Chapter 8

Radiographic fracture features predicting failure of internal fixation of displaced femoral neck fractures

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ABSTRACT

Aim

Fixation related complications of displaced femoral neck fractures treated by internal fixation are accompanied by high mortality and morbidity. The aim of this study is to investigate the pre- and postoperative radiographic fracture characteristics in relation to patient age and the occurrence of reoperation caused by fixation failure.

Methods

The preoperative radiographs of all patients presenting with a proximal femur fracture between January 2004 and December 2012 were retrospectively assessed for fracture type and dislocation (AP and lateral view). Patients with a displaced femoral neck fracture treated by closed reduction and internal fixation were included. The postoperative radiographs were assessed on adequate fracture reduction and correct position of the implant. Patient characteristics and outcome in terms of occurrence of fixation failure (implant break out, non-union) and reoperation rate were recorded.

Results

Hundred-and-forty-nine patients were admitted with a displaced femoral neck fracture and treated by internal fixation. Fixation failure was seen in 34 (23%) patients, 9 patients suffered from osteonecrosis. In total, 37 (25%) patients underwent reoperation caused by fixation related complications. Taking the different age categories into account 44% of the patients over 75 years suffered fixation failure, compared with 17% of the patients under 65 years. Postoperative incorrect reduction, with persisting dorso-ventral dislocation and/or lack of medial support resulted in reoperation in 37% of the patients, compared to 19% reoperations in patients with adequate reduction.

Conclusion

The results of this study show that patient age and fracture reduction are important predictors for reoperation. In the preoperative treatment plan, patient age should be taken into account and surgeons should strive for anatomical reduction. Patients over 75 should always undergo arthroplasty. In patients aged 65-75, conversion to arthroplasty should be strongly considered if anatomical reduction is impossible.

INTRODUCTION

Hip fractures are associated with a 30% mortality rate in the first year postoperatively.[1] In this fragile population, reoperation is accompanied by a dramatic increase in morbidity and mortality rates, and should therefore be avoided by all means.
Non-displaced femoral neck fractures are commonly treated by internal fixation. However, closed reduction and fixation of displaced fractures remains controversial, as it is related to high rates of fixation failure (10% to 33%) such as implant break-out or non-union.[2] Despite advances in implant design and postoperative care these numbers have not changed over the years.[3,4] Some patient and fracture related factors associated with fixation failure such as improper fracture reduction and higher age have been identified but never investigated thoroughly.[5-7]
It is generally accepted, for patients with a natural age above 80 years to treat a displaced fracture by (hemi-)arthroplasty.[8] Despite an international tendency of treating patients aged between 65 and 80 by (hemi-)arthroplasty, it remains controversial in terms of scientific evidence, whether femoral head preservation should be intended or (hemi)-arthroplasty should be considered.[8-12] For instance, for this group of patients depending on comorbidity, head preserving treatment is still incorporated in the Dutch guidelines.[8]
The aim of this retrospective cohort study is to investigate predicting pre- and postoperative radiographic fracture characteristics and compare these to the reoperation rate caused by fixation failure and patient age.

METHODS

All patients presenting in a large teaching hospital in The Hague, The Netherlands, between January 2004 and December 2012 due to a proximal femur fracture, were recorded. Based on the radiographs at admittance, fractures were classified as extracapsular (trochanteric) or intracapsular, and as non-displaced or displaced. Displacement was defined as dislocation on the anterior-posterior (AP) radiograph (Garden III/IV) and/or dislocation on the axial view. All patients with a displaced intracapsular fracture treated by three cancellous screws (CS) or dynamic hip screw (DHS) were included. The operative procedures could be performed by surgical residents, general surgeons, trauma surgeons or orthopedic surgeons.
Gender, age at admission and ASA score (a global score that assesses the physical status of patients before surgery)[13] were recorded.
Generally, all patients had a radiological follow up until one year after trauma or until reoperation or death occurred. In cases with a follow-up period of less than one year, the

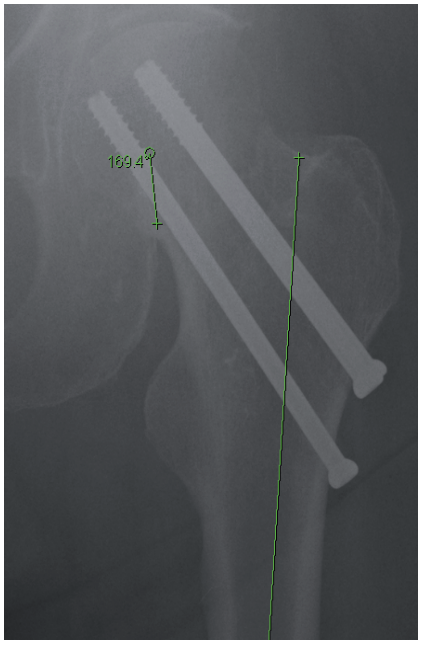

Figure 1

Garden angle: correct between 160-180 degrees

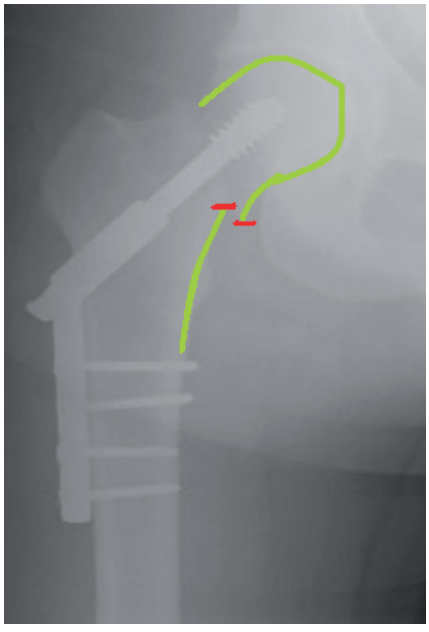

Figure 2

No post-operative medial support

files of other specialisms were checked to see if the patient had any complaints. If not, the follow-up was set at one year.

The following parameters were recorded for the preoperative radiographs. A displaced fracture was characterized by: 1) translation in AP view (Garden III/IV) and/or 2) dorso-ventral translation (in lateral view) present in AP non-displaced fractures.

Postoperative radiographs were analyzed for adequate fracture reduction and correct position of the screw(s). Fracture reduction was assessed according to 1) the Garden angle between 160-180 degrees (Figure 1), 2) presence of medial support (Figure 2), and 3) dorso-ventral angulation between 5 degrees anteversion and 10 degrees retroversion (Figure 3)[8].

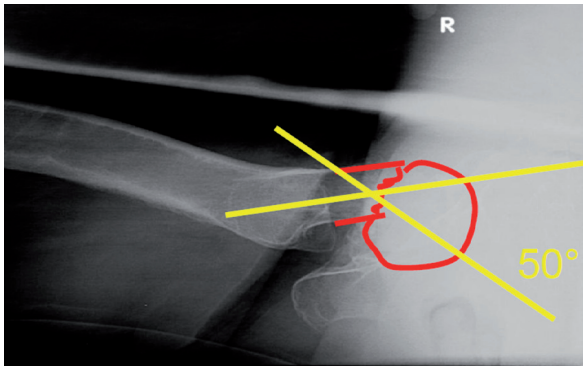

Figure 3

Dorso-ventral dislocation, angle correct between 5 degrees anteversion and 10 degrees retroversion

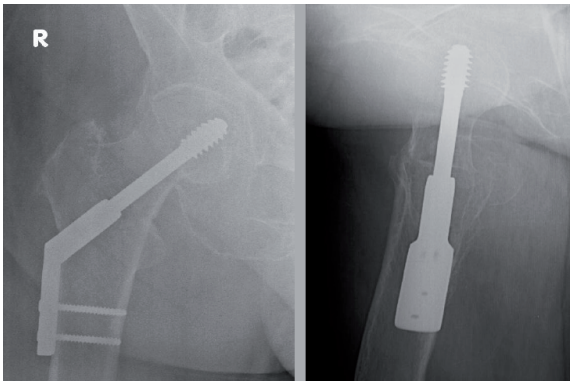

Figure 4

Positioning of the DHS, defined correct as the head screw in the central or caudal 1/3 part of the femoral neck in AP view and in axial view in the central part or dorsal 1/3 part of the femoral neck, with a tip-apex distance between 5-10mm

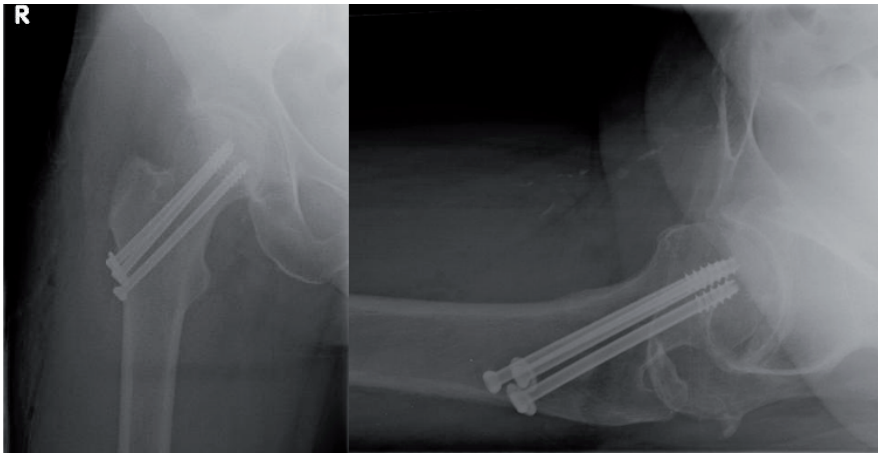

Figure 5

Positioning of the CS, defined correct as a screw placed onto the calcar femoris in AP-view and in axial view a screw placed onto the dorsal cortex of the femoral neck, with a tip-apex distance between 5-10mm

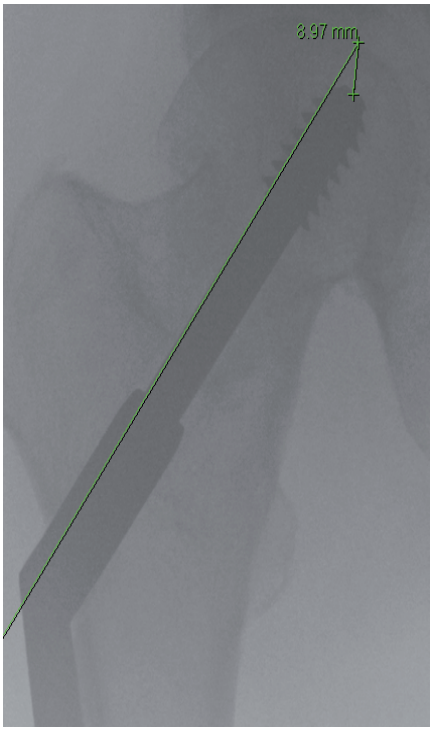

Figure 6

Tip-apex distance, correct between 5-10mm

Finally, implant position was assessed. For the CS, adequate positioning of the parallel screws was recorded. This was defined by a screw placed onto the calcar femoris in AP-view and in axial view a screw placed onto the dorsal cortex of the femoral neck. (Figure 4)[8] Correct placement of a DHS was defined by placement of the head screw in the central or caudal 1/3 part of the femoral neck in AP view and in axial view in the central part or dorsal 1/3 part of the femoral neck[8] (Figure 5) Finally, to complete the assessment of adequate implant positioning the tip-apex distance (correct between 5-10 mm) was calculated[14] (Figure 6).

All radiographs taken during follow-up were reviewed for occurrence of implant breakout, non-union after one year and osteonecrosis of the femoral head. The complications, implant breakout and nonunion were collectively termed fixation failure. The number of patients needing reoperation (both revision surgery and implant removal for different reasons) was recorded.

Reoperation-rate caused by fixation failure is used as primary outcome.

Statistical analysis was performed with SPSS statistics 20.0.

RESULTS

Of all 2402 patients presenting with a proximal femur fracture, 149 patients were diagnosed with a displaced femoral neck fracture *and* treated by closed reduction and internal fixation.

Patient characteristics are presented in Table 1.

Preoperative displacement in AP-view was found in 116 (78%) patients, 33 (22%) fractures showed solely dorso-ventral dislocation without displacement in AP.

Table 1

	Mean (S.D.)	**62 (13.8)**
	Range	**20-94**
Age	**Age <65 year**	**93 (62%)**
	Age 65-75 year	**29 (20%)**
	Age >75 year	**27 (18%)**
Groups		
Sex	f/m (%)	83 (56%)/ 66 (44%)
ASA	1	36 (24%)
	2	85 (57%)
	3	24 (16%)
	4	4 (3%)

Sixty-five (44%) patients were treated by DHS, 14 (9%) by DHS in combination with an antirotation screw and 70 were treated by 3 CS (47%).

Fracture related complications

Forty-four patients suffered from a fracture related complication. In 34 (23%) patients fixation failure occurred during follow up. Twenty-five patients suffered from break-out of the implant, in 6 patients this was combined with non-union and in two patients this was combined with osteonecrosis. Nine patients had non-union without break-out of the implant after one year. The mean time to a complication was 5 months (SD 3.8 months). Of all patients with fixation failure 27 underwent conversion to (hemi-)arthroplasty. One patient was treated by osteotomy and another patient suffered from loss of reduction directly postoperative and underwent a redo. Since, no 'normal' postoperative radiograph could be obtained the quality of reduction and implant position could not be assessed. Three patients did not undergo re-operation, two patients were lost in follow-up after fixation failure occurred but before re-operation was performed and one patient had moved to another country before surgery.

Ten (7%) patients suffered from osteonecrosis. Four patients underwent conversion to (hemi-)arthroplasty due to osteonecrosis alone. One received a shorter screw and one underwent removal of the implant. Four had no complaints but only signs of osteonecrosis on the radiograph and did not undergo a re-operation. Implant removal after consolidation, due to other reasons than fixation failure or osteonecrosis was performed in 8 patients.

Complications, specified by age are listed in Table 2. With increasing age the reoperation-rate increases from 17% in patients <65 years up to 44% in patients >75 years of age.

Table 2

Complications listed by age category

Complications by age	Number of patients	Fixation failure	Osteonecrosis	Reoperation
< 65 years	93	16 (17%)	7 (8%)	16 (17%)
65 - 75Years	29	7 (24%)	2 (7%)	9 (31%)
ASA 1-2	24	6 (25%)	2 (8%)	8 (33%)
ASA 3-4	5	1 (20%)	0 (0%)	1 (20%)
> 75 years	27	11 (41%)	1 (4%)	12 (44%)
Total	149	34 (23%)	10 (7%)	37 (25%)

Taking the different age categories into account 44% of the patients over 75 underwent a reoperation, due to fixation failure compared to 17% of the patients under 65.

Fracture reduction and implant position

In Table 3, incorrect fracture reductions and the occurrence of malreduction and reoperation are listed.

Fracture reduction was performed perfect in 99 patients (67%). Twenty-eight (57%) of the 49 patients with postoperative malreduction had malreduction in lateral view (dorso-ventral displacement), 10 (36%) of them underwent a reoperation. Twenty-six (53%) had lack of medial support, in twelve (46%) reoperation was performed. Three (50%) out of 6 patients suffering malreduction in lateral view combined with lack of medial support underwent a reoperation.

Table 3
Causes of malreduction

Cause of malreduction	Number of patients	Reoperation
Incorrect garden angle	2	0
No medial support	14	6
Incorrect dorso-ventral angulation	19	4
Incorrect dorso-ventral angulation + no medial support	6	3
Incorrect garden angle + no medial support	5	2
Incorrect garden angle + incorrect dorso-ventral angulation	2	2
Incorrect garden angle + incorrect dorso-ventral angulation + no medial support	1	1

Twenty-eight (57%) of the 49 patients with postoperative malreduction had malreduction in lateral view (dorso-ventral displacement), 10 (36%) of them underwent a reoperation. Twenty-six (53%) had lack of medial support, in 12 (46%) reoperation was performed. Three (50%) out of 6 patients suffering malreduction in lateral view combined with lack of medial support underwent a reoperation

In Table 4, the stabilization methods and the occurrence of fixation failure and reoperation are listed. Eighteen (28%) of the patients treated with a DHS suffered fixation failure, compared to 13 (19%) patients treated by CS. Seven (11%) patients treated with a DHS suffered from osteonecrosis compared to 1 (1%) patient treated with CS. Together leading to a reoperation in 23 (35%) patients treated with a DHS and a reoperation in 11 (16%) patients treated by CS.

Table 4

The different stabilization techniques and de occurrence of complications

	N	Age (mean)	Perfect reduction*	Perfect implant position*	Perfect implant position + perfect reduction*	Fixation failure	Osteonecrosis	Reoperation
CS	70	60.5	45 (64%)	49 (71%)	32 (46%)	13 (19%)	1 (1%)	11 (16%)
DHS	65	64.7	45 (69%)	39 (60%)	32 (49%)	18 (28%)	7(11%)	23 (35%)
DHS + antirotation screw	14	61.1	9 (64%)	6 (43%)	5 (36%)	3 (21%)	2 (14%)	3 (21%)

* In one patient treated with CS the post-operative characteristics could not be assessed because of occurrence of fixation failure on the first radiograph post-operative.

* Eighteen (28%) of the patients treated with a DHS suffered fixation failure, compared to 13 (19%) patients treated by CS. Seven (11%) patients treated with a DHS suffered from osteonecrosis compared to 1 (1%) patient treated with CS. Together leading to a reoperation in 23 (35%) patients treated with a DHS and a reoperation in 11 (16%) patients treated by CS.

Table 5

Overall complications listed according to 'perfect' implant position and 'imperfect' position and reduction

	Number of patients	Fixation failure	Osteonecrosis	Reoperation
'Perfect' implant position and reduction	69	11	7	14
'Imperfect' implant position and/or reduction	79	22	3	22

'imperfect' positioning led to fixation failure in 22 out of 79 patients. All patient with a fixation failure needed a reoperation

* n = 148 because in one patient the post-operative characteristics could not be assessed because of occurrence of fixation failure on the first radiograph post-operative.

Implant position was assessed as perfect according to the strict criteria in 94 (63%) patients. In Table 5, implant position and fracture reduction are combined. Correct implant position *and* correct reduction was seen in 69 patients (47%).

DISCUSSION

In this study we show in a retrospective manner a detailed overview of patient and fracture related factors influencing treatment outcome if head preservation was attempted in the treatment of displaced femoral neck fractures.

In our study, reoperation-rate caused by fixation failure is used as primary outcome measure, as it is a second surgery that is associated with high morbidity and mortality rates in this fragile patient population.

Analysis showed 37 (25%) patients underwent reoperation caused by fixation failure or osteonecrosis. Fixation failure occurred in 23% of the patients. Obviously, this is a high percentage, but slightly less than the overall failure rate summarized in a meta-analysis, which shows a rate of 33%.[2]

Clearly these are disappointing results that do not seem to have changed over the last decades.

Despite an overall international tendency of treating the displaced femoral neck fractures more and more by (hemi-)arthoplasty, evidence on the causes of high fixation failure rates is lacking. By identifying pre-, and postoperative fracture characteristics we

could select and improve the head preserving treatment of those patients that can and should be treated by osteosynthesis.

Parker et al. showed that fracture displacement had some predictive value in occurrence rate of nonunion[15]. It his study, fractures were included that seemed to be displaced in AP-view. In our study fractures were also included if dislocation only was seen in lateral view so in dorso-ventral direction as our study shows a high rate of reoperations (up to 50%) in patients with malreduction in lateral view and/or lack of medial support. These results suggest that these patients suffer from higher rates of fixation failure caused by malreduction in dorsal-ventral direction and/or lack of medial support. Therefore perioperatively adequate assessment of the lateral-axial view might be of value. Almazedi et al. studied this subject before and also concluded that fractures that appear non-displaced in AP view require a lateral radiograph to preoperative classify the femoral neck fracture properly.[16]

Our high rate of incorrect fracture reduction (33%) could be overstated as we used three combined criteria for assessment of perfect. The three single parameters, Garden angle (Figure 1), presence of medial support (Figure 2) and angulation between 5 degrees anteversion and 10 degrees retroversion (Figure 3), were adopted from the Dutch Guidelines for the treatment of proximal femur fracture, and although rarely investigated they seem to give a good idea on correct fracture reduction.

Patient age seem to be another predictor of fixation failure of the fixated displaced femoral neck fracture. Before the publication of the Dutch guidelines for femoral neck fractures in 2007, which incorporates treatment of displaced femoral neck fractures in patients over 80 by hemi-arthroplasty [11], some patients above 80 were treated by internal fixation. In our study, still 17 patients above 80 were treated by internal fixation, they were operated on mainly before 2007. Above 75 years, 27 patients were operated and because of the high failure rate of 44%, we plead for (hemi-)arthroplasty in these patients.

In our study a higher rate of complications, especially the occurrence of osteonecrosis, is seen in the group of patients treated by a DHS compared to the patients treated by CS. This could be partially explained by the slightly higher age (mean age of 65 years vs. 61 years) of the patients treated by DHS and a lower percentage of 'perfect implant position' in the DHS group (60% vs. 71%).

It is generally accepted that young patients (under 65) femoral head preservation should be intended but head preserving treatment in the group of patients aged 65-75 years is clearly debatable as they suffer from a reoperation rate of 30% [2]. Internationally there is a tendency to treat these fractures by arthroplasty, although not a lot of studies have been performed proving superiority of the (hemi-)arthroplasty over head-preserving treatment. As clinical studies regarding the elderly hip fracture population are very difficult to conduct this evidence might never be found and as a failure rate in an elderly and

fragile population of 30% is unacceptable, (hemi-)arthroplasty should be considered for all patients over the age of 75.
Limitations of this study are the incomplete follow-up, the relatively small number of patients, the retrospective character of the study and the use of different stabilization techniques in one cohort. Especially, the number of patients suffering from a fracture with solely dorso-ventral dislocation is limited so no definitive conclusions can be made. Although this study presents data of a small retrospective patient population, which could be seen as a clinical audit, it is likely that these results are very well comparable to the results in other large teaching hospitals.

In summary, this study shows a high complication rate of internal fixation of displaced femoral neck fractures, especially in patients older than 75. We also establish the high importance of anatomical reduction, especially in dorso-ventral direction (displacement seen in lateral view). We conclude that, in order to make a correct treatment plan, e.g. internal fixation or (hemi-)arthroplasty, the factor age and a proper lateral radiograph should be taken into account and performed.

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