

Outcome of undisplaced and moderately displaced femoral neck fractures

A prospective study of 466 patients treated by internal fixation

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Background The optimal treatment for femoral neck fracture is a matter of controversy. We compared the outcome of displaced fractures with good healing potential (moderately displaced fractures) to the outcome of undisplaced fractures treated by internal fixation with 2 parallel screws.

Methods In a consecutive series of hip fracture patients, the rates of reoperation and mortality for 225 undisplaced fractures were compared to those for 241 moderately displaced fractures. The patients were followed for 1–6 years.

Results The total rate of reoperation was 19% (9% because of healing complications) for the undisplaced fractures and 33% (20% because of healing complications) for the moderately displaced fractures. Fracture displacement was the main predictor of reoperation. There was no difference in mortality between the groups, and patient-related background parameters (rather than fracture displacement) were the main predictors of mortality.

Interpretation Undisplaced fractures should be treated by internal fixation. The best treatment for moderately displaced fractures remains to be determined. ■

The best treatment for femoral neck fractures is still under debate. They can be treated by various methods including hip compression screw, percutaneous pinning, two or three parallel screws, or arthroplasty (Bhandari et al. 2003, Rogmark and Johnell 2006)—or in rare cases, nonoperatively

(Cserhati et al. 1996). Femoral neck fractures are commonly classified as undisplaced (Garden 1–2) or displaced (Garden 3–4), as it has been shown that the reliability of the original staging of the Garden (1961) and Pauwels (1935) classifications is low (Frandsen et al. 1988, Pryor 1995, Thomsen et al. 1996). The undisplaced fractures are thought to be inherently stable and are commonly believed to have good healing potential (Pryor 1995). In general, they are treated with parallel screws—but even so, in several studies the failure rate ranges from 5 to 20% (Stromqvist et al. 1987, Nilsson et al. 1988, Sernbo et al. 1990, Holmberg et al. 1990, Conn and Parker 2004). One study found increased risk of healing disturbance with greater degrees of lateral angulation even when AP radiographs showed no displacement (Conn and Parker 2004).

In the displaced fracture, the degree of comminution of the femoral calcar, the size of the head fragment, and the degree of varus angular displacement may predict the healing potential of the fracture (Alho et al. 1991, 1992). However, the optimal treatment for fractures with better healing potential (i.e. moderately displaced fractures) remains to be determined. The purpose of this investigation was to compare the outcome of displaced fractures with good healing potential (moderately displaced fractures) to the outcome of undisplaced fractures treated by internal fixation with 2 parallel screws.

Patients and methods

All hip fracture patients treated at Østfold Hospital in Fredrikstad between September 1, 1998 and August 31, 2003 were included in a prospective hip fracture audit. Preoperative health status was assessed by anesthesiologists by means of ASA staging (American Society of Anesthesiologists 1963, Michel et al. 2002). We also recorded time of operation, duration of operation, and fluoroscopy time. Predefined endpoints in the investigation were reoperation and death. The data was reviewed and validated retrospectively. 555 patients with intracapsular or basocervical fractures that were treated with internal fixation with 2 cannulated screws (Olmed, Ortomedic, Oslo, Norway) were identified. The basocervical fractures (11) were not included in the study, as we felt that they are most often extracapsular. In the present investigation, we included patients older than 60 years (30 in the undisplaced group and 25 in the moderately displaced group were younger than this). We excluded 3 patients with pathological fractures and 20 patients who sustained more than one femoral neck fracture during the study period. This left 466 patients, who were followed for 1–6 years.

The radiographs were assessed preoperatively by the attending physician. All physicians were familiar with the radiographic criteria of Alho et al. (1992). We have previously conducted a study investigating the interobserver reliability of the criteria (Bjorgul and Reikeras 2002) and found that the kappa values for the specific criteria showed low to moderate values. A small head fragment was defined as a distance of less than 15 mm from the center of the femoral head to the fracture line. The femoral calcar was assessed in both the frontal and the lateral plane, and comminution was defined as either present or absent. Displacement of the head was defined as varus angulation of less or more than 30 degrees. All radiographs were on films, and no allowance was made for the 10–20% magnification.

Preoperatively, the intracapsular fractures were first classified as being either undisplaced or displaced. The undisplaced fractures were those with a complete or incomplete fracture line with no dislocation on AP radiographs. We also included those with impaction and slight posterior tilting

(< 30 degrees) of the femoral head seen on the lateral radiographs. These fractures were all treated with internal fixation with 2 parallel cannulated screws.

The displaced fractures were further classified as being moderately displaced fractures and displaced fractures with reduced healing potential. Fractures that were thought to have reduced healing potential were those with a small head fragment, comminution of the femoral calcar, or varus angulation of the femoral head in excess of 30 degrees. These fractures were treated with hemiarthroplasty and were not included in this study. The moderately displaced fractures were all treated with closed reduction and internal fixation with 2 parallel screws.

Residents operated 96% of the undisplaced fractures and 95% of the moderately displaced fractures. There was no significant difference in the proportion of patients operated during daytime (0800–1600 hours), evening (1600–2400) and night time (2400–0800) (31%, 43%, and 25% for undisplaced fractures and 39%, 42%, and 19% for moderately displaced fractures, respectively).

The endpoints were reoperation and death. The decision to reoperate was made by an orthopedic surgeon based on clinical evaluation of the patient and also an assessment of the radiographs. No formal guidelines were used, but secondary malalignment of the screws and protrusion of the screws by more than 20 mm were considered indicative of nonunion (Alho et al. 1999). Reoperations, including the reason for the reoperation, were reported in the study. All patient files were reviewed to ensure that no reoperation went unreported and that the correct date of death was recorded. We included all reoperations, and time to reoperation was the primary endpoint. For survival analysis of implants, we included all reoperations that removed the implant. We recorded death data on all patients. For survival studies, the data were censored September 1, 2004.

All patients were scheduled for follow-up visits at 4 months and at 1 and 2 years. Most patients were seen several times, and the mean longest follow-up for the patients was 39 months for those with undisplaced fractures and 40 months for those with moderately displaced fractures. The proportion of patients lost to follow-up or deceased within 120 days in each group was 28% for those

Table 1. Follow-up of patients

	Undisplaced (225)	Moderately displaced (241)
Months of follow-up (95% CI)	38 (34–43)	40 (35–45)
No. followed up	163	168
No. not followed up	29	40
No. dead in < 120 days	33	33
No. not followed up or dead in < 120 days	62 (28%)	73 (30%)

with undisplaced fractures and 30% for those with moderately displaced fractures (Table 1).

Statistics

For categorical data, we determined the proportion of patients belonging to each category and calculated the 95% confidence interval of that proportion. For survival analysis, we used Kaplan-Meier plots. To explore risk factors for reoperation and death, we used logistic regression analysis and Cox regression analysis. The 95% confidence interval for the estimated change in risk is given. All statistical analyses were done with SPSS v.12 software.

Results

For categorical data, the confidence intervals of the proportions showed no significant difference between the two groups of patients (Table 2). There was no statistically significant difference in average age.

Of the undisplaced fractures 42 of 225 (19%) were reoperated, whereas 79 of the 241 (33%) moderately displaced fractures were reoperated ($p < 0.001$; Chi-squared test). Regarding reoperations due to healing disturbance only, 4 were for fracture dislocation and 16 were for nonunion, which gives a rate of 9% for the undisplaced fractures. 20% of the moderately displaced fractures were reoperated ($p = 0.001$; Chi-squared test) for healing disturbance: 12 for fracture dislocation, and 35 for nonunion. In the undisplaced group there were 10 reoperations due to femoral head necrosis, 6 due to local pain, 3 due to loss of position of implant without fracture displacement, 2 due to new fracture around the implant, and 1 due to infection. Of the moderately displaced fractures there were 9 reoperations due to femoral head necrosis, 11 due to local pain, 2 due to loss of position of implant without fracture displacement, 1 due to new fracture around the implant, and 9 due to infection

Table 2. Background information. There was no significant difference between the groups in any category, as seen from overlapping 95% confidence intervals (CI)

	Undisplaced fractures (225)			Moderately displaced fractures (241)		
	n	Proportion (%)	95% CI (%)	n	Proportion (%)	95% CI (%)
Habitat						
Own home	158	70	64–76	161	67	61–73
Sheltered living	31	14	9–18	30	12	8–16
Nursery home	36	16	11–21	42	17	13–22
Other		0	0–0	8	3	1–6
Walking ability						
Outdoors independently	142	63	57–69	134	56	49–62
Outdoors with aid	25	11	7–16	22	9	6–13
Indoor dweller	58	26	20–31	85	35	29–41
ASA groups						
1–2	126	56	50–62	115	48	41–54
3–4	99	44	38–50	126	52	46–59
Age						
Men	64	79 ^a	77–81 ^b	75	80 ^a	78–81 ^b
Women	161	81 ^a	79–82 ^b	166	81 ^a	80–82 ^b

^a Mean age (years); ^b 95% CI (years)

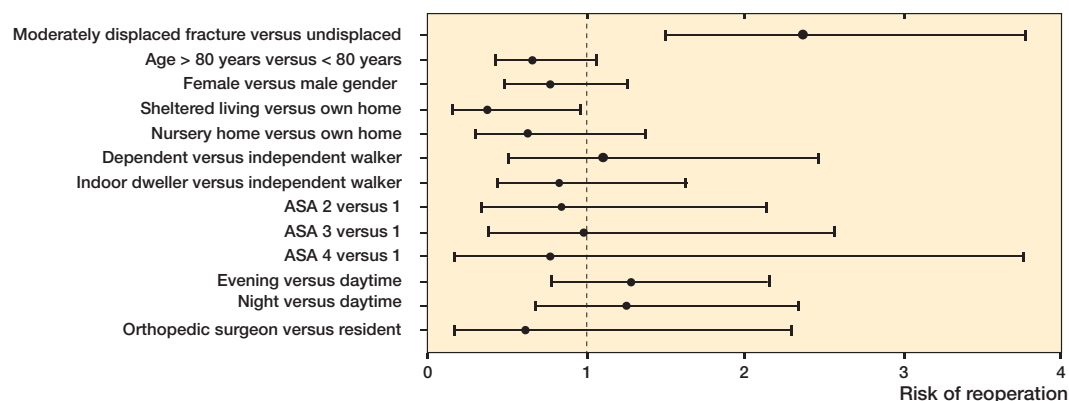


Figure 1. Logistic regression exploring various assumed risk factors for their influence on risk of reoperation. Values less than 1 indicate reduced risk of reoperation. Values greater than 1 indicate increased risk of reoperation. Error bars indicate 95% CI for the change in risk.

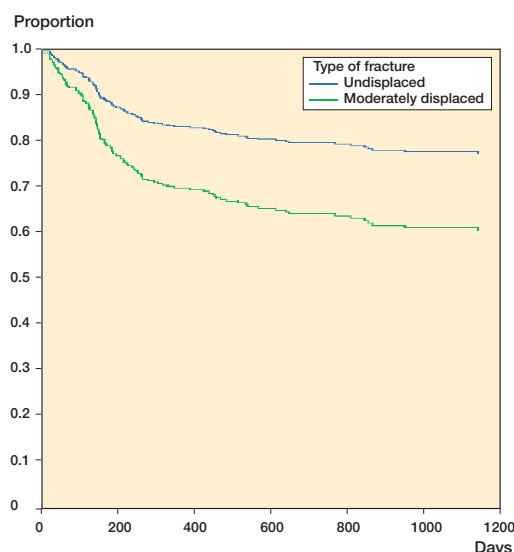


Figure 2. Survival of osteosynthesis, generated in a Cox regression model adjusted for age group, sex, and ASA-group.

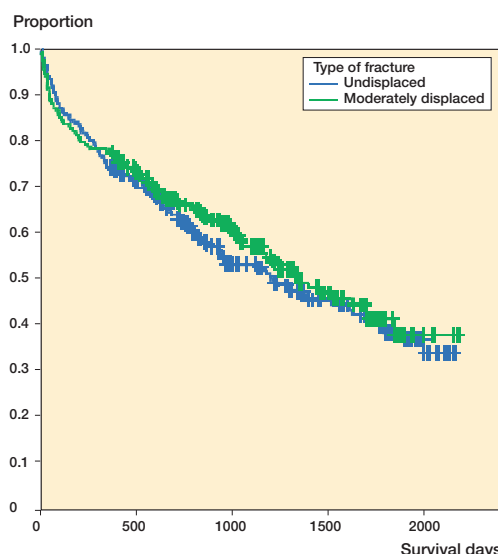


Figure 3. Survival of patients as shown with unadjusted Kaplan-Meier survival curves, including ticks for censored patients.

and hematoma. Parameters thought to be associated with risk of reoperation (Alberts and Jervaeus 1990, Nilsson et al. 1993, Kaehle et al. 2001) were entered into a logistic regression model, but only fracture type had a significant influence on risk of reoperation (Figure 1) by a factor of 2.4 (1.5–3.8). Survival of the implant was lower in the moderately displaced fractures (Figure 2).

There was no significant difference in mortality between the groups. At 30 days, 120 days and 1 year, the mortality was 7%, 16%, and 22% for undisplaced

fractures and 5%, 14%, and 25% for moderately displaced fractures (Figure 3). In a Cox regression model, male sex, ASA groups 3–4, and age above 80 years were associated with a significantly increased risk of dying after surgery (Figure 4).

Discussion

70% of the patients in this study were followed up clinically. The rates of follow-up were equal in the

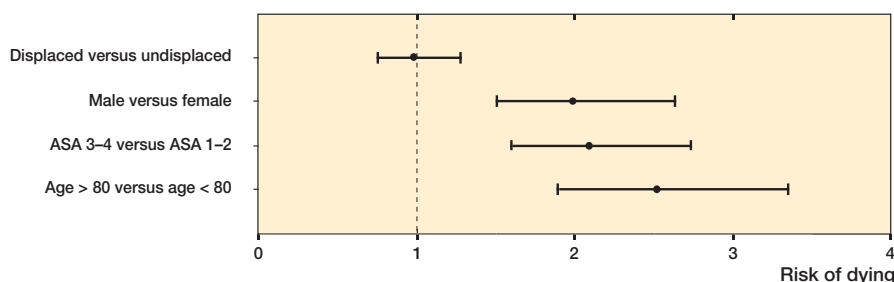


Figure 4. Factors influencing mortality, as generated in a Cox regression model. Dots mark the estimated change in risk associated with a particular variable. Error bars show the 95% CI of the change in risk.

two groups (72% and 68%), and these reflect the difficulties encountered in studying old and frail patients (Davison et al. 2001, Parker and Pearson 2004). All patients' records were examined, and this ensured that all reoperations were recorded despite the lack of complete follow-up.

The total rate of reoperation was significantly higher for moderately displaced fractures than for undisplaced fractures. The rate of femoral head necrosis was equal in the two groups, which is somewhat surprising. The degree of displacement might parallel the degree of vascular compromise, which is in turn thought to be part of the etiology of femoral head necrosis. This rate of necrosis has also been seen in other studies (Nilsson et al. 1988, Sernbo et al. 1990, Chiu and Lo 1996). We found that healing complications were significantly more frequent in the moderately displaced fractures; thus, the method with two parallel screws may be insufficient, resulting in nonunion. The higher rate of reoperation because of local hip pain may reflect the degree of comminution and subsequent compression at the fracture site, which causes protrusion of screws into the soft tissues of the thigh. Our results correspond well with the results from a study of 250 undisplaced femoral neck fractures treated with percutaneous Knowles pinning, in which 10% had healing complications (Chiu and Lo 1996). However, in a more recent study on undisplaced fractures Conn and Parker (2004) found 6% nonunion and 4% avascular necrosis. In that study, the authors also reviewed the literature and found 20% nonunion and 3% avascular necrosis for fractures treated nonoperatively. The corresponding findings for fractures treated by internal fixation were 4% and 2%, respectively.

For displaced fractures, we have previously shown that the results of hemiarthroplasty in worst cases are better than the results of internal fixation in best cases (Bjorgul and Reikeras 2006). For undisplaced fractures, the rate of reoperation we found for healing complications was below 9%—which does not justify hemiarthroplasty in order to further reduce the rate of reoperation. Hemiarthroplasty carries an increased risk of infection, dislocation, femoral fracture, and loosening with a reoperation rate of 6% (Rogmark et al. 2002a, b, Bjorgul and Reikeras 2006) and possibly higher mortality (Bhandari et al. 2003, Rogmark and Johnell 2006). However, given the high number of patients suffering from these fractures, further reduction of the rate of reoperation is certainly warranted. As it is known that both degree of reduction and screw placement are predictors of outcome (Weinrobe et al. 1998, Johansson et al. 2000, Gurusamy et al. 2005), we suggest that perfecting the technique of reduction and internal fixation is better than primary hemiarthroplasty for the undisplaced fracture.

We did not find any difference in mortality between undisplaced fractures and moderately displaced fractures. This held true when mortality was calculated at 30, 120, and 365 days, as well as in survival analysis correcting for patient- and treatment-related factors. The health status of the patient (as measured by ASA grouping, age, and sex) clearly has a much stronger bearing on mortality than the degree of displacement of the fracture. For this reason, mortality is not a relevant outcome measure in studies on treatment of the intracapsular hip fracture.

In some previous studies on femoral neck fractures treated with parallel nails, the proportion

of undisplaced fractures has ranged from 17% to 35% (Stromqvist et al. 1987, Nilsson et al. 1988, Holmberg et al. 1990, Sernbo et al. 1990, Wihlborg 1990), which indicates that the distinction between undisplaced and displaced fractures is not easy. Furthermore, it could jeopardize the comparison between different studies since inclusion of too many undisplaced fractures amongst the displaced fractures could lower the rate of reoperation reported.

This study provides evidence of the usefulness of classifying the fractures as being undisplaced or moderately displaced. Previous studies have shown that the Garden classification system is unreliable (Eliasson et al. 1988, Frandsen et al. 1988, Thomsen et al. 1996, Bjorgul and Reikeras 2002), but the interobserver reliability may be acceptable when distinguishing between displaced and undisplaced fractures (Eliasson et al. 1988, Frandsen et al. 1988, Thomsen et al. 1996, Bjorgul and Reikeras 2002). The significant difference in healing complications in our study indicates that moderately displaced fractures behave differently from undisplaced fractures. However, it may be difficult to determine the healing potential of the fracture. We have demonstrated that the interobserver reliability of the signs predicting healing disturbances is low (Bjorgul and Reikeras 2002). Since the fracture pattern most likely reflects a continuum of increasing displacement, a clear distinction between undisplaced fractures and moderately displaced fractures may not exist. In future research, the exact degrees of displacement should be documented as degrees of angulation in the lateral plane and the distance between the fragments in the frontal plane, which in most cases of undisplaced or moderately displaced fractures should be zero mm.

It seems that the best treatment for displaced fractures with poor healing potential is prosthetic replacement (Bjorgul and Reikeras 2006), whereas undisplaced fractures should be treated by internal fixation. The best treatment for moderately displaced fractures remains to be determined.

Contributions of authors

KB: designed the study, collected data, did statistical work and prepared the manuscript. OR: supervised the work, prepared manuscript.

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