Cortical screw support in femoral neck fractures

A radiographic analysis of 87 fractures with a new mensuration technique

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In 87 femoral neck fractures, operated on with 2 von Bahr screws and followed for up to 2 years, the positions of the fixating screws were determined with a new mensuration technique which compensates for the variations in hip rotation in routine radiographs. The union rate of the fractures was related to the position of the screws. A posterior placement of the proximal screw and an inferior placement of the distal screw in both the femoral head and neck improved the outcome substantially.

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In routine radiographs of the hip, assessment of the exact position of the fixation device is difficult since the rotation of the hip often varies in successive radiographic examinations and also in successive exposures. This variation in rotation can give rise to substantial errors in measurements of the positions of the fixating screws, up to 25 percent of the diameter of the femoral head if the rotation of the hip is 40 degrees or more (Lindequist 1992). However, the variation in femoral neck rotation, as projected in the AP and lateral radiographs, can be compensated for mathematically (Ogata and Goldsand 1979, Herrlin and Ekelund 1983, Lindequist 1992). In previous studies of femoral neck fractures, no such correction has been made, and the screw positions have generally not been given in the form of coordinates but in terms of quadrants of the femoral neck and head (Barnes et al. 1976, Frandsen and Andersen 1981, Strömqvist et al. 1984, Johansson et al. 1986).

I analyzed the union rate in relation to the position of the screws, measured by a new technique with a known degree of accuracy.

Patients and methods

In a prospective study, 108 patients (82 women, 26 men; mean age 77 years) with cervical hip fracture were treated with 2 von Bahr screws. 3 patients could not be followed due to missing radiographs and were excluded from the study. 18 patients died before 1 year, all without any known healing complication. 5 patients died between 1 and 2 years of follow-up, all were healed at the 1-year follow-up and were included in the study. Thus 87 patients, 19 with undisplaced (Garden I–II) and 68 with displaced (Garden III–IV) fractures were followed for up to 2 years or up to failure.

Internal fixation was performed with the patient on a fracture table, and displaced fractures were reduced by closed methods with the aid of a 2-plane image intensifier. All but 8 patients were operated on within 2 days of admission. 13 surgeons performed the surgery, with similar distribution between the Garden groups. The patients were mobilized on the day after operation and encouraged to take full weight bearing. Routine AP and lateral radiographs were taken within 2 days postoperatively, and at 3, 12 and 24 months.

The quality of reduction was considered good if there was a displacement of not more than 5 mm, if the AP Garden angle was 160–175 degrees, and if there was a posterior angulation of not more than 10 degrees. These measurements were made directly on the radiographs without correction for hip rotation.

In the AP and lateral radiographs, the distances from each screw to the center of the femoral head, perpencidular to the central femoral neck axis, were measured. For the femoral neck, the distance from each screw to the central femoral neck axis, perpendicular to the axis, was measured at the intersection point between the sphere of the femoral head and the central femoral neck axis. The distances constituted the coordinates for the screw. Screw coordinates in the inferior or posterior part of the femoral head and neck were assigned negative values. Thus, for each screw 4 different position coordinates were recorded (Figure 1). Cortical support was defined as a distance from the screw to the femoral neck cortex not exceeding 3 mm.

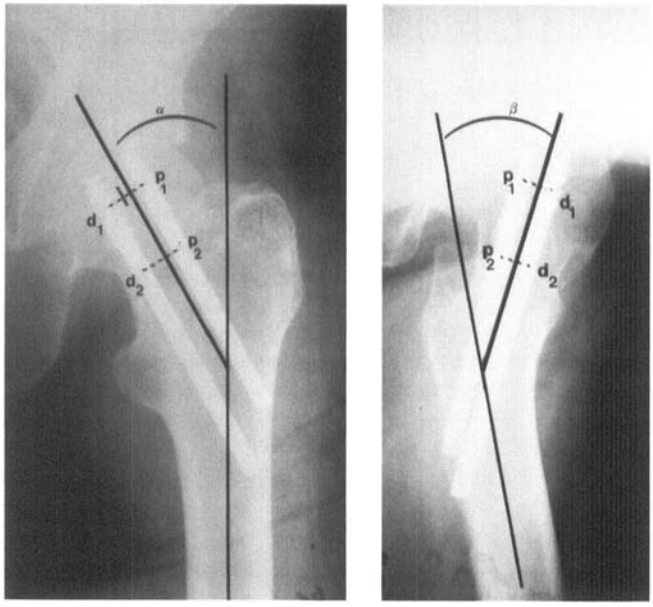

Figure 1. Femoral neck fracture treated with 2 von Bahr screws. The femoral neck and shaft axes, the center of the femoral head and the neck-shaft angles α and ß are marked. The distances from the center of the femoral head and from the femoral neck axis to the measuring points on the screws (d_1, d_2, p_1, p_2, = the non-transformed coordinates for the screws) are indicated by dotted lines.

As the magnification factors for heterogeneous radiographic material frequently differ, all distances in millimeters were converted to units of measurement by dividing the distances by the radius of the femoral head on the particular film.

All measurements of screw coordinates were corrected for variations in hip rotation in the routine radiographs, using a new correction method (Lindequist 1992). For the distances from a screw to the center of the femoral head, or to the central femoral neck axis, the mean error was 3 percent of the femoral head diameter (≈ ± 1.5 mm), with a standard deviation of 2 percent. For the distances from a screw to the femoral neck cortex, the mean error was 4 percent of the femoral head diameter (≈ ± 2.1 mm) with a standard deviation of 3 percent. The distances from the femoral neck cortex to the central femoral neck axis were measured at the same level as the screw coordinates and adjusted according to the calculated hip rotation.

A computer program was used to present the screw positions both as numerical coordinate values and as true scale points in 2-dimensional cross-sections of the femoral head and neck (Figure 2). In the cross-sections of the femoral head and neck, the distances from the screws to the central femoral neck axis, to the center of the femoral head, and to the femoral neck cortex

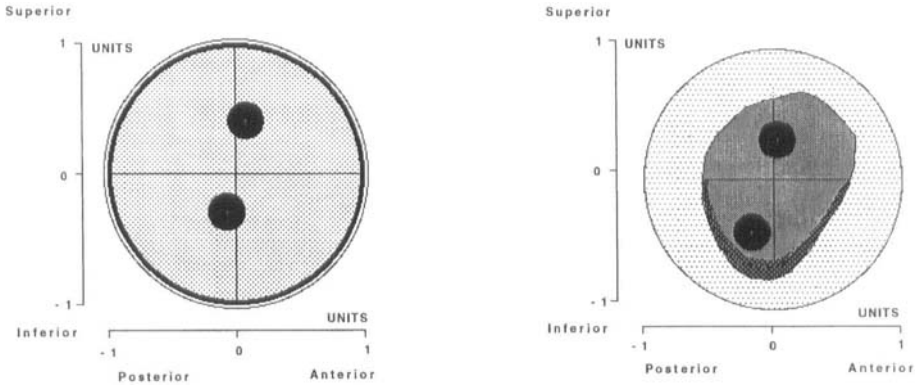

Figure 2. Cross-sections of the femoral head and the femoral neck with the transformed screw position coordinates indicated with black dots. The screw position coordinates were computed from measurements made in Figure 1. The cross-section level of the head is at the center of the femoral head. The cross-section level of the femoral neck is at the intersection point of the femoral head sphere and the femoral neck axis. Note the dark dotted area indicating medial cortical bone support for the distal screw.

Table 1. Screw position coordinates in 87 femoral neck fractures, operated on with 2 von Bahr screws. Distances from the central femoral neck axis or the femoral head center to the screws in units (1 unit ≈ 25 mm). Negative values represent an inferior or posterior position of the screw. Mean *SD*

			Head				Neck			
			Distal screw		Proximal screw		Distal screw		Proximal screw	
		n	AP	Lat.	AP	Lat.	AP	Lat.	AP	Lat.
Undisplaced	Union	19	−.31 *.22*	−.19 *.29*	.17 *.26*	−.09 *.28*	−.27 *.28*	−.11 *.26*	.14 *.22*	−.04 *.20*
Displaced	Union	43	−.35 *.20*	−.17 *.27*	.19 *.24*	−.11 *.25*	−.38 *.15*	−.17 *.16*	.15 *.18*	−.11 *.21*
			*			*	*			**
	Non-union	25	−.22 *.34*	−.11 *.25*	.21 *.22*	.04 *.29*	−.26 *.23*	−.11 *.19*	.20 *.19*	.03 *.18*

Levels of significance: $^{*}P < 0.05$, $^{**}P < 0.01$, Student's *t*-test.

were measured using the coordinate tracking system of the computer.

The following definitions were used in the radiographic analysis:

Union: Radiographically visible trabeculations across the fracture line.

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

Statistics

Chi-square test with Yates' correction and Fischer's exact test were used to study univariate correlations. Student's *t*-test was used to compare group means.

Results

At the 2-year follow-up all of the 19 undisplaced (Garden I–II) fractures had united regardless of the position of the screws. No difference in screw positions in relation to the central femoral neck axis was observed between the undisplaced group and the displaced group of fractures (Table 1). There were no differences in cortical support in the femoral neck for 1 or for 2 screws between the undisplaced and displaced group of fractures (Table 2).

Of the displaced fractures, 43/68 had united at the 2-year follow-up. Reduction was classified as good in 38/43 of the fractures with union and in 18/25 of the fractures with non-union. The difference was not significant.

There was a higher union rate in displaced fractures with cortical support for 2 screws in the femoral neck, compared to displaced fractures with suppport for only 1 screw. A higher union rate was also observed in fractures with cortical support for 1 screw, compared to fractures with no cortical screw support ($P < 0.05$; Table 2, Figure 3).

The proximal screw was placed more posteriorly in the femoral head, and in the femoral neck, in displaced fractures with union, compared to fractures with non-union. The distal screw was placed more inferiorly in the femoral head and neck in displaced fractures with union, compared to fractures with non-union (Table 1).

10/68 fractures with union developed segmental collapse, and 4 of these were reoperated with a total hip. 1 of the 10 fractures with segmental collapse had cortical support for 2 screws, 2 had no cortical screw support, and the remaining 7 had support for 1 screw.

No differences were found between the group with union, compared to the group with non-union with reference to:

1. the distances from the screw tips to the femoral head cortex (mean 0.23 ± 0.11/0.24 ± 0.05 units [≈6 mm]);
2. the distances between the screws in the femoral head and neck (mean 0.61 ± 0.15/0.56 ± 0.10 units [≈15 mm]);
3. the number of cases where the screws had perforated the femoral head (2/43 and 3/25);
4. the number of cases with non-parallel screws (5/43 and 8/25).

Table 2. Cortical support (+ /–) in the femoral neck for 2 von Bahr screws (P proximal, D distal) in 87 femoral neck fractures. Number of fractures with poor reduction in parentheses

P/D		n	+/+	−/+	+/−	−/−
Undisplaced	Union	19	4	8	2	5
Displaced	Union	43	20 (2)	18 (3)	3	2
	Non-union	25	1	12 (4)	1	11 (3)

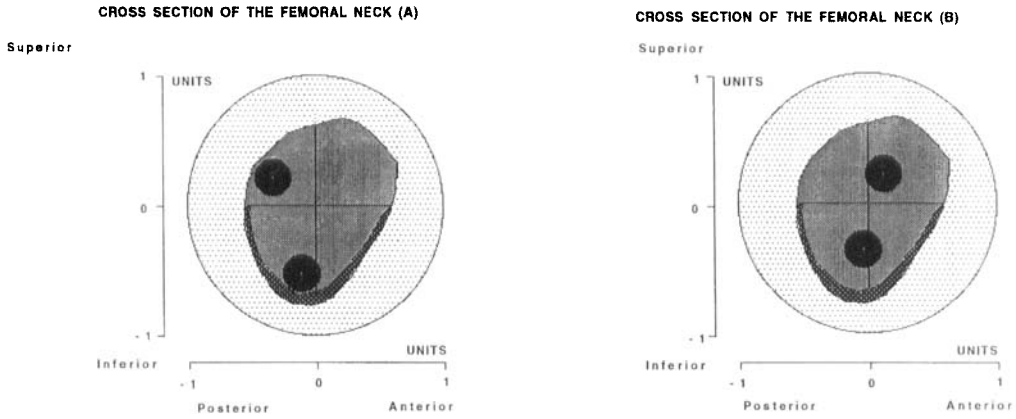

Figure 3. Cross-sections of the femoral neck illustrating screw positions with cortical support for both the distal and proximal screws (A), and screw positions with no cortical support for the distal and proximal screws (B).

Discussion

The importance of a correct positioning of the fixating device in femoral neck fractures has been underlined in many previous reports (Garden 1961, Banks 1962, Söreide et al. 1977, Rehnberg and Olerud 1989a). However, the definition of screw positions in routine postoperative radiographs has generally been restricted to comparison of the parallelism of the screws (Rehnberg and Olerud 1989b, Wihlborg 1990), the visible penetration of the femoral head (Elmerson 1987), and the placement of the screws in different quadrants of the femoral head (Barnes et al. 1976, Strömquist et al. 1984, Elmerson 1987, Rehnberg and Olerud 1989c, Sernbo et al. 1990), or neck (Strömquist et al. 1984, Rehnberg and Olerud 1989c). Only a few authors discuss the influence of hip rotation and flexion on radiographic measurements of the hip (Ogata and Goldsand 1979, Herrlin and Ekelund 1983, Lindequist 1992).

It is generally agreed that a medial cortical support for the distal screw, which often can be observed in the AP projection even if the hip is rotated, is important for fracture union, since it gives a 3-point fixation (von Bahr et al. 1974, van Audekercke et al. 1979). Regarding the screw positions in the lateral plane, where the projected screw positions are more variable, there is no such consensus. Kofoed and Alberts (1980) recommended parallel or crossed screws in the lateral plane, with no preference for any segment of the femoral head or neck, while others have advocated a posterior placement of both screws in the femoral head (von Bahr et al. 1974), a central position for both screws in the femoral head and neck (Rehnberg and Olerud 1989c), or a central position for the distal screw and a posterior position for the proximal screw in the femoral head and neck (Strömquist et al. 1984, Johansson et al. 1986).

A main difficulty in evaluating screw position in operated femoral neck fractures is the variations in hip rotation in routine radiographic examinations. Theoretically, screw positions could be accurately determined by standarized radiographic examinations, keeping the affected leg in a constant, reproducible degree of internal rotation. In routine radiographic examinations, however, this is impracticable and hard to achieve.

By using an algorithm for mathematical correction of the variations in hip rotation in routine radiographs, the position of the fixating screws can be determined with a known degree of accuracy (Lindequist 1992).

Experimental studies of the mechanical property distribution in the cancellous bone of the femoral neck have shown a substantial reduction in stiffness and strength in Ward's triangle and in the intertrochanteric regions (Brown and Fergusson 1980). The subchondral bone of the femoral head, on the contrary, has good quality (Brown and Fergusson 1980, Rehnberg and Olerud 1989c). A screw with anchorage in the lateral femoral cortex and in the subchondral bone of the femoral head, but supported only by the less dense and weaker cancellous bone in the neck, would thus have a tendency to displace inferiorly and posteriorly when the hip is loaded. For both the distal and the proximal screws, a position close to the posterior femoral neck cortex would theoretically yield a 3-point fixation, resisting a posterior displacement. A positioning of the distal screw close to the medial cortex of the femoral neck has experimentally been shown to prevent inferior displacement (van Audekercke et al. 1979).

The importance of fracture stablity is reflected by the fact that undisplaced fractures, where the bone sur-

faces have good contact, have a healing rate of up to 80 percent, even without surgical treatment (Bunata et al. 1973, Hansen and Solgaard 1978).

As with Rehnberg and Olerud (1989a), Holmberg et al. (1990), and Sernbo et al. (1990), but in contrast to many other studies (Barnes et al. 1976, Skinner and Powles 1986, Elmerson 1987, Wihlborg 1990), no influence of the quality of the reduction on the healing rate was found in this study. Good positioning of the fixation device can to some extent compensate for a poor fracture reduction (Parker et al. 1991).

The rate of non-union in the displaced group of fractures in this study, 37 percent, was high but accords with previous reports (Elmerson 1987, Holmberg et al. 1990, Sernbo et al. 1990).

The higher rate of union in fractures with cortical support for both screws in the femoral neck in this study is in accordance with previous studies in which cortical support for the screws has been reported to be important for the stability of experimental femoral neck fractures (van Audekercke et al. 1979, Lindequist et al. 1992), and in which fracture stability has been shown to improve union in femoral neck fractures (Rehnberg and Olerud 1989c).

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