Failed internal fixation of femoral neck fractures

Summary

Background. There are two main types of surgical treatment for fractures of the femoral neck; internal fixation and arthroplasty. One of the disadvantages of internal fixation is that many patients subsequently require reoperation. We have attempted to identify procedure-related factors that aincrease the risk of fixation failure.

Material and method. A retrospective study was conducted based on the medical records and x-ray images of 337 patients sustaining intracapsular fractures of the hip during the time period 1999–2000. The patients were treated with closed reduction and internal fixation at Oslo University Hospital, Aker. The reduction of the fracture and the placement of the fixation implants were evaluated and scored (six points representing best achievable result).

Results. Internal fixation failed in 23 (18,3 %) out of 126 patients with displaced fractures awarded six points for the reduction. ,Internal fixation failed in 5 (50 %) out of 10 patients given a score of three points or less (p = 0.017). The risk of non-union increased when patients were treated more than 48 hours after the initial injury. In this group, 5 (25 %) out of 20 patients developed non-union compared to 16 (8 %) out of 200 patients treated within 48 hours (p=0.014).

Discussion. Our findings emphasise the importance of achieving anatomical reduction of displaced femoral neck fractures, and to perform surgery within 48 hours unless there are medical contraindications.

The article is based on a student paper delivered at the Faculty of Medicine, University of Oslo (1).

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Norway is one of the countries with the highest incidence of hip fractures, and in 2009 about 5 000 primary operations resulting from femoral neck fracture were recorded in the Norwegian Hip Fracture Register (2). Femoral neck fractures can be divided into two groups: undisplaced (Garden I–II) and displaced fractures (Garden III–IV).

Fractures of the femoral neck are either treated by closed reduction and internal fixation using screws or pins, or by replacing the femoral head and neck with a prosthesis (arthroplasty). The major disadvantage of internal fixation is the high number of patients requiring reoperation, and the risk is greatest for patients with displaced fractures (3, 4). The most common cause of reoperation is fixation failure with secondary displacement of the fracture, followed by failure to heal (non-union) and avascular necrosis of the femoral head (5). The clinical presentations of the last two phenomena are lack of progress in mobilising the patient and persistent pain in the groin area. The majority of failed internal fixations are salvaged by secondary arthroplasty

The 2009 report from the Norwegian Hip Fracture Register showed that a majority of the undisplaced and less than 20 % of the displaced femoral neck fractures were treated with internal fixation (2), and comparing this report with previous publications from the registry, reveals a trend towards performing more arthroplasty procedures. However, when treating younger patients, efforts are often made to preserve the hip joint by performing closed reduction and internal fixation.

We have attempted to identify procedure-related factors that increase the risk of failed internal fixation when femoral neck fractures are treated. Knowledge of these factors could potentially reduce the number of reoperations, thereby improving treatment results.

Material and method

Selecting patients

Patients with medial femoral neck fractures treated with closed reduction and internal fixation in the period 1.1.1999–31.12.2000 at the Orthopaedic Department, Oslo University Hospital, Aker, were identified with the aid of the hospital's incident register. Patients with malignant diseases or amputations of the lower extremities and patients who sustained new fractures of the lower extremities during the first three months following the femoral neck fracture were excluded from the study.

Follow-up

All patients treated for femoral neck fractures were offered follow-up after three months. Later follow-up was offered if conditions were not satisfactory at the three-month check-up, or at the request of the patient, relatives or the primary doctor. These requests were mainly made as the result of persistent pain or impaired gait.

Data collection

Patient records and X-ray images for the first five years following the fracture were reviewed retrospectively. Assessment of the individual X-ray pictures with respect to Garden's classification (6), cause of fixation

Main points

- Patients with fractures of the femoral neck treated by closed reduction and internal fixation run a high risk of treatment failure.
- Poor reduction of the fracture leads to a higher risk of treatment failure following internal fixation of displaced fractures of the medial neck.
- Surgery more than 48 hours after time of injury increases the risk of failed internal fixation of displaced medial neck fractures.

Box 1

X-ray criteria for assessing the reduction of the fracture (a) and placement of the hip pins. (b) (7)

a. Reduction of the fracture

Anteroposterior (AP) view:

- No varus or up to 15° valgus
- Less than 2 mm displacement

Lateral view:

- Less than 20° ventral or 10° dorsal angulation
- Less than 2 mm displacement

3 points: all criteria are satisfied
2 points: one criterion is not satisfied
1 point: two criteria are not satisfied
Points are given for both AP and lateral views.
Maximum score is 3 + 3 = 6 points.

b. Placement of the hip pins

AP view:

- Caudal pin must lie along calcar
- Distance between pins must be as large as the anatomy of the femoral neck allows
- Both pins must lie parallel with the femoral neck
- Both pins must be inserted to subchondral bone, less than 5 mm from the cartilage

Lateral view:

- None of the pins must lie in the anterior third of the femoral head. 1 point is deducted for each pin placed in the anterior third.

3 points: all criteria are satisfied
2 points: one criterion is not satisfied
1 point: two or more criteria are not satisfied
Points are given for both AP and lateral views.
Maximum score is 3 + 3 = 6 points.

failure, quality of the fracture reduction and placement of the hip pins was carried out jointly by a specialty registrar in orthopaedic surgery and a senior orthopaedic consultant. The same specialty registrar and two different senior consultants contributed to these assessments. In the event of disagreements, all three observers judged the X-ray images in question. Fractures were divided into Garden I–II and Garden III–IV. However, it is important to emphasise that Garden's classification only considers the position of the fracture in the anteroposterior plane so that fractures classified as undisplaced, are sometimes reduced. Information about time of death was obtained from the National Population Register. The Data Protection Officer at Oslo University Hospital approved the collection and processing of health information used in the study.

Analysis

Fixation failure, non-union and necrosis of the femoral head were chosen as end-points. If no secondary displacement occurs, a femoral neck fracture will usually heal within the first three months following surgery (7). We therefore defined fixation failure as failure of the osteofixation and re-displacement of the fracture during the first three months as determined by radiographic examinations. A persistent radiolucent fracture line after three months without re-displacement of the fracture defined non-union. In the event of femoral head necrosis, there was avascular collapse of the femoral head. We chose to use the terms treatment failure and failed internal fixation collectively for fixation failure, non-union and femoral head necrosis, as these three conditions constitute the main causes for re-operations.

The quality of the fracture reduction and placement of the hip pins were registered as explanatory factors. We also considered whether the timing of the operation had a significant influence on the outcome. Evaluation of the fracture reduction and placement of the hip pins was based on the criteria shown in Box 1 (7). These criteria were found to have prognostic significance in a previous study (8).

We used Fleiss' kappa for multiple observers to calculate inter-observer reliability. The results can be divided into: slight agreement (0.00–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80) and near perfect agreement (0.8–1.00). Kappa values were calculated on the basis of evaluations performed by the same three doctors who assessed the X-ray pictures included in this work, and were based on 50 anonymised, randomly selected X-ray images assessed in random order, none of which were included in the study.

Statistical methods

We used Pearson's chi-squared test with cross tables in bivariate analyses. Logistic regression for dichotomous outcomes was carried out by means of multivariate analyses. Survival analyses were performed according to the Kaplan-Meier method.

Results

A total of 385 patients were considered for inclusion in the study. Sixteen patients lacked documentation in the form of patient records or X-ray pictures, and 32 patients did not satisfy the inclusion criteria. The Garden classification and age and gender composition of the 337 patients who were included in the study are shown in Table 1. Of the patients who were included, 250 (74.2 %) returned for follow-up after three months, and 94 (27.9 %) of the patients were followed for more than three months.

Only 17 of the 117 patients with undisplaced fractures were given less than 6 points for the reduction of the fracture, and the internal fixation failed in only one of these patients (Table 2). Thus, we found no increased risk of failure of the internal fixation in patients with undisplaced fractures who were given a lower score for the reduced fracture. This was in contrast to patients with displaced fractures, where the percentage of failed internal fixations was significantly higher in patients given a poorer score (Table 2). The fracture reduction criteria had an inter-observer kappa value (95 % confidence interval (CI)) of 0.50 (0.39–0.61). However, the kappa value increased to 0.71 if we divided reduction quality into the following three groups: satisfactory (6–5 points), less than satisfactory (4–3 points) and unsatisfactory (2 points).

We observed no significant influence on the treatment results due to the placement of the hip pins (Table 3), and adjusting for the quality of the fracture reduction and time of surgery by logistic regression did not significantly alter these findings. The criteria for placement of the hip pins had a kappa value (95 % CI) of 0.42 (0.34–0.51).

Surgery performed more than 48 hours after time of injury on patients sustaining undisplaced fractures, did not increase the risk of internal fixation failure (Table 4). However, the number of patients was too small to reveal any minor differences. In contrast, the risk of treatment failure was higher for displaced fractures treated more than 48 hours after time of injury. Non-union was the most frequent cause of failure in this group, and the proportion was significantly higher than in patients who were treated surgically within 48 hours (Table 4). Based on experience, older fractures tend to be more challenging with respect to fracture reduction, but regression analyses adjusting for the fracture reduction score did not bring about any significant changes.

Mortality rates for patients treated within and after 48 hours were the same. Nor was there any difference in mortality between patients awarded a higher and a lower score for fracture reduction. The group found to have the lowest mortality consisted of patients experiencing failure of the internal fixation. These patients had a three-year survival rate of 66 % compared with 52 % in patients without failure (p = 0.015) (Fig. 1).

Discussion

Closed reduction and internal fixation of femoral neck fractures has traditionally been associated with a high risk of treatment failure. In our material, the proportion of internal fixation failure was low compared to other studies, with reported incidences varying between 8–24 % and 35–62 % for undisplaced and displaced fractures, respectively (8–11). These inconsistencies may in part be explained by our study's retrospective design. Only a minority of the patients were followed up after three months, and consequently, instances of treatment failure may

not have been disclosed. Some patients were probably treated at other hospitals without their treatment being registered in our material. If the patients had been followed prospectively, the number of registered cases of failed internal fixations would probably have been higher. However, there is little reason to believe that the distribution of unrecorded cases was so skewed as to significantly affect the comparisons of treatment failure between the different patient groups.

We found no significant association between the risk of treatment failure and the quality of the fracture reduction in patients with undisplaced fractures. This was not unexpected, since the reduction scores were more uniform and the risk of internal fixation failure was considerably lower compared to displaced fractures. Moreover, a large proportion of undisplaced fractures are impacted and have a high degree of inherent stability. These impacted fractures have a good prognosis and should be stabilised without attempts to reduce the fracture. With regard to to displaced fractures, we found a higher risk of treatment failure in patients whose fractures were poorly reduced. These findings are consistent with earlier studies (8, 12, 13).

A number of attempts have been made to establish radiological criteria that have prognostic significance for the outcome in patients treated with closed reduction and internal fixation of femoral neck fractures (14–17). The emphasis has primarily been on pre-operative factors, and inter-observer reliability has varied between 0.20–0.58 (18–20). In our material we achieved a kappa value of 0.50 for the reduction criteria, which is acceptable by comparison.

We did not observe that placement of the hip pins significantly influenced the risk of failure of the internal fixation, and the criteria we chose might simply not affect treatment results. However, the number of patients may have been too small to reveal any slight differences, and our criteria did not take into account potentially important factors such as support in the posterior cortex of the femoral neck and perforation of the femoral head. Furthermore, the X-ray images were not standardised with respect to hip rotation. We also found that our criteria lacked precision, and the kappa value for inter-observer reliability was lower than the criteria for assessing fracture reduction. There was a tendency for patients awarded a lower score for placement of the hip pins to have a higher proportion of failed internal fixations, but these differences were not statistically significant. This is in contrast to some studies that have found that placement of the screws or pins is of significance for the prognosis (21, 22).

When we looked at delay of surgical treatment and its influence on the outcome, we found a significantly higher risk of non-union for patients treated more than 48 hours after injury. This is possibly the result of the blood supply to the femoral head being bet-

Table 1 Median age, gender composition, failed internal fixations and mortality of the included patients. Number of patients (%)

	Undisplaced fractures (Garden I–II)	Displaced fractures (Garden III–IV)	Total
Number of patients	117	220	337
Median age	81	82	82
Women	89 (76.1)	179 (81.4)	268 (79.5)
Failed internal fixation	12 (10.3)	59 (26.8)	71 (21.1)
Fixation failure	3 (2.6)	34 (15.5)	37 (11.0)
Non-union	6 (5.1)	21 (9.5)	27 (8.0)
Avascular necrosis	3 (2.6)	4 (1.8)	7 (2.1)
Mortality			
1 mo.	4 (3.4)	12 (5.5)	16 (4.7)
3 years	52 (44.4)	96 (43.6)	148 (43.9)

Table 2 Number of failed internal fixations broken down by the score given for fracture reduction. The odds ratio (OR) describes the odds of fractures awarded 5 or fewer points ending with treatment failure compared to 6 points

Score given for fracture reduction	Undisplaced fractures with internal fixation failure (n = 12)		Displaced fracture with internal fixation failure (n = 59)	
	Number	OR (95 % CI)	Number	OR (95 % CI)
6	11	Reference	23	Reference
5	0	–	17	2.1 (1.0–4.3)
4	1	1.6 (0.17–15.2)	14	3.9 (1.7–9.2)
≤ 3	0	–	5	4.5 (1.2–16.8)

Table 3 Number of failed internal fixations broken down by the score given for placement of the hip pins. The odds ratio (OR) describes the odds of fractures awarded 5 or fewer points ending with treatment failure compared to 6 points

Score given for placement of the hip pins	Undisplaced fractures with failure of the internal fixation (n = 12)		Displaced fracture with failure of the internal fixation (n = 59)	
	Number	OR (95 % CI)	Number	OR (95 % CI)
6	2	Reference	8	Reference
5	2	0.9 (0.1–6.8)	16	1.1 (0.4–2.9)
4	5	2.1 (0.4–11.4)	18	2.0 (0.8–5.2)
≤ 3	3	2.7 (0.4–18.0)	17	1.5 (0.6–4.0)

Table 4 Numbers of failed internal fixations broken down by time of surgery

	Undisplaced fractures (n = 117)			Displaced fractures (n = 220)		
	< 48 hours (n = 92)	> 48 hours (n = 25)	P-value	< 48 hours (n = 200)	> 48 hours (n = 20)	P-value
Failed internal fixation	9 (9.8)	3 (12.0)	0.72	50 (25.0)	9 (45.0)	0.054
Fixation failure	3 (3.3)	0	0.36	31 (15.5)	3 (15.0)	0.95
Non-union	4 (4.3)	2 (8.0)	0.46	16 (8.0)	5 (25.0)	0.014
Avascular necrosis	2 (2.2)	1 (4.0)	0.61	3 (1.5)	1 (5.0)	0.26

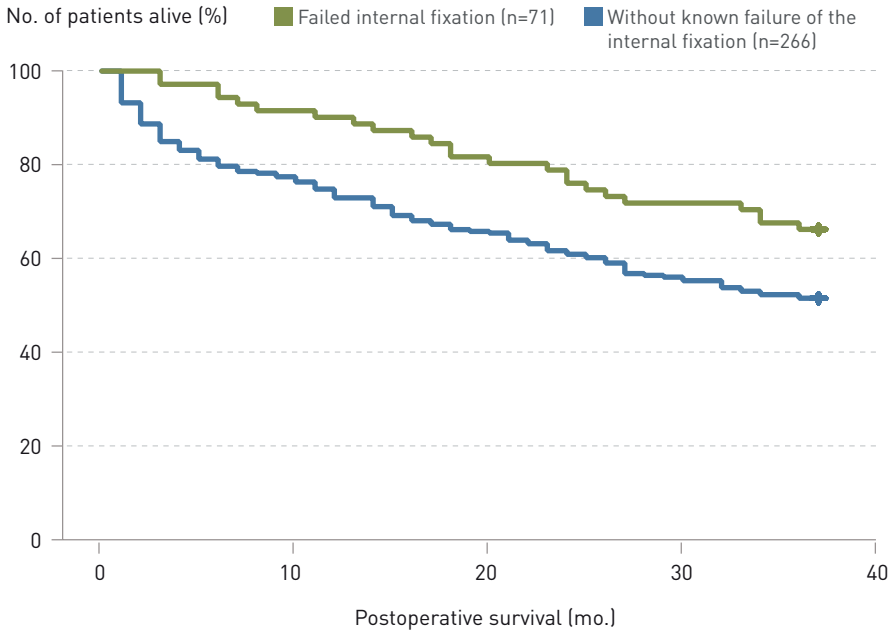

Figure 1 *Kaplan-Meier survival curves for patients with femoral neck fractures with and without failed internal fixation.*

ter maintained by prompt reduction and stabilisation. According to our material, closed reduction and internal fixation should therefore be performed within 48 hours, as a short time between injury and surgery has also been shown to reduce the risk of perioperative complications (23–26). However, it is important to emphasise that we did not take into consideration other factors that may be of significance, such as comorbidity, dementia and function level. These are factors that possibly have a skewed distribution between patients treated before and after 48 hours. Nor have we examined whether there is a linear or proportional relationship between the risk of failure of the internal fixation and the time elapsed between injury and surgery, a relationship for which earlier work has provided evidence (27).

Closed reduction and internal fixation entails a longer period of rehabilitation and a higher risk of re-operation than arthroplasty. This raises the question of whether poorer function and inadequate mobilisation of patients with failed internal fixation lead to higher mortality. However, we did not observe differences in mortality in patients who had poorer reduction results or in patients who were treated surgically more than 48 hours after injury. This may indicate that there are other factors of considerably greater importance. Lower mortality in patients with failure of internal fixation is probably due to the fact that some patients died before treatment failed, but it may also imply inadequate follow-up of the weakest patients. Moreover, the healthiest patients may expose their internal fixations to higher loads and strains. Even though higher risk of treatment failure did not result in increased mortality in our material, the patients' quality of life depends largely on relief from pain and good functional results. This again stresses the need for close, thorough follow-up of a vulnerable patient group who, in our experience, make few demands on the health services.

Conclusion

We have attempted to identify procedure-related factors that increase the risk of internal fixation failure in patients with medial femoral neck fracture. We show that surgical treatment more than 48 hours after time of injury increases the risk of treatment failure in patients with displaced fractures, indicating that these patients should be treated within 48 hours or until acute medical problems have been addressed. We also show that the risk of treatment failure increases when displaced fractures are poorly reduced. Accordingly, when treating displaced fractures with internal fixation it is imperative to achieve the best possible reduction in both anteroposterior and lateral views. In cases where satisfactory reduction cannot be attained, conversion to arthroplasty should be considered.

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