands, over 20,000 patients sustain a hip fracture annually (1). The incidence of hip fractures is expected to increase, mainly due to the aging of the population. A first hip fracture is a risk factor for sustaining a second hip fracture at the contralateral side. Other reported predictors for a second hip fracture include age, female gender, living alone, alcoholism, any prior fracture, functional status, dementia, and osteoporosis (2-6).

Despite a declining trend in hip fractures in western countries (7-11), a worldwide increase is expected as a result of aging of populations by improving health care globally and increasing industrialization and urbanization (12). An increase in incidence of the first hip fracture implies that an increase in incidence of a subsequent hip fractures is to be expected as well. The latter is associated with an increased mortality risk; the one-year mortality ranges from 9 % to 27% following a first hip fracture and 8% to 32% after a second hip fracture (2, 13, 14). The 5-year mortality rate after a first and second hip fracture is 46% and 67%, respectively (2).

The overall cumulative incidence of non-simultaneous bilateral hip fractures, regardless of fracture location or subtypes, is reported to range from 2% to 15% (2-4, 6, 15-22). The reported interval between both fractures is 2-5 years (2-4, 6, 13, 15, 18, 21, 22). In 60-81% of the patients with bilateral hip fractures the second fracture is of the same type as the first hip fracture (*i.e.*, trochanteric or femoral neck) (3, 4, 13, 14, 18, 21, 23). Most reports on characteristics of bilateral hip fractures involved patients with both trochanteric and femoral neck fractures. A minority of patients with a primary trochanteric fracture sustains a subsequent contralateral femoral neck fracture. The opposite, a femoral neck fracture as a second fracture with a first trochanteric fracture, is even rarer (14, 17). Especially the

treatment of non-simultaneous femoral neck fractures has received little attention in previous studies.

Controversy on the treatment of active patients with a displaced femoral neck fracture still exists, particularly on the type of implant (*i.e.*, sliding hip screw or cannulated screws) or prosthesis (*i.e.*, hemi-arthroplasty or total hip arthroplasty). One would expect that two fractures of the same type in patients with unchanged characteristics would be treated the same. In addition to these patient and fracture characteristics, preferences of the surgeon may also contribute to the treatment selection. Detailed information on the treatment of patients with non-synchronous femoral neck fractures is limited, to the best of our knowledge. Therefore, the objectives of this study were to determine the cumulative incidence of non-simultaneous bilateral femoral neck fractures and to describe patient characteristics, mortality and treatment characteristics of these patients.

Patients and Methods

This study was conducted as a multicenter retrospective cohort study of patients who sustained non-simultaneous bilateral femoral neck fractures. The study was approved by the local medical research ethics committee (ref. No MEC-2011-419, approval date November 4, 2011). In a previous retrospective multicenter study a database was developed, containing data for 1,250 consecutive patients with a femoral neck fracture who were treated in 14 Dutch hospitals between February 2008 and August 2009 (24). Patients were identified by searching the electronic hospital databases for DBC code (Diagnosis Treatment Combination; comparable to the North-American Diagnosis Related Groups), surgical codes and ICD-codes (International Classification of Diseases, version 9 and 10).

Two investigators (PTPWB and AKEM) independently assessed pelvic and hip X-rays of all patients for the presence of any sign of a previous fracture at the contralateral side (*i.e.* implant, arthroplasty, or healed fracture). Presence of a non-simultaneous bilateral femoral neck fracture was confirmed with data in the patient files.

Patients were eligible for enrolment if details on the treatment (*i.e.*, non-operative treatment, type of implant or arthroplasty) of both femoral neck fractures were available from radiographs or medical correspondence. Pathological fractures, simultaneous bilateral fractures, and fractures following a high energetic trauma were excluded.

The following data were collected for both fractures:

- Patient characteristics: age at fracture, gender, ASA (American Society of Anesthesiologists) class, prior and concomitant fractures;
- Fracture characteristics: Garden classification (*i.e.*, undisplaced or displaced);
- Treatment characteristics: type of treatment, and for internal fixation: quality of reduction and positioning of the implant (*i.e.*, acceptable or unacceptable);
- Post-treatment details: length of hospital stay and in-hospital mortality.

The Garden classification was assessed independently by two senior trauma surgeons (MJH and MHJV) from blinded preoperative, peroperative and postoperative X-rays; classifications were done according to the description made in 1961 (25). These surgeons also rated the quality of reduction and positioning of the implant (for internal fixation), using the criteria as defined in the guideline of the Association of Surgeons of the Netherlands (26) (Table 1), as described elsewhere (24). If two out of three criteria were met, fracture reduction and positioning of implants were scored as 'acceptable'. Disagreement was solved by a third senior trauma surgeon (GRR), who independently reviewed the X-rays in order to reach a final decision.

Statistical Analysis

Statistical analyses were conducted using SPSS (SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc). Normality of continuous data was tested with the Shapiro Wilk test and by inspecting frequency histograms (Q-Q plots). All continuous variables were non-parametric and are therefore presented as medians with the first and third quartiles. Categorical variables are presented as numbers with percentages. The traditional Wald confidence interval formula for proportions was used for calculating the 95% confidence interval around the cumulative incidence of bilateral femoral neck fractures. Descriptive analyses were performed in order to describe the patient, treatment and post-operative variables for the first and second fracture. An additional analysis of treatment was performed for a subgroup of patients in whom the Garden class of the first and second fracture were of the same type.

Results

Patient demographics

The total population consisted of 1,250 patients with a femoral neck fracture. Of these, 176 patients showed radiographic signs of bilateral femoral neck fractures. After reviewing the medical files, 67 patients were excluded; 29 patients underwent arthroplasty because of arthrosis rather than a fracture, 32 patients had a subtrochanteric or pertrochanteric fracture, and six patients were treated for another reason than for osteoporotic femoral neck fracture (Figure 1). In the remaining 109 patients the occurrence of non-simultaneous bilateral femoral neck fractures (9%, 95% CI 7 to 10%) was confirmed.

Patient characteristics of these 109 included patients are shown in Table 2. The median age was 81 years (P_{25}-P_{75} 74-86 years) at the time of the first fracture and 86 years (P_{25}-P_{75} 79-89 years) at the time of the second fracture. Seventy-six patients (70%) were female. The median time between the first and the second fracture was 25 months (P_{25}-P_{75} 12-62 months). The shortest interval between the two fractures was three days (and occurred following a fall) and the longest was 20 years. The right hip was the first affected side in 51 patients (47%). At the time of the first fracture 30 of 41 patients (73%) for whom data were available lived at home. At the time of the second fracture 49 of 80 patients (61%) lived at home. Concomitant fractures were found in 5% of patients at the time of the first fracture and in 7% of patients at the time of the second fracture. Twenty-two patients (20%) had sustained another type of fracture prior to the second femoral neck fracture, with a median interval of seven years . Especially fractures of the wrist (6%), humerus (7%), spine (1%), rib (2%), olecranon (2%), and foot (2%) were found. The median hospital length of stay was 10 days (P_{25}-P_{75} 7-17 days) after the first fracture and nine days (P_{25}-P_{75} 5-13 days) after the second. One patient (1%) died during admission for treatment of the second fracture. Of the 1141 excluded patients, 42 (3.7%) died in hospital.

Fracture and treatment characteristics of the first and second femoral neck fracture

Details of the fractures and treatments of the total population of 109 patients are shown in Table 3. Data on the Garden classification of the first fracture were available in 50% of the patients. In patients for whom data were available, the first fracture was displaced in 72% of the patients (39 of 44); the second fracture (with 90% data availability) was displaced in 68% (67 of 98). Arthroplasty was performed in 65% of the first fractures and in 70% of the second fractures. The majority was treated with a hemi-arthroplasty (92% and 99% of the first and second fractures, respectively). Internal fixation was applied in 35 patients for the first fracture (32%) and in 30 patients (28%) for the second fracture. In these patients, cannulated hip screws (CHS) were then used in 49% of the first fractures and 70% of the second fractures. A sliding hip screw (SHS) was used in 49% and 30% of the first and second fractures, respectively.

An overview of similarity in characteristics and treatment of the first and second fracture is shown in Table 4. Data are presented for the entire group of 109 patients as well as for a subgroup of 33 patients in whom both fractures had the same Garden classification. This subgroup was treated identically in 88% of the patients in terms of non-operative treatment, internal fixation or arthroplasty. When the type of implant and arthroplasty were also taken into account, bilateral fractures of the same Garden classification were treated similarly in 73%. If arthroplasty was used, the same type of device was used in 100% of patients, whereas only in two out of seven patients (27%) treated with internal fixation the same type of implant was used. Table 5 shows the relation between Garden classification and treatment for the total population of 109 patients. Undisplaced fractures were mostly treated with internal fixation; 67% of the first fractures, 58% of the second fractures. Displaced fractures were treated with arthroplasty in 82% of first and in 81% of second fractures.

Discussion

Out of 1,250 patients with a femoral neck fracture, 109 had previously sustained a contralateral femoral neck fracture. The cumulative incidence of non-simultaneous bilateral fractures was 9%. This result is comparable with the recent literature, reporting a cumulative incidence of bilateral proximal femur fractures between 2% and 20% depending on the follow up period (2-6, 13, 15, 17). These studies however included both trochanteric and femoral neck fractures, implying that the cumulative incidence of bilateral femoral neck fractures in these studies had been lower than the percentages reported.

The median time between the first and second fracture in the current study was 25 months (P_{25}-P_{75}: 12.4-61.8 months). This is in line with literature data, where intervals from 2 to 5 years between the first and second hip fracture are reported (2, 4, 6). Given this short period, substantial changes in patient characteristics were not very likely.

Additional injuries, especially fractures, are likely to impair postoperative rehabilitation, to prolong hospital stay, and to increase the total health care costs. In the current study concomitant additional significant injuries such as a wrist fracture, head injury, or humeral fracture were seen in 5% and 7% of the patients at the time of the first and second hip fracture, respectively. Approximately a quarter of patients had already had a fracture in their medical history, prior to their femoral neck fracture (28%), which corresponds with a previous study on non-simultaneous bilateral femoral neck fractures (30%) (16). These results emphasize the vulnerability of this population, as a prior fracture increases the risk of a hip fracture and the occurrence of a first hip fracture increases the risk of subsequent (hip) fracture (5, 23). In the growing, fragile population that often suffers from multiple risk factors for falling and sustaining subsequent fractures, there might be great potential for multidisciplinary secondary prevention strategies. In this retrospective study documentation of osteoporosis screening was found in only 19% of the patients and anti-osteoporosis

medication was prescribed in only 24% (data not shown). This indicates too little attention has been paid to osteoporosis screening and management. Although circumstances and protocols differ between hospitals, there is a clear need for better compliance to the Dutch guideline on osteoporosis and fracture prevention (27). Regular evaluation of the local progress of the implementation should ensure a stricter protocol compliance and ultimately a better quality of fracture care (28). Also, independent community dwelling elderly have an increased risk of sustaining a second hip fracture (2). This emphasizes that the environment of the patient (*i.e.*, modifications in their home) and adequate rehabilitation (*i.e.*, appropriate use of walking aids and physical therapy) deserve attention to minimize the risk of falling and sustaining a new fracture as much as possible.

Over 80% of the displaced fractures were treated with arthroplasty and about 60% of the undisplaced fractures were treated with internal fixation. It seems that trauma and orthopedic surgeons generally agree on the treatment of the different types of femoral neck fractures, as 88% of the patients with a bilateral femoral neck fracture with similar Garden classification were treated similarly in terms of a non-operative treatment, internal fixation, or arthroplasty. However, heterogeneity in the use of the specific type of implant or prosthesis remains. This is supported by the finding that in only 27% of the patients with an identical Garden classification of both fractures the type of treatment was not the same when the type of implant/ arthroplasty was also considered. Heterogeneity was especially high in the use of implant for internal fixation. This was not unexpected, as insufficient evidence on the use of implant or arthroplasty type for femoral neck fractures is known (29). It was however unexpected, that the controversy in the essential details of treatment seemed larger in undisplaced fractures (67 versus 58% internal fixation in first and second fracture), than in displaced fractures (82 versus 81% arthroplasty in first and second fracture). Diverging

treatment decisions may however partially be explained by other variables such as coxarthrosis, comorbidity, surgeons preferences, material availability.

The strength of the current study is that a database of a large number of 1,250 consecutive patients treated in fourteen different hospitals was used (24). However, due to the retrospective design data were incomplete from a substantial number of patients. Data concerning the first fracture were often missing for patients in whom the first fracture was treated at another hospital. In addition, some radiographs were not available, *e.g.*, when they were made analogous, during external storage, or during digital exportation. There are no indications for a selective pattern of missingness of data. As a consequence, a reliable multivariable analysis was not possible. For the same reason the one year mortality could not be calculated, therefore the in-hospital mortality was used as a relevant alternative. Moreover, as no data on the cumulative incidence in a matched control cohort were available, it was not possible to carry out a risk assessment. Due to the relatively small number of patients per hospital, a subgroup analysis of similarity of management for both fractures if treated at the same hospital was not possible. It is unfortunate that data on osteoporosis or osteoporosis treatment were often not documented. As discussed above, attention for osteoporosis screening and treatment can still be improved. For this reason, osteoporosis guidelines have been implemented in 1999 and were revised in 2002 and 2011 (28). Despite duplicate assessment of radiographic images, non-operatively treated fractures or fractures in which implants are removed could have been missed. However, if only the slightest doubt existed patient files were checked; in none of those patients a previous fracture was confirmed. Therefore it is unlikely that bilateral fractures were missed.

Conclusion

In a population of 1,250 patients who sustained a femoral neck fracture during the study period, 9% had previously sustained a femoral neck fracture at the contralateral side. The median time interval between both fractures was 25 months. If both fractures were undisplaced or both were displaced, the same treatment was applied in 88% of patients. Surgeons generally agreed on the use of internal fixation or arthroplasty for the different types of femoral neck fractures. The relatively high risk of sustaining a second femoral neck fracture supports the importance of national secondary prevention guidelines, especially in patients with a prior wrist or vertebral fracture.

References

1. CBS. Statistics Netherlands (CBS). Health care use and hospital admission statistics in The Netherlands. Den Haag: Centraal Bureau voor de Statistiek. Health care use and hospital admission statistics in The Netherlands. 2010.

2. Berry SD, Samelson EJ, Hannan MT, McLean RR, Lu M, Cupples LA, et al. Second hip fracture in older men and women: the Framingham Study. Arch Intern Med. 2007;167:1971-6.

3. Fukushima T, Sudo A, Uchida A. Bilateral hip fractures. J Orthop Sci. 2006;11:435-8.

4. Kok LM, van der Steenhoven TJ, Nelissen RG. A retrospective analysis of bilateral fractures over sixteen years: localisation and variation in treatment of second hip fractures. Int Orthop. 2011;35:1545-51.

5. Ryg J, Rejnmark L, Overgaard S, Brixen K, Vestergaard P. Hip fracture patients at risk of second hip fracture: a nationwide population-based cohort study of 169,145 cases during 1977-2001. J Bone Miner Res. 2009;24:1299-307.

6. Vochteloo AJ, Borger van der Burg BL, Roling MA, van Leeuwen DH, van den Berg P, Niggebrugge AH, et al. Contralateral hip fractures and other osteoporosis-related fractures in hip fracture patients: incidence and risk factors. An observational cohort study of 1,229 patients. Arch Orthop Trauma Surg. 2012;132:1191-7.

7. Hartholt KA, Oudshoorn C, Zielinski SM, Burgers PT, Panneman MJ, van Beeck EF, et al. The epidemic of hip fractures: are we on the right track? PLoS One. 2011;6:e22227.

8. Icks A, Arend W, Becker C, Rapp K, Jungbluth P, Haastert B. Incidence of hip fractures in Germany, 1995-2010. Arch Osteoporos. 2013;8:140.

9. Jean S, O'Donnell S, Lagace C, Walsh P, Bancej C, Brown JP, et al. Trends in hip fracture rates in Canada: An age-period-cohort analysis. J Bone Miner Res. 2013;28:1283-9.

10. Korhonen N, Niemi S, Parkkari J, Sievanen H, Palvanen M, Kannus P. Continuous decline in incidence of hip fracture: nationwide statistics from Finland between 1970 and 2010. Osteoporos Int. 2013;24:1599-603.

11. Cooper C, Cole ZA, Holroyd CR, Earl SC, Harvey NC, Dennison EM, et al. Secular trends in the incidence of hip and other osteoporotic fractures. Osteoporos Int. 2011;22:1277-88.

12. Cheng SY, Levy AR, Lefaivre KA, Guy P, Kuramoto L, Sobolev B. Geographic trends in incidence of hip fractures: a comprehensive literature review. Osteoporos Int. 2011;22:2575-86.

13. Gaumetou E, Zilber S, Hernigou P. Non-simultaneous bilateral hip fracture: epidemiologic study of 241 hip fractures. Orthop Traumatol Surg Res. 2011;97:22-7.

14. Sawalha S, Parker MJ. Characteristics and outcome in patients sustaining a second contralateral fracture of the hip. J Bone Joint Surg Br. 2012;94:102-6.

15. Chapurlat RD, Bauer DC, Nevitt M, Stone K, Cummings SR. Incidence and risk factors for a second hip fracture in elderly women. The Study of Osteoporotic Fractures. Osteoporos Int. 2003;14:130-6.

16. Dinah AF. Sequential hip fractures in elderly patients. Injury. 2002;33:393-4.

17. Dretakis KE, Dretakis EK, Papakitsou EF, Psarakis S, Steriopoulos K. Possible predisposing factors for the second hip fracture. Calcif Tissue Int. 1998;62:366-9.

18. Kaukonen JP, Luthje P, Nurmi-Luthje I, Kataja M, Naboulsi H. Second hip fracture and patients' medication after the first hip fracture: a follow-up of 221 hip fracture patients in Finland. Arch Gerontol Geriatr. 2011;52:185-9.

19. Lonnroos E, Kautiainen H, Karppi P, Hartikainen S, Kiviranta I, Sulkava R. Incidence of second hip fractures. A population-based study. Osteoporos Int. 2007;18:1279-85.

20. Melton LJ, 3rd, Ilstrup DM, Beckenbaugh RD, Riggs BL. Hip fracture recurrence. A population-based study. Clin Orthop Relat Res. 1982:131-8.

21. Schroder HM, Petersen KK, Erlandsen M. Occurrence and incidence of the second hip fracture. Clin Orthop Relat Res. 1993:166-9.

22. Shabat S, Gepstein R, Mann G, Kish B, Fredman B, Nyska M. The second hip fracture--an analysis of 84 elderly patients. J Orthop Trauma. 2003;17:613-7.

23. Hagino H, Sawaguchi T, Endo N, Ito Y, Nakano T, Watanabe Y. The risk of a second hip fracture in patients after their first hip fracture. Calcif Tissue Int. 2012;90:14-21.

24. Zielinski SM MM, Heetveld MJ, Verhofstad MHJ, Roukema GR, Patka P, Van Lieshout EMM, On behalf of the Dutch femoral neck fracture investigator group. Adherence to a femoral neck fracture treatment guideline. Int Orthop. 2013;37:1327-34.

25. Garden R. Low-angle fixation in fractures of the femoral neck. J Bone Joint Surg Br. 1961;43:647-63.

26. ASN. NVvH. Richtlijn: Behandeling van de proximale femurfractuur bij de oudere mens (Guideline Association of Surgeons of the Netherlands: Treatment of proximal femur fractures in the elderly patient). 2007.

27. Sale JE, Beaton D, Posen J, Elliot-Gibson V, Bogoch E. Systematic review on interventions to improve osteoporosis investigation and treatment in fragility fracture patients. Osteoporos Int. 2011;22:2067-82.

28. CBO. Kwaliteitsinstituut voor de gezondheidszorg, CBO. Richtlijn Osteoporose en Fractuurpreventie. Derde herziene richtlijn; 2011. The Institute for Health Care Quality, CBO. Guideline Osteoporosis and fracture prevention. Third revision; 2011. 2011.

29. Bhandari M, Devereaux PJ, Tornetta P, 3rd, Swiontkowski MF, Berry DJ, Haidukewych G, et al. Operative management of displaced femoral neck fractures in elderly patients. An international survey. J Bone Joint Surg Am. 2005;87:2122-30.

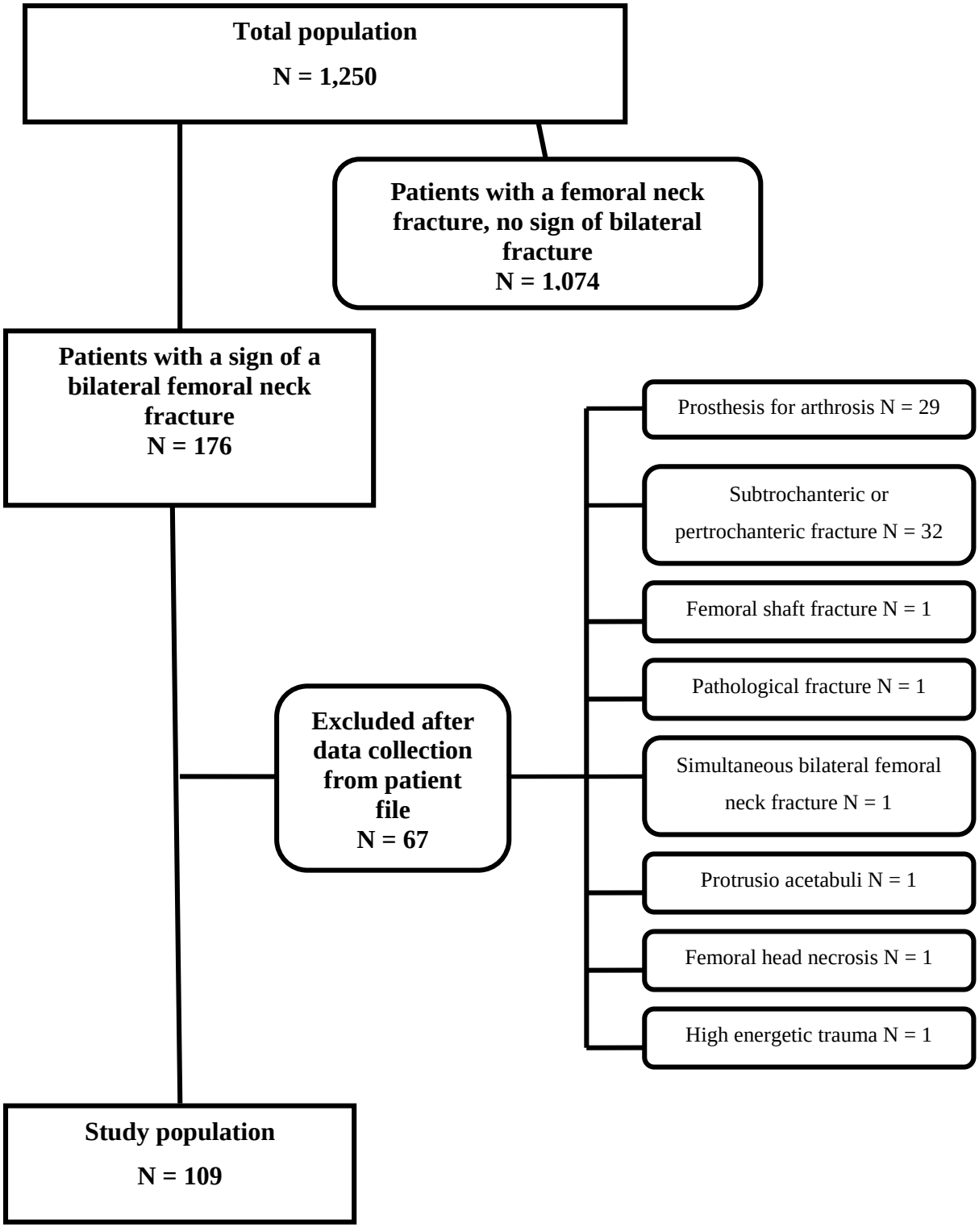

Figure 1. Flowchart of enrolled patients.

Table 1. Criteria for acceptable reduction and positioning of the implant for internal fixation of a femoral neck fracture, according to the guideline of the Association of Surgeons of the Netherlands (26).

Acceptable reduction	Varus- valgus dislocation: maximum Garden index: 160–180° [+] Femoral neck shortening neutralized[+] Dorsoventral dislocation: maximum 10° retroversion - 5° anteversion[++]
Acceptable position cannulated screws	One screw placed caudally over the calcar femoris[+] One screw placed over the dorsal cortex[++] Screws positioned into the subchondral bone (maximum distance between screw tip and femoral head lining: 5-10 mm)[+]
Acceptable position sliding hip screw	Screw positioned in the central or caudal 1/3 part of femoral head[+] Screw positioned in the central or dorsal part of femoral head[++] Screw positioned into the subchondral bone (maximum distance between screw tip and femoral head lining: 5-10 mm)[+]

[+] On AP (Anterior-Posterior) view. [++] On axial view.

Table 2. Patient characteristics by first and second fracture

Characteristic	**Overall**	**First Fracture**	**Second fracture**
	N= 109	**N=109**	**N=109**
Age [1] (year)		81 (74-86)	86 (79-89)
Female gender [2]	76 (70)		
Right side affected [2]		51 (47)	58 (53)
Additional injuries at presentation[2]		5 (5)	8 (7)
Wrist/hand fracture		4 (4)	1 (1)
Humeral fracture		0 (0)	3 (3)
Tibia fracture		0 (0)	1 (1)
Head injury/wound		1 (1)	3 (3)
Not documented		34 (31)	3 (3)
Prior other fracture [2]	23 (21)		
Not documented	27 (25)		
Pre-operative ASA-class [2]			
ASA I-II		21 (19)	65 (57)
ASA III-IV		12 (11)	34 (31)
Unknown		76 (70)	13 (12)

[1] Data are displayed as median, with the first and third quartile given within brackets;
[2] Patient numbers are displayed with percentages within brackets

Table 3. Fracture and treatment characteristics by first and second fracture

Characteristic	**First fracture N=109**	**Second fracture N=109**
Garden classification		
Non-displaced (Garden I-II)	15 (14)	31 (28)
Displaced (Garden III-IV)	39 (36)	67 (62)
Missing*	55 (51)	11 (10)
Therapy		
Non-operative treatment	3 (3)	3 (3)
Internal Fixation	35 (32)	30 (28)
Cannulated screws	17 (16)	21 (19)
Sliding hip screw	17 (16)	9 (8)
PFN-A	1 (1)	0 (0)
Arthroplasty	71 (65)	76 (70)
Hemi-arthroplasty	65 (60)	75 (69)
Total hip arthroplasty	6 (6)	1 (1)
Internal fixation: Reduction		
Adequate	20 (57)	28 (93)
Not adequate	0 (0)	2 (7)
Not able to determine	4 (11)	0 (0)
Missing	11 (31)	0 (0)
Internal fixation: Implant position		
Adequate	19 (54)	26 (87)
Not adequate	1 (3)	4 (13)

Not able to determine	4 (11)	0 (0)
Missing	11 (31)	0 (0)
Implant position Cannulated screws		
Adequate	8 (47.1)	17 (81.0)
Not adequate	1 (5.9)	4 (19.0)
Not able to determine	2 (11.8)	0 (0.0)
Missing	6 (35.3)	0 (0.0)
Implant position Sliding Hip Screw		
Adequate	11 (64.7)	9 (100.0)
Not adequate	0 (0.0)	0 (0.0)
Not able to determine	1 (5.9)	0 (0.0)
Missing	5 (29.4)	0 (00.0)

Patient numbers are displayed, with the percentages given within brackets.

* Garden classification could not be determined if adequate diagnostic images were not available, *e.g.*, if trauma diagnostic had been done at another hospital.

Table 4. Identical characteristics and treatment of first and second fracture

	Entire group (N=109)	Same Garden classification for both fractures (N=33)
	N (%)	N (%)
ASA classification	15/109 (14)	10/33 (30)
Garden class	33/109 (30)	N.A.
Treatment[a]	62/109 (57)	24/33 (73)
Treatment[b]	80/109 (73)	29/33 (88)
Type of prosthesis[c]	54/60 (90)	22/22 (100)
Type of implant[c]	8/20 (40)	2/7 (29)
Reduction[c]	11/20 (55)	5/7 (71)
Position implant[c]	9/20 (45)	6/7 (86)
Position cannulated screws[c]	2/4 (50)	2/2 (100)
Position SHS[c]	2/4 (50)	N.A.

Data are shown as numbers with the percentage within brackets.

N.A.; not applicable.

[a] Treatment separated into non-operative, CHS, SHS, PFN-A, hemiarthroplasty and total hip arthroplasty.

[b] Treatment separated into non-operative, internal fixation, and arthroplasty.

[c] Data are shown for the subgroup of patients (denominator) where this applies to and for which data were available for both fractures.

Table 5. Association between the Garden classification and treatment (all 109 patients)

Treatment	Garden I-II	Garden III-IV	Unknown
First fracture	N=15	N=39	N=55
Non-operative	2	0	1
Internal fixation	10	7	18
Arthroplasty	3	32	36
Second fracture	N=31	N=67	N=11
Non-operative	1	1	1
Internal fixation	18	12	0
Arthroplasty	12	54	10

Data are shown as numbers.