Fixation of femoral neck fracture

Prospective comparison of von Bahr screws, Gouffon screws, and Hessel pins

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We report a prospective study of 214 patients with femoral neck fractures operated on with multiple pinning. The fractures were randomly allocated to fixation with either von Bahr screws or Hessel pins in 1983 and 1984 or von Bahr or Gouffon screws in 1984 and 1985. After 2 years, the failure rate was one third in the von Bahr and the Gouffon screw groups and one half in the Hessel pin group.

We conclude that the nonthreaded Hessel pin is inferior to the von Bahr and Gouffon screws for fixation of femoral neck fractures.

In femoral neck fractures, complications from nonunion and segmental collapse are still a major problem. Even if the impaired vascular supply to the femoral head is responsible for most of the complications of femoral neck fractures, the type of fixation device can influence the outcome (Strömqvist et al. 1984, Svenningsen et al. 1984, Elmerson 1987, Madsen et al. 1987). Fixation with von Bahr screws, Gouffon screws, and Hessel pins has achieved good results (von Bahr et al. 1974, Kofoed and Alberts 1980, Elmerson 1987), but the three devices have not been prospectively compared.

We have compared the rate of healing complications in femoral neck fractures after fixation with these fixation devices (Figure 1). The von Bahr and the Gouffon devices are thin screws inserted either after predrilling (von Bahr) or without (Gouffon). The Hessel device is a thin, smooth pin without threads, which is inserted by hammering.

Patients and methods

In a prospective study, 220 consecutive patients with femoral neck fractures were randomly allocated to treatment with von Bahr screws or Hessel pins in 1983 and 1984 and with von Bahr screws or Gouffon screws in 1984 and 1985. The design of the study, with two consecutive series of patients, was chosen to reduce the number of fixation devices for femoral neck fractures in use at the same time. Informed consent was obtained from the patients.

There were 156 women with a mean age of 78 (32–97) years and 64 men with a mean age of 76 (40–94) years. Three patients from the von Bahr group, 1 from the Gouffon group, and 2 from the Hessel group could not be followed because of missing radiographs or missing medical reports, and they were excluded from the study. Thus, 105 patients treated with von Bahr screws, 64 treated with Gouffon screws, and 45 treated with Hessel pins were followed for 2 years or to failure. Clinical and radiographic examinations were made at 3, 6, 12, and 24 months.

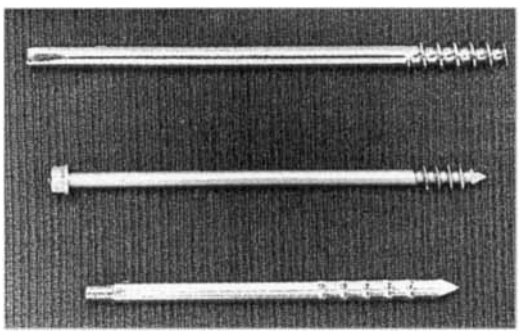

Figure 1. Type of fixation device. von Bahr screw (top), Gouffon screw (middle) and Hessel pin (bottom).

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The three treatment groups did not differ in age, sex, general health, or medication. One hundred and thirty of the patients were admitted from home, 39 from geriatric wards or other hospital wards, and the remaining 45 patients from old peoples' homes. Forty-four patients died before the 2-year follow-up, all without any known healing complication. The three groups did not differ in mortality.

Superficial postoperative infection occurred in 4 cases in the Gouffon group and in 1 case in each of the von Bahr and Hessel groups. There were no deep infections. One postoperative thrombosis was diagnosed in the Hessel group.

Operation

All but 9 patients in the von Bahr group and 3 in the Gouffon group were operated on within 2 days of admission. The operations were performed by 13 different surgeons with the same distribution in all three treatment groups. Most of the patients were operated on under spinal anesthesia, and all of them were given 500 mL of dextran-70 (Macrodex®) on the day of the operation and the day after as a prophylaxis against thrombosis. Prophylactic antibiotics were not used. The mean operation time was less than 30 minutes in all three groups, and the blood loss was less than 100 mL in over 90 percent of the patients. The patients were mobilized the day after operation and encouraged to undertake full weight bearing.

The operations were performed with the patient on an extension table. Displaced fractures were reduced by closed methods with the aid of a two-plane image intensifier. In all three treatment groups the intention was to place the most distal screw/pin central in the femoral head and resting on the medial cortex of the femoral neck. For the von Bahr and the Gouffon group, the remaining screws should be placed parallel to the first and preferably reaching the subchondral bone in the femoral head. For the Hessel group, the pins could be placed either parallel or crossed in the lateral view (Kofoed and Alberts 1980). Compression of the fracture is possible only with the Gouffon screw, but was not used as a routine in this study.

According to Garden (1961), 80 percent of the fractures were displaced. The quality of reduction was considered good if there was a displacement of less than 5 mm, if the anterior-posterior Garden angle was 160°–175°, and if there was a posterior angulation of less than 10°.

The position of the screws/pins were considered poor if no screws/ pins had calcar support, if any screw/pin penetrated the femoral head, if the distances from the articular cortex to the tip of any screw/pin exceeded 10 mm, or if all the scews/pins were placed in the anterior or superior half of the femoral head. Changes in the position of the screws/pins within the femoral head was recorded when there was either an increasing penetration or backing out of more than 5 mm.

The following definitions were used in the radiographic analysis:

Union: Radiographic visible trabeculations across the fracture line.

Nonunion: No radiographically visible trabeculations across the fracture line including early redisplacement or progressive displacement necessitating a second operation.

Segmental collapse: Appearance of a clearly visible depressed segment of the femoral head.

Reoperation: Replacement of the femoral head, either with a total or a hemiarthroplasty.

Statistics: The results are presented both in the traditional way and according to the actuarial method of Armitage (1971; Table 1). The chi-square test with Yate's correction and Fisher's exact test were used to study univariate correlations. The Student's *t*-test was used to compare group means, and linear regression analysis was used to study correlation between age and failure rate.

Results

After 2 years, 25/105 of the fractures treated with the von Bahr screws had not united (nonunion), and 17 of these were reoperated on. Of the united fractures, 10 had developed segmental collapse and four of these were reoperated on.

In the Gouffon group, 17/64 had nonunion after 2 years and 12 of these were reoperated on. Of the united fractures, five had developed segmental collapse and two of these were reoperated. In the Hessel pin group 18/45 fractures had not united after 2 years, and 13 of these were reoperated on. Of the united fractures, eight had developed segmental collapse and six were reoperated on (Table 1).

The differences between the Hessel group and the von Bahr group, as well as between the Hessel group and the Gouffon group, were significant regarding both total complications ($P < 0.01$) and incidence of prosthetic hip replacements ($P < 0.05$).

According to the actuarial method of analysis, the cumulative success rate after 2 years' follow-up was 63 percent in the von Bahr group, 61 percent in the Gouffon group, and 35 percent in the Hessel group (Table 1).

No difference in failure rate was noted when the results from the von Bahr group in the first part of the

Table 1. The cumulative success rate of 220 femoral neck fractures. Failure was defined as radiographic evidence of early displacement, nonunion, or segmental collapse

Fixation device	Period (yr)	No. at start	No. failed	No. excluded		No. at risk throughout period	Cumulative success rate (fraction)
				Dead	Lost to follow-up		
von Bahr	0–1	108	26	18	2	98	0.74
	1–2	62	9	5	1	59	0.63
Gouffon	0–1	65	17	10	1	60	0.71
	1–2	37	5	3	–	36	0.61
Hessel	0–1	47	19	6	2	43	0.56
	1–2	20	7	2	–	19	0.35

study (1983–1984) were compared with the results from the von Bahr group in the second part of the study (1984–1985).

As regards the quality of reduction and the position of pins in displaced as well as in nondisplaced fractures, there were no differences between the groups. In 190/214 (89 percent) the reduction was good and in 153/214 (72 percent), the position of the pins was satisfactory. There was no difference in the rate of hip replacements in the Hessel group with parallel pins (5/11) compared with the Hessel group with crossed pins (14/34).

Changes in screw/pin position occurred in 13/105 in the von Bahr group, 3/64 in the Gouffon group, and in 13/45 in the Hessel group. The difference between the Hessel group and the two other groups was significant ($P < 0.01$).

Removal of the screws/pins as a final operation was performed in 6 patients in the von Bahr group, in 10 patients in the Gouffon group, and in 10 patients in the Hessel group.

There was no correlation between the age of the patient and the rate of failure (correlation coefficient = 0.174).

Discussion

Initial displacement, the quality of reduction, and the age of the patient are important factors predicting the outcome after femoral neck fractures (Garden 1961, Barnes et al. 1976, Skinner and Powles 1986). The type of fixation device can, however, influence the outcome (Barnes et al. 1976, Svenningsen et al. 1984, Madsen et al. 1986). It is also known that the type of follow-up will influence the result of the study (Skinner and Powles 1986, Madsen et al. 1986, Elmerson et al. 1987).

In this and other studies, the results in nondisplaced fractures were better than in displaced fractures regardless of the type of fixation device used. The results in nondisplaced fractures in the Hessel group, however, were inferior to that of both the von Bahr group and the Gouffon group.

Contrary to Kofoed and Alberts (1980) and Elmerson (1987), but similar to Madsen et al. (1987), no differences could be found between fractures with adequate reduction and those with poor reduction. The reason for this is probably the small percentages of fractures with poor reduction, 24/214 (11 percent), in the present study.

The higher rate of change in the position of the pins within the femoral head in the Hessel group compared with the two other groups is probably due to the design of the Hessel pin, lacking threads to secure the position in the cancellous bone. The increased rate of screw removal in the Gouffon group compared with the von Bahr group can be explained by difficulties in deciding the appropriate pin length at operation, which as a routine was done percutaneously and without predrilling.

At the 2-year follow-up, the one-third failure rate in the von Bahr and Gouffon group were in good accordance with previous studies (Søreide et al. 1977, Holmberg and Thorngren 1984, Elmerson 1987). In a prospective study of 165 displaced femoral neck fractures treated with the Hessel pin, Kofoed and Alberts (1980) reported a complication rate of 25 percent. Our results with the Hessel pin were inferior to this regarding both nonunion and late segmental collapse. However, their definition of union was absence of secon-

Table 2. General table of 214 femoral neck fractures

Key to data in Table 2.

Preoperative variables

1 ex: 1 male, 2 female.
2 Age, years.
3 General health: 1 heart disease, 2 diabetes, 3 hypertension, 4 psychiatric disease, 5 other, *[combinations (1+3=13)]*.
4 Previous fracture: 1 upper extremity, 2 lower extremity, 3 hip fracture, 4 other.
5 Admitted from: 1 own home, 2 old people's home, 3 geriatric hospital , 4 other hospital.
6 Place of injury: 1 out-door, 2 in-door.
7 Time of injury, year.
8 Time of injury, month.
9 Time laps injury-operation, days.

Operative variables

10 Anesthesia: 1 spinal, 2 general, 3 other.
11 Osteosynthesis: 1 von Bahr screws, 2 Hessel pins, 3 Gouffon screws.
12 Operation time, min.
13 Blood loss: 1 < 100 mL, 2 100–300 mL, 3 > 300 mL.

Fracture and osteosynthesis variables

14 Dislocation: 1 undisplaced (Garden I–II), 2 displaced (Garden III–IV.
15 Reduction: 1 good, 2 poor (see p. 5).
16 Pin position: 1 good, 2 poor (see p. 5).
17 Parallel pins/screws: 1 yes, 2 no.

Postoperative variables

18 Discharged to: see 5.
19 Complications: 1 wound infection, 2 thrombosis , 3 other.
20 Pin/screw reoperation: 1 pin/screw extraction for complications, 2 pin/screw extraction for local symptom, pin/screw reinsertion.
21 Time laps operation-reoperation pin/screw, months.
22 Hip replacement: 1 hemiathroplasty, 2 total hip replacement.
23 Time laps operation-reoperation hip replacement/Girdlestone, months.
24 Cause of death: 1 cardiac failure, 2 pulmonary embolism, 3 pulmonary infection, 4 malignancy, 5 other, 6 unknown.
25 Time fracture to death, months.

Outcome at 12-month follow-up

26 Union: 1 without dislocation, 2 with dislocation.
27 Nonunion/displacement: 1 reoperation, 2 no reoperation.
28 Segmental collapse: 1 reoperation, 2 no reoperation.
29 Changes in pin/screw position > 5 mm: 1 penetrating, 2 backing out.

Outcome at 24-month follow-up

30 Union: 1 without dislocation, 2 with dislocation,.
31 Nonunion/displacement: 1 reoperation, 2 no reoperation.
32 Segmental collapse: 1 reoperation, 2 no reoperation.
33 Changes in pin/screw position > 5 mm: 1 penetrating, 2 backing out.

dary dislocation after 2 years regardless of if there were visible trabeculations across the fracture line or not. The definition of union used in our study was more precise, taking into account also the obliteration of the fracture gap.

Srömqvist et al. (1987) reported a hip replacement frequency at 2 years of 11 percent for fractures treated with the LIH hook-pin (Hansson 1982), indicating that the design of the fixation device is of importance. Both the LIH hook-pin and the Hessel pin are thin nails lacking threads; the LIH pin, however, has a hook to secure the position in the femoral head. Further, the Hessel pin is hammered in without predrilling, which may cause distraction of the fracture and add to the vascular damage of the femoral head (Strömqvist et al. 1984).

The multitude of internal fixation devices for femoral neck fractures in use today necessitates prospective, randomized, and comparative studies to distinguish the optimal technique for the treatment of these fractures (Editorial 1988).

Figure 2. Methods of fixation. A. von Bahr screws. B. Gouffon screws. C. Hessel pins.

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