

Prediction of disturbed healing in femoral neck fracture

Radiographic analysis of 149 cases

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To determine factors predictive of early healing disturbances after fixation of femoral neck fracture, the radiographic and clinical data of 149 patients were subjected to a logistic regression analysis comparing them with the results 3 months postoperatively. As in previous studies, fracture reduction distinguished between fractures with or without healing distur-

bances. The following signs in the preoperative radiographs were predictive of unfavorable outcome: small head fragment, comminution of the calcar femorale, and varus angulation of the head. Fractures with negative predictive signs may be selected for primary arthroplasty.

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Because of the unpredictability of the result of internal fixation of subcapital femoral fractures (Barnes et al. 1976, Husby et al. 1989), many authors advocate primary prosthetic replacement (D'Arcy and Devas 1976, Rae et al. 1989). However, dislocation, loosening, and protrusion of the hemiprosthesis create morbidity and deterioration of the late result (Søreide et al. 1980b, Skinner et al. 1989). If reliable criteria could be delineated to choose the right fractures for osteosynthesis versus endoprosthesis, the reoperation rate could be minimized. So far, none of the classifications has been satisfactorily predictive.

We have analyzed the primary radiographs of patients with femoral neck fracture to find factors associated with early healing disturbance after primary osteosynthesis.

Patients and methods

In 1988-89, we treated a series of 192 femoral neck fractures, randomizing them between two types of osteosynthesis, Richards® sliding hip screw supplemented with a parallel proximal AO 6.5 mm cancellous screw or two Olmed® screws. 10 fractures, where satisfactory reduction was not obtained, had a primary Chamley-Hastings® bipolar arthroplasty. For inclusion in the present analysis, the patients should have adequate primary radiographs (an AP view of the pelvis and AP and lateral hip views) and a follow-up period of at least 3 months. 16 patients died within 3 months, and 17 patients had inadequate preoperative films.

Of the remaining 149 patients, 111 were women and 38 were men (Table 1). Their median age was 81 (56-97) years. 127 fractures were operated on during the first 24 hours and the remainder within 3 days.

The following variables were studied for their presumptive prognostic importance (Alho et al. 1991): age, sex, time from injury to operation, shortening of the leg in the AP view of the pelvis, fracture displacement, varus or valgus angulation of the head, posterior angulation of the head, comminution of the calcar femorale, and perpendicular distance of the center of the head to the fracture line in the AP view, where 15 mm became discriminative for "small head fragment". Further, Pauwel's (1935) angle, Garden stage, fixation device, and result of fracture reduction were recorded. For a good reduction 3 points were given. One point was deducted from a maximum of 3 for each of the following findings: any varus angulation, distal fragment above the level of head fragment, and posterior angulation of the head > 5°. No corrections were made for the radiographic magnification effect of 10-20 percent.

The healing disturbances were defined as:

1. *Malalignment*, change of the position of the screws in relation to each other and/or to the original position by more than 5°;
2. *Shortening*, collapse of the fracture by more than 20 mm with protruding screws (Alho et al. 1988);
3. *Perforation* of the femoral head by screw(s);
4. *Salvage* with arthroplasty

The patients were examined clinically and radiographically 3 months after the operation. All radiographs were evaluated by the authors analyzing the

Table 2. Predictive variables in 149 femoral neck fractures

Variable	Number	Odds ratio	95% confidence interval	Disturbed healing n	%
Age (10-year groups)		1.8	1.0-3.3		
Imperfect fracture reduction	60	3.0	1.3-6.8	24	40
Small head fragment	46	3.0	1.3-6.9	22	48
Comminuted calcar	53	3.8	1.7-8.5	27	51
Varus angulation (> 30°)	11	6.5	1.6-28	7	64

primary radiographs in separate sessions without knowing the outcome. The 3-month cutting point was chosen for the study of mechanical factors, because later failures are affected to an increasing extent by avascular necrosis. However, at one year the rate of reoperations was still 77 percent among patients with early healing disturbances compared with 12 percent among patients who had not had such signs.

Statistics

A stepwise logistic regression analysis was made to find out which factors had the highest odds ratios to differentiate between uncomplicated and disturbed healing (Hosmer and Leweshow 1989). A model was devised where the significant factors were tested for confounding and interaction. We also tested whether any of the factors could be removed by the maximum likelihood test. For the analysis, all healing disturbances (groups 1-3) were combined into one group. The significance level was set at $P < 0.05$.

Results

103 fractures showed progressive healing without major shortening or malalignment. None of them was reoperated. The fracture slipped in 28 cases, 17 fractures shortened by more than 20 mm, and the head was perforated by screws in one case. 4 patients with shortening and 5 with malalignment who had much pain and poor walking function were reoperated on within 3 months.

13 nondisplaced fractures were included in the analysis, since it was felt that a primary exclusion of any fractures might have invalidated the multifactorial analysis. Only one nondisplaced fracture dislocated. The Garden (1961) classification was not helpful in differentiating between the fractures. However, when the fractures were dichotomized into nondisplaced and displaced, a different prognosis was, of course, found.

Less than ideal fracture reduction was correlated with, on average, a 3-fold risk for disturbed healing (Table 2). The same was true of the age of the patient, where an increase of 10 years increased the risk by 1.8. The following signs on the primary radiographs correlated adversely with the healing result: varus angulation of the head, defect of the calcar, and small size of the femoral head fragment.

To exemplify the importance of age, a dichotomy was made. 50 patients 85 years of age or older had 19 healing disturbances (risk factor 0.38), while the younger patients had 27 healing disturbances (0.27). 31 patients with shortening of the leg by 20 mm or more had 13 healing disturbances (risk factor 0.42), while the remainder had 33 (0.28). This difference was not significant.

46 patients had a small head fragment. 22 of them had healing disturbances (risk factor 0.48), while patients with a larger head fragment had 24 disturbances (0.23). 53 patients had comminution of the calcar femorale, 27 of them had disturbed fracture healing (0.52); the remainder had 19 disturbances (0.20). 11 patients had the proximal fragment angulated more than 30 degrees of varus, seven had disturbed healing (0.64); the risk of disturbed healing in the remaining 138 patients was 0.28.

40 of 46 patients with healing disturbances had at least one of the three significant signs (small head, comminution, or varus). A total of 80 patients in the series had at least one of the three signs. Had these three signs been used as preoperative predictors of poor prognosis after internal fixation, the 80 hips would have had a primary arthroplasty. 6 hips which did not have these adverse signs but developed healing disturbances would have been fixed by screws.

Discussion

10-20 percent of femoral neck fractures fail within the first 3 months (Barnes et al. 1976, Husby et al. 1989). In the prospective study by Barnes et al. (1976) these

early failures (11 percent) comprised almost one-half of all failures (26 percent). The failures have been difficult to predict, and primary prosthetic replacement has been advocated for all displaced femoral neck fractures in the elderly (D'Arcy and Devas 1976, Rae et al. 1989). However, such a policy may not solve all problems (Skinner et al. 1989), and it is more expensive (Søreide et al. 1980a).

A goal might be to predict the healing so that fractures that have a good healing potential could be subjected to internal fixation, and fractures with a poor prognosis to arthroplasty.

We defined healing disturbances according to previous studies (Alho et al. 1988, Husby et al. 1989) which showed that backing and lost position of screws were the two commonest reasons for early replacement with endoprosthesis. Such an operation was not always performed because of the poor condition of the patient. Thus the reoperations themselves, either at 3 months or at one year, do not exactly define the healing disturbance. Obviously, the importance of late segmental collapse, not related to mechanical factors, becomes increasingly important in long-term follow-up (Strömquist et al. 1984).

In the present study, we could confirm earlier findings on the importance of fracture dislocation (Barnes et al. 1976, Alho et al. 1991) and the quality of reduction (Alberts and Jervaeus 1990). The Garden classification had no prognostic importance when the grading from 1-4 was used. This may be due to the inaccuracies inherent in any overall evaluation (Frandsen et al. 1988).

In the logistic regression analysis, fracture displacement in the AP-radiograph had some predictive value, as in a previous study (Alho et al. 1991). Increasing age of the patient also increased the risk of failure. Thus, a 90-year-old patient has a doubled risk of failure compared with an octogenarian. High age may be used as an additional indication for arthroplasty, if the patient's general condition allows the potentially increased risk of such an operation.

Comminution of the calcar obviously reduces the strength of the implant/bone construct. Good quality radiographs in several planes may be required to fully appreciate this phenomenon. Varus angulation, an aspect of fracture displacement, was more predictive in the present study than shortening of the leg itself. The predictive importance of small size of the head fragment is interesting. Whether it is connected with the risk of circulatory disturbance could be a subject of a closer analysis.

How should we use this information? Obviously, one must accept the immediate consequences of an unsuccessful reduction and perform an arthroplasty in the same sitting.

If the three predictive factors, comminution, varus angulation, and small femoral head fragment, present alone or in combination, were used in the decision about internal fixation versus hemiendoprosthesis replacement, about one-half of patients having at least one of the signs would be subjected to prosthesis replacement. Obviously, a more accurate prediction is desirable.

Using reliable predictive criteria based on good quality preoperative radiographic studies, it might be possible in the future to select fractures for internal fixation versus primary arthroplasty. In this way, the reoperation rate would be reduced and the patient given an optimal chance for a good long-term result.

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