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Factors predicting secondary displacement after non-operative treatment of undisplaced femoral neck fractures

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Abstract
Introduction We quantified the risk and the time of occurrence of secondary fracture displacement in non-operatively treated femoral neck fractures in our clinic, as well as investigated potential predicting patient- and fracture-related factors.
Methods The records of 593 patients with femoral neck fractures from January 2000 to December 2009 were reviewed. Sixty-one patients [mean age 83.0 years (SD 9.9)] with undisplaced femoral neck fractures initially received non-operative treatment. The occurrence and the time of secondary fracture displacement were documented, as well as demographics and radiological parameters. Radiographs were evaluated independently by two surgeons. Multivariable regression and Kaplan–Meier survival analyses were used.
Results Thirty-four (55.7 %) fractures showed secondary displacement occurring within the first 12 weeks after initiation of non-operative treatment. Twenty (38 %) fractures originally classified as Garden I were found to be Garden II. The risk of secondary displacement was three times higher (RR = 2.8; 95 % CI 1.7–4.8, $p < 0.001$) for these fractures in comparison with those confirmed as Garden I. Patients with a history of previously diagnosed osteoporosis were at a higher risk of secondary displacement as well (RR = 1.3; 95 % CI 1.0–1.5).
Conclusions Non-operative treatment of femoral neck fractures is a treatment option, but only in well-selected cases. The majority of secondary displacements were associated with initial misdiagnosis using the Garden classification. For Garden II, primary surgical treatment is likely a better option, and therefore careful application of the Garden classification in this context is essential.

Keywords Femoral neck fracture · Secondary displacement · Conservative treatment · Non-operative treatment · Undisplaced femoral neck fractures · Garden's classification

Introduction

Worldwide, the total number of hip fractures is expected to surpass six million by the year 2050 [1–3]. Treatment of these fractures is generally operative and the surgical options, either internal fixation or hemiarthroplasty, are closely linked to individual patient factors and to the location and degree of fracture displacement [2, 4]. Non-operative treatment of femoral neck fractures is limited to the undisplaced/impacted fractures; however, there is no consensus regarding treatment in the elderly [5]. Most often, the basis for treatment recommendations and/or decision is the Garden classification of femoral neck fractures [5], although there is ongoing controversy, in particular for the treatment of Garden I femoral neck fracture

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considering the various available options; non-operative [6], percutaneous fixation [7], internal fixation or arthroplasty [8].

Non-operative treatment avoids risks of an operation and postoperative complications, particularly in elderly patients; this treatment, however, was reported to fail in many patients leading to secondary displacement (SED) with rates reported between 14 and 52 % [5, 9–11], as observed in our clinic. SED is manifested by pain exacerbation associated with the loss of impaction of the fracture or displacement of a primary undisplaced fracture. These patients were generally treated by hemiarthroplasty, which caused additional health-related burden and costs, instead of being primarily treated surgically by joint preserving internal fixation. Identifying these patients before treatment would help avoiding unnecessary harm associated with SED.

This study was, therefore, set to quantify the rate of SED and understand the patient factors associated with SED to help the decision process for surgery in high risk patients.

Patients and methods

593 patients with femoral neck fractures were admitted to our surgical department between January 2000 and December 2009. Conventional anterior–posterior (AP) and axial X-rays were performed at admission. All X-rays were done in the radiological department of our hospital, according to the standard protocols. AP X-rays were obtained in the supine position with the hips in a neutral position. The radiation beam was centred on the superior aspect of the pubic symphysis and was perpendicular to the patient. The axial X-rays were taken with the contralateral hip flexed to 90°. The direction of the beam was parallel to the examination table and 45° cephalad to the long axis of the body. The X-ray was held perpendicular to the examination table using a cassette holder.

Patients with an undisplaced (intracapsular) femoral neck fracture, who had primarily received non-operative treatment were included. Patients with pathological fractures and history of previous fracture in the studied hip were excluded. Sixty-one patients met the eligibility criteria. These included 48 females (79 %) and had an average age of 82.4 years (SD 9.9; range 37–96). Three patients died within 3 months after trauma and were lost to follow-up at 10, 26 and 45 days, respectively. The study was approved by the local ethical committee.

According to our clinic's guidelines, all elderly patients diagnosed with impacted (Garden I) femoral neck fracture were to be treated non-operatively;

- Patients were given analgesics to reduce the pain
- Weight bearing as tolerated supported by crutches or a walker under guidance by a physiotherapist.
- Scheduled follow-up examination (including AP and axial X-rays) was conducted at 3 months postoperatively or sooner whenever the patient experienced a pain recurrence or exacerbation after mobilisation

The fracture classification and related decision for non-operative treatment for each patient was taken by a trauma consultant.

Patients' data including: age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) classification and co-morbidities were documented (Table 1).

All AP X-rays of the pelvis and the studied hip axial X-rays were re-assessed by two independent observers, including a senior department surgeon and a resident surgeon, who were blinded to the patient outcome. The following parameters were recorded; (a) signs of arthrosis including sclerosis, reduced joint space, osteophytes, and osteolysis; (b) Pauwels' classification [12], referring to the angle the fracture line makes with the horizontal as Grade 1 (0–30°), Grade 2 (30–50°), or Grade 3 (>50°); and (c) Garden classification. To avoid bias due to different opinions regarding the Garden classification, the original description was given to the observers [13]. Although all fractures should have been Garden I according to the clinic's guidelines, they were re-classified as Garden I (undisplaced incomplete fracture, including valgus impacted fractures) or Garden II (undisplaced complete fracture). Discrepant data between the two observers were resolved by consensus.

In the follow-up, SED was considered in the AP and/or axial view, which was manifested by pain exacerbation associated with loss of impaction of the fracture or displacement of a primary undisplaced fracture. The occurrence of SED and additional related hospital stay after initiation of non-operative treatment were documented. Affected patients were operated with a hemiarthroplasty and were allowed to weight bear as tolerated. The patients and/or their family were contacted at the time of the study (2–11 years postoperatively) to ensure that no SED was missed or treated elsewhere. Patients were divided into the SED group with a record of SED and the undisplaced (UD) group.

Data were entered into a MS Excel® spreadsheet and imported for statistical analyses into the software Stata® Version 11 (StataCorp LP, Texas, USA). The rate of SED within 3 months after initiation of non-operative treatment was calculated as the total number of SEDs recorded divided by the total number of eligible and included patients. A binomial exact 95 % confidence interval was calculated. The time to SED was assessed by Kaplan–

Table 1 Patient demographics and co-morbidities per outcome group

Factors	UD group *n* (%)	SED group *n* (%)	Fischer's exact *p* value
Age (years)			0.84
≤70	3 (11)	2 (6)	
>70-80	6 (22)	7 (21)	
>80	18 (67)	25 (74)	
Gender			0.53
Male	7 (26)	6 (18)	
Female	20 (74)	28 (82)	
Body mass index (kg/m^2)			1.00
Up to 25 (normal weight)	8 (89)	17 (77)	
>25-30 (overweight)	1 (11)	4 (18)	
>30 (obese)	0 (0)	1 (5)	
ASA Classification			0.69
II	7 (28)	9 (27)	
III	14 (56)	22 (64)	
IV	4 (16)	3 (9)	
History of diagnosed osteoporosis			0.21
No	26 (96)	29 (85)	
Yes	1 (4)	5 (15)	
History of other fracture			0.29
No	19 (70)	19 (56)	
Yes	8 (30)	15 (44)	
Hip prosthesis on the contralateral side			0.20
No	20 (71)	29 (88)	
Yes	8 (29)	4 (12)	

SED and UD: patients with and without secondary displacement of intracapsular femoral neck fractures, respectively

Meier survival analysis, whereby three deceased patients were censored at the time of death. A multivariable binomial regression model to derive adjusted risk ratios (RR) was carried on. Sensitivity analysis was implemented to assess the influence of mortality [14].

Results

Secondary displacement (Fig. 1) occurred in 34 patients with a risk of 55.7 % (95 % CI 42.4–68.4 %). The median time to secondary displacement and operation was 9.5 weeks, and 90 % of SEDs occurred within 6 weeks after trauma as illustrated by the Kaplan–Meier curve (Fig. 2). No SED occurred later than 3 months after initiation of the non-operative treatment. Twelve patients (35.3 % of patients with SED) experienced the SED at home after hospital discharge. If only patients with confirmed Garden I fracture had been considered for non-operative treatment, the SED rate would have decreased at our hospital from 55.7 to 30.3 % (10/33).

The group of 34 patients with SED and other group of 27 patients with UD fractures had an average age of 82.6 and 82 years, respectively. At the univariable analysis, patient demographic factors and ASA classification did not show any significant association with the occurrence of SED (Table 1). Similarly radiological parameters, except the Garden classification (Garden I/Garden II), did not show significant relationship with the occurrence of SED (Table 2).

The history of diagnosed osteoporosis, presence of another hip prosthesis on the contralateral side, revised Garden classification and degree of head displacement (Pauwels) were considered together into multivariable regression analyses (p value ≤0.30). The final binomial regression model included two significant factors. Patients confirmed to have a Garden II fracture had a 2.8-times higher risk of SED (95 % CI 1.7–4.8; $p < 0.001$) compared to Garden I fractures. In addition, patients with a history of osteoporosis were at a significantly higher risk of SED than patients without such history (RR = 1.3; 95 % CI 1.0–1.5; $p = 0.028$). The database included five patients with a documented history of osteoporosis, four of them showing a Garden I fracture. Combining these two factors, patients with either a history of osteoporosis or a Garden II fracture showed a 3.6-times higher risk of SED (95 % CI 1.9–6.9; $p < 0.001$) compared to patients with Garden I fracture and no history of osteoporosis. Three months later, the proportion of patients without SED in these two groups was 24 and 88 %, respectively (Fig. 3).

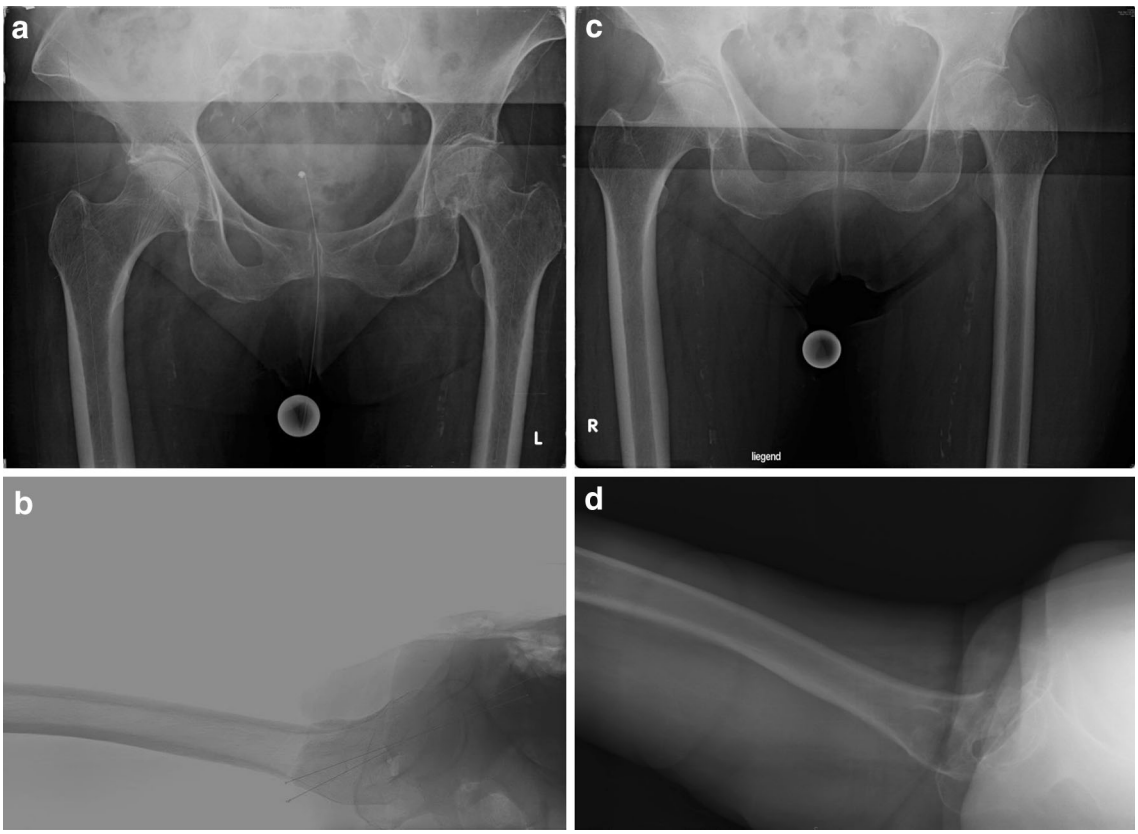

Fig. 1 Primary non-operative treatment of a 75 years old female patient, initial AP (**a**) and axial (**b**) X-ray after trauma, classified as Garden I. AP (**c**) and axial (**d**) X-ray after pain exacerbation and secondary displacement

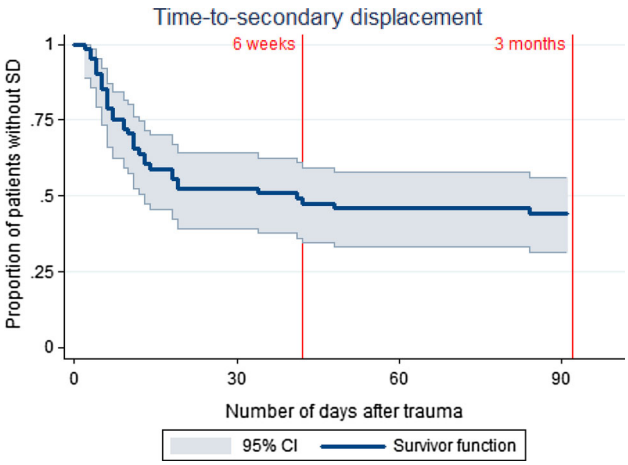

Fig. 2 Kaplan–Meier curve of time to occurrence of secondary displacement

Discussion

This study was conducted to investigate factors associated with SED after non-operative treatment of femoral neck fractures. Functional treatment of Garden I femoral neck fractures is considered a viable treatment option [5]. This regimen has been applied in our clinic for approximately two decades; however, 55.7 % of concerned patients experienced secondary displacement. This represents a burden for the affected patients because they received an operation with hemiarthroplasty, while many of them would have benefited from a joint preserving internal fixation or primary intervention [8]. Being able to identify these patients, hence, would improve the decision making process for better patient care.

The diagnostic and fracture classification process appeared to be a significant contributor for the high rate of SED in our clinic. The relatively high rate of SED in our study might be due to the presence of both Garden I and Garden II femoral neck fractures in our patient group. This is consistent with Helbig et al. [11] who reported in a retrospective case series a rate of 52 % SED among 54 patients with Garden I or II managed similarly in terms of early mobilisation and full weight bearing.

Considering alternative regimens of non-operative treatment for Garden I femoral neck fractures, Verheyen et al. [9] noted in retrospective series 46 % SED in patients treated with partial weight bearing collected data from four different hospitals. These pre-classified the patients as Garden I and treated them non-operatively, still 5 (4.5 %) from 110

Table 2 Radiological parameters

Factors	UD group[a] *n* (%)	SED group[b] *n* (%)	Fischer's exact *p* value
Fracture side			0.61
Right	15 (56)	16 (47)	
Left	12 (44)	18 (53)	
Osteophytes			0.41
No	9 (36)	14 (50)	
Yes	16 (64)	14 (50)	
Reduction in joint space			1.00
No	12 (48)	14 (50)	
Yes	13 (52)	14 (50)	
Sclerosis			0.58
No	10 (40)	9 (32)	
Yes	15 (60)	19 (68)	
Osteolysis			0.40
No	21 (84)	26 (93)	
Yes	4 (16)	2 (7)	
Garden Classification			<0.001
I	23 (92)	10 (36)	
II	2 (8)	18 (64)	
Pauwels classification			0.45
I (≤30)	3 (12)	7 (25)	
II (>30–50)	19 (76)	18 (64)	
III (>50)	3 (12)	3 (11)	

SED and UD: patients with and without secondary displacement of intracapsular femoral neck fractures, respectively

[a] 2 X-rays were missing

[b] 6 X-rays were missing

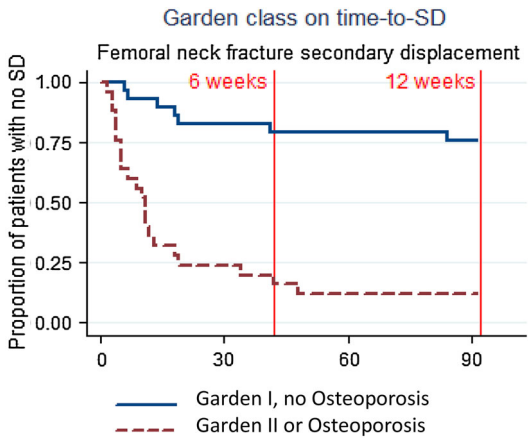

Fig. 3 Effect of Garden classification and history of osteoporosis on Kaplan–Meier curves for secondary displacement

patients had Garden II or III. Shuqiang et al. [10] reported a similar rate of 41 % in a series of 115 patients treated with skin traction and delayed weight bearing until after callus formation was confirmed on plain X-rays. Recently, Buord et al. [5] pointed out a 33 % rate of SED in a prospective study including 56 patients older than 65 years after delaying the full mobilisation 48 h after trauma. The X-rays were assessed by two observers but no information about the inter-observer variation was mentioned.

The patient's age, gender, ASA classification did not show prognostic value for SED. The previous studies considering these factors [5, 9–11] showed no impact on SED as well. This might be related to the fact that the non-operative treatment is usually chosen in elderly patients affected by co-morbidities who in general, already have reduced activity. Raaymakers and Martin [15] recommended operating on all patients above 70 years, even prophylactically, as they are a risk group of secondary displacement. Ninety-two percent of our patients were in this age category and indeed the occurrence of SED can be considered as high. However, in our clinic, this risk may be more related to fracture type rather than patient age per se.

The Garden classification was rated above the Pauwel's or AO Classification by 72 % of 298 surveyed surgeons in Canada and the United States as the most clinically relevant and useful classification [16]. In our study, fractures classified as Garden II had a 3-times higher risk of experiencing SED, which may explain the higher rate of SED compared to previously published studies [5, 9, 10]. Our hospital internal guidelines recommended non-operative treatment only for Garden I fractures; however, 37 % of non-operatively treated patients likely had in fact a Garden II fracture which highlights the problem of inter-observer variation and accuracy of the diagnostic process. Frandsen et al. [17] reported that 8 orthopaedic surgeons and radiologists agreed on the Garden classification for only 22 out

of 100 cases of femoral neck fractures and that the differentiation between Garden types I and II was not reliable. Thomsen et al. [18] reported a 15 % agreement in the classification among six observers. Beimers et al. [19] concluded that the Garden classification was unreliable involving 11 observers to decide on 34 cases [16]. In our study, we therefore reviewed each fracture carefully. Our consensus classification is more accurate than the original rating made by a single surgeon during clinical routine.

Melvin et al. [20] reported recently on the increase in agreement in Garden classification by attending orthopaedic surgeons with CT, either alone or combined with plain X-ray, and modification of the Garden classification (displaced/Undisplaced fracture), achieving moderate agreement (Kappa = 0.547 and Kappa = 0.505, respectively).

In our study, indication of previously diagnosed osteoporosis was documented from patient history, and a significant weak association was observed with the occurrence of SED, after considering the Garden classification in the same multivariable model. This result has not been reported before and should be interpreted with caution given that no bone density was measured around the time of the fracture. Measuring the Singh index from available radiographs was not considered a suitable surrogate due to its poor reliability and poor correlation with the bone density [21]. Our observation, nevertheless, is consistent with the limited available literature. The effect of osteoporosis on SED has been demonstrated in some biomechanical as well as clinical studies, while considering the complications of fracture fixation in osteoporotic bone [22]. Bonnaire et al. [14] demonstrated that fixing the fracture in proximal femur using different implants and applying limited cyclic testing in combined loading axis showed a significant direct correlation between bone density parameters and mechanical performance. Spangler et al. [23] identified patients as having osteoporosis from the international classification of disease (ICD) code for osteoporosis found in hospital records. Fixation failure requiring revision surgery in this population was 7.8 times (95 % CI, 1.8–32.8) more likely in osteoporosis patients than in patients without osteoporosis after adjusting for age and accuracy of reduction.

This is a small retrospective study associated with missing data; nevertheless, the rate of SED could be evaluated with adequate precision. The analysis of prognostic factors was explorative and could only identify factors that were collected with sufficient accuracy and have a strong association with the occurrence of SED. Intensive monitoring allowed a reliable outcome for all patients. Three patients died within 3 months without SED; however, only one patient died early in the first 6 weeks when the vast majority of SEDs occurred. Considering that this patient could have had an SED if not deceased, Garden Fracture classification results would have remained the same. Negligible change was also noted after imputation of missing values. Finally, data were collected at a single hospital in Europe; results may not apply to different hospitals where different diagnostic processes or treatment guidelines for undisplaced femoral neck fractures apply.

Conclusion

Non-operative management appears to remain a viable treatment option for non-osteoporotic patients with Garden I femoral neck fractures with a risk of SED close to 10 %. Other patients are to be informed about the high rate of SED in an effort to help make an informed decision. In case of Garden II fracture, especially in osteoporotic patients, primary operative treatment should be suggested due to increased risk of SED. Cross-check of Garden I diagnosis by experienced surgeon peers, together with a CT scan, can be considered to reduce the risk of misclassification. SED should be reduced as it is associated with health-related burden for the patients and higher costs for society.

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Conflict of interest There is no conflict of interest.

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