Prediction of fixation failure in femoral neck fractures

Comminution and avascularity studied in 40 patients

Antti Alho, Jan G Benterud, Carl Müller and Torstein Husby

We performed ^{99m}-Tc diphosphonate scintimetries in 40 elderly patients who had undergone screw fixation for a recent subcapital femoral fracture and analyzed their preoperative radiographs. The data were subjected to a logistic regression analysis. Both comminution of the calcar femorale and reduced scintimetric uptake were predictive for failure of the osteosynthesis during the first year. Fracture comminution was more predictive for early failures during 3 months and scintimetry for the later failures.

Department of Orthopedics, Ullevaal Hospital, University of Oslo, N-0407 Oslo, Norway. Tel +47–22 119500. Fax –22 119558
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A number of internally-fixed femoral neck fractures fail independently of the primary surgical result (Madsen et al. 1987, Sernbo et al. 1990, Strömqvist et al. 1992, Benterud et al. 1993). The number of failures might be reduced by improved prognostication of failures. The prognostic significance of ^{99m}Tc phosphonate scintimetry in femoral neck fractures is well documented (Strömquist et al. 1984, Alberts et al. 1987, Alberts 1990). Recently, we showed that fracture comminution and displacement also have predictive importance (Alho et al. 1991, 1992).

In the present study, the predictive role of scintimetry in relation to radiographic factors, such as fracture displacement and comminution, was analyzed.

Patients and methods

26 women and 14 men were treated with two 5 mm screws (von Bahr®; von Bahr 1974) for a recent subcapital femoral fracture. Their median age was 79 (62–94) years. 2 or 3 days after the fracture, a ^{99m}Tc-MDP scintimetry was performed (Strömquist et al. 1983). Each patient received an i.v. dose of 600 MBq ^{99m} Tc-MDP. Imaging was started after 2 hours, using a Siemens Digitrack gamma-camera equipped with a 1/2" thick crystal, low energy all purpose collimator, and 75 PM-tubes. Planar anteroposterior images of the hips were obtained in a 256 × 256 matrix. Approximately 8×10^5 counts were collected on the fractured side, and the same collection time was used on the contralateral side. Regions of interest (ROI) were drawn on both femoral heads, avoiding the high uptake zone of fracture, and an uptake ratio fracture to control was obtained. The ROI area consisted of 160 to 320 pixels; in a given patient, the shape of the ROI and the number of pixels within the ROI were the same on both sides. The ratio 1.0 was selected as discriminative between normal and reduced vascularity.

2 patients died within 8 weeks and were excluded from the study. The remaining 40 patients (Table 1) were followed for 1 year (or until earlier death). 3 types of healing disturbances/failures were discerned: protrusion of the pins by > 20 mm (Alho et al. 1988), displacement of osteosynthesis implants by > 5°, or of fracture by > 9 mm, and replacement by hemiendoprosthesis. The first 2 types of disturbed healing were not necessarily imcompatible with maintained function, but were highly predictive of later failure (Benterud et al. 1993). The pretreatment radiographs were analyzed for fracture displacement and comminution of the calcar, which in our previous studies were predictive of early failure (Alho et al. 1991, 1992). The later radiographs were also analyzed for late signs of avascular necrosis (Calandruccio and Anderson 1980).

The data were analyzed in a stepwise logistic regression (Hosmer and Lemeshow 1989) testing for confounders and interaction.

Results

During 3 months, 17 healing disturbances were observed. In 7 cases the screws protruded by > 20 mm. In 7 there was a displacement of implants by > 5 degrees. In 3 cases a major displacement resulted in replacement by a hemiprosthesis. After 3 months, 4 further healing disturbances were observed and in 9 cases with healing disturbances during 3 months, a prosthetic replacement was done later during the first

Table 1. 40 patients with femoral neck fracture

Case	Age	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	81	1	3	0	15	–	30	0	–	17	0	0	0	0	1.52
2	64	2	2	0	–	–	–	–	–	–	1	0	0	0	2.83
3	80	1	4	0	15	3	0	0	35	22	0	1	1	9	0.88
4	90	2	3	0	5	10	10	0	40	20	1	1	1	0	1.34
5	79	1	4	1	15	7	30	0	70	15	1	0	0	0	0.87
6	89	1	4	0	12	5	30	0	40	20	0	0	0	0	1.01
7	76	2	3	0	–	–	–	–	–	–	1	0	0	0	0.93
8	74	2	3	0	–	–	–	–	–	–	1	1	1	0	1.67
9	91	1	2	0	0	0	10	0	10	8	0	0	1	3	1.27
10	81	1	4	0	12	2	20	0	45	15	1	1	1	0	0.54
11	68	2	4	1	20	5	0	0	45	18	1	0	1	0	1.36
12	69	1	2	0	0	0	0	0	0	18	0	0	0	0	3.13
13	83	2	2	0	0	0	0	0	0	12	0	0	0	0	1.23
14	92	2	3	1	5	2	10	0	30	18	1	1	1	11	2.95
15	81	1	4	0	10	7	10	0	55	15	0	0	0	0	1.97
16	79	2	2	0	0	0	0	0	0	30	0	0	0	0	2.41
17	74	1	4	1	10	5	20	0	45	20	1	1	1	7	2.03
18	74	1	2	0	0	0	0	5	5	15	0	0	0	0	1.98
19	94	1	2	0	0	0	5	0	5	15	0	0	0	0	1.16
20	79	1	4	1	12	5	20	0	40	10	1	1	1	10	1.07
21	76	2	2	0	0	0	0	0	0	18	0	0	0	0	1.10
22	74	1	4	0	10	2	30	0	80	10	1	0	0	0	2.46
23	72	2	3	0	5	0	0	0	20	20	0	0	1	0	0.59
24	84	1	1	0	0	0	0	0	5	15	0	1	1	5	0.34
25	72	2	4	1	18	3	0	0	20	18	0	1	1	0	0.54
26	88	1	4	1	10	5	0	0	80	18	0	0	0	0	1.50
27	87	1	4	0	13	5	0	0	40	16	1	1	1	0	0.96
28	81	1	3	0	2	2	0	0	55	5	0	0	0	0	3.73
29	75	1	4	1	16	5	0	55	80	14	1	1	1	5	0.90
30	62	1	3	1	5	0	0	30	60	12	0	1	1	0	1.02
31	77	1	1	0	0	0	0	10	0	12	0	0	0	0	0.95
32	80	1	4	0	13	2	42	0	35	12	1	1	1	9	0.64
33	75	2	4	0	15	5	30	0	45	17	1	0	0	0	1.10
34	77	1	4	1	25	30	0	0	50	20	1	1	1	11	1.07
35	85	1	4	0	11	0	30	0	20	15	1	1	1	11	1.13
36	80	2	4	1	10	10	40	0	50	15	1	1	1	0	1.34
37	89	2	3	1	6	5	0	0	20	20	0	0	0	0	3.15
38	72	1	4	0	15	5	40	0	45	15	1	1	1	1	0.86
39	76	1	3	0	2	5	90	0	40	12	0	0	1	1	0.78
40	81	1	4	1	8	8	0	5	40	24	1	0	0	0	1.08

A Sex
1 female
2 male
B Garden 1–4
C Reduction
0 ideal
1 deviation from ideal
D Displacement in A–P view (mm)
E Displacement in side view (mm)
F Varus angulation in A–P view (degrees)
G Valgus angulation in A–P view (degrees)
H Posterior angulation in side view (degrees)
I Relative size of the caput fragment (mm)
J Fragmentation of calcar
K Failure at 3 months
L Failure at 12 months
J–L 0 no
1 yes
M Month of reoperation during the first 12 months
0 no reoperation
N Scintimetric ratio

year. Thus, the total number of failures during the first year were: protrusion of screws—3 cases, displacement—6 cases, and hemiprosthesis replacement—12 cases. 5 cases with late segmental collapse of the upper femoral head were included in the group of displacements, because change of screw position or position of the head was found simultaneously.

The mean scintimetric ratio *SD* of 17 femoral heads that failed during 3 months was 1.13 *0.15*. The mean scintimetric ratio of 23 non-failures was 1.66 *0.18* ($P < 0.05$, *t*-test). The total number of failures during 12 months was 21; their mean scintimetric ratio was 0.96 *0.09*, while the ratio of 19 non-failures was 1.80 *0.21* ($P < 0.001$, *t*-test). Of 17 fractures, where fixation failed within 3 months, 13 were comminuted, while comminution was present in 7 of 23 non-failures ($P < 0.01$, X^2-test). At 12 months, 6 of 19 non-failures and 14 of 21 failures had fracture comminution on the preoperative radiographs ($P < 0.025$, X^2-test).

In the logistic regression analysis of the failures at 3 months, a 3.3-fold risk of failure (confidence interval (CI) 1.0–11) was found for a decrease in the scintimetric ratio by 1.0. At the same time, a fracture comminution indicated an 8.7-fold risk of failure (CI 1.9–41).

At 12 months, a decrease of the scintimetric ratio by 1.0 indicated a 4-fold increased risk of failure (CI 1.3–14). At the same time, a fracture comminution indicated a 5-fold increased risk of failure (CI 1.2–24).

Fracture comminution and scintimetry were both necessary factors in the final models for failure both at 3 months and 1 year (maximum likelihood test), although scintimetry was not significant at the 0.05 level at 3 months. They were separate predictors without any interaction.

Discussion

Our results suggest the separate prognostic importance of reduced blood circulation in the femoral head after the injury and of fracture comminution. If either of these factors is present, the risk of failure is increased. Our series is small, which may explain that only 1 of the potentially predictive radiographic signs (Alho et al. 1991, 1992) became significant. Hence, the separate role of the circulation disturbance becomes even more obvious.

Comminution of calcar femorale was more important than scintimetry for predicting failures during the first 3 months. This suggests that the mechanical strength of the bone/implant construct is important during the early healing period. Reduced blood flow, as indicated by scintimetry, was indicative of a later failure. The radiographic picture of late segmental collapse varies (Calandruccio and Anderson 1980), and some failures after 3 months result from delayed union (Alho et al. 1988). We could not establish any distinct difference in the radiographic findings of early and late disturbances of fracture healing. The difference is more a question of the likelihood of mechanical versus circulatory failure.

Our results suggest that a circulatory disturbance is not directly related to fracture mechanics, such as displacement and comminution, and becomes symptomatic later than a mechanical failure. The fracture anatomy was read in the preoperative radiographs, while the scintimetric studies were postoperative. In contrast to Holmberg and Thorngren (1984), Alberts (1990) while corroborating the predictive value of postoperative scintimetry could not demonstrate any prognostic significance of preoperative scintimetric studies. These aspects need further study.

If we were able to predict the failure of osteosynthesis preoperatively, a differentiated approach for the treatment of the subcapital femoral fracture could be applied and the heads at great risk replaced with endoprostheses, using osteosynthesis in cases with a good prognosis.

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