# Screw positions in femoral neck fractures

## Comparison of two different screw positions in cadavers

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**To evaluate the influence of different screw positions on the stability of fixation in femoral neck fractures, 30 cadaveric proximal femora were osteotomized and fixed with 2 cannulated screws. The proximal screw was placed either with a posterior cortical support in the femoral neck or centrally, supported only by cancellous bone. The distal screw rested on the femoral calcar. The specimens were tested in bending, using the force at 2 and 5 mm deflection at the osteotomy site and at fracture, as an expression of the stability of fixation. The test sequences were recorded on a x-y plotter and on videotape. Bone density measurements were made at the femoral neck, Ward's triangle, and the trochanter region.**

**Our findings indicate that a posterior position with cortical support for the proximal screw, compared to a central screw position with only cancellous bone support, increases the stability of femoral neck fractures.**

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We have compared the stability in femoral neck osteotomies, fixed with 2 screws, where the proximal screw either had a posterior cortical support or was placed centrally in the femoral neck, supported only by cancellous bone, and the distal screw had a uniform placement supported by the medial cortex.

## Material and methods

36 fresh proximal femoral segments from 18 human cadavers were collected at autopsy. All but 2 were macroscopically and radiographically normal. The 2 abnormal specimens were from the same cadaver and showed arthritic changes; these 2 specimens were excluded from the study. Due to technical problems during testing the results from 2 specimens from the same cadaver were not recorded, and these specimens were also excluded. Further, in 1 specimen a residual displacement at the osteotomy site of 2.3 mm was observed in the AP radiograph. Since this was considered to influence the results of the test this specimen, together with the contralateral specimen from the same cadaver, were excluded. The 6 excluded specimens did not differ from the specimens included in the study regarding age or bone mineral density measured at the femoral neck area and Ward's triangle (the area centrally in the femoral neck with the lowest bone density). The 2 specimens with arthritic changes, however, had low BMD values (0.35/0.31 $g/cm^2$) at the trochanteric area compared to the specimens included in the study (mean 0.67 $g/cm^2$).

30 specimens from 15 human cadavers (mean age 79 ± 7 years, 8 women, 7 men) were evaluated. All specimens were tested within 6 hours of autopsy. After stripping off the soft tissue, the proximal femur was measured by dual-photon absorptiometry with the isotope Gadolinium-153. In all measurements a constant mix of ethanol and water was used to simulate soft tissue. The femoral neck area, Ward's triangle, and the trochanteric area were examined; the latter 2 regions were chosen automatically. The results were expressed as bone mineral density (BMD) in $g/cm^2$.

With a power-saw an osteotomy was performed perpendicular to the femoral neck axis at the midcervical level, producing an identical inclination of the plane of the cut for all specimens (Elmerson 1987, Clark et al. 1990). From the osteotomy surface 2 K-wires were inserted parallel to each other in a retrograde direction into the distal fragment. The osteotomy was then closed and the K-wires were advanced into the femoral head. 2 cannulated screws (stainless steel, shank diameter 6.0 mm, wing diameter 8.0 mm; Olmed AB) were inserted over the K-wires from the lateral femoral cortex and advanced into the subchondral bone.

In each pair of specimens 1 of the osteotomies was fixed with the proximal screw placed in close contact with the posterior femoral neck cortex, and in the AP plane just above the central femoral neck axis (Group A). The other osteotomy was fixed with the proximal

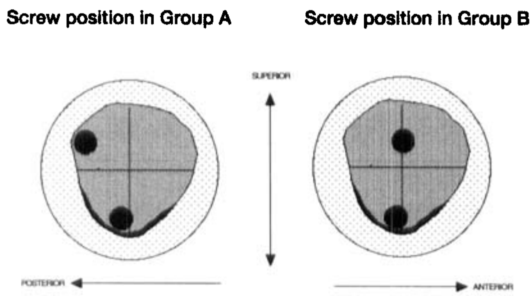


Figure 1. Cross-sections of the femoral neck at the osteotomy site. The screw positions are indicated with 2 black dots. The sphere represents the femoral head.

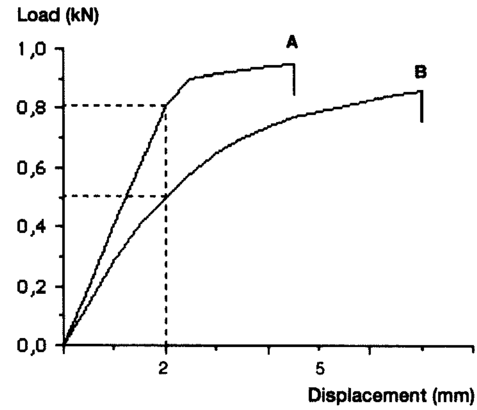


Figure 2. Typical load-deflection curves for a fixed femoral neck osteotomy with a posterior cortical support for the proximal screw (A), and for a fixed femoral neck osteotomy with a centrally placed proximal screw (B). Loads at 2 mm deflection are marked by slotted lines.

screw placed in the center of the femoral neck, and in the AP plane proximal to the central femoral neck axis (Group B). The right and left hips were randomized to either Group A (8/15 right hips) or Group B (7/15 right hips). In all specimens the distal screw was aimed at medial cortical support (Figure 1). To simulate a comminution of the posterior wall with loss of cortical support, a full-thickness wedge of the posterior cortex was removed at the osteotomy site (Rubin et al. 1981).

The quality of reduction and the position of the screws were determined from AP and lateral radiographs of the specimens. The residual displacement at the osteotomy site did not exceed 1.2 mm in any of the specimens. All proximal screws were successfully placed according to the criteria. The distal screw had a medial cortical support in all specimens except in 1 case in each group (3 and 5 mm deviation, respectively). Both of these displaced 5 mm before fracture but only the specimen in Group B with 5 mm displacement rotated posteriorly. All screws were parallel (≤ 5 degrees). 53 screw tips were placed in the subchondral bone without penetrating the cartilage (Rehnberg and Olerud 1989). 4 screw tips in Group A and 3 in Group B were placed close to the subchondral bone.

The specimens were vertically mounted in an electromechanical test machine with the proximal femur held between purpose-built grips. A concave stamp allowing for sufficient contact area to prevent load damage to the femoral head was used to apply the load. The head applicator was lubricated with silicon to prevent rotatory constraint. Each specimen was loaded with a constant deformation speed of 8 mm/min and the load was applied on the anterosuperior portion of the femoral head with 15–20 degrees of inclination from the vertical, following the direction of the resultant of the joint reaction force for walking (Davy et al. 1988, Hodge et al. 1989).

The loading sequence was registered on videofilm. The load was recorded on a load versus time x-y plotter and the real time-axis was indicated on the videoscreen by a diode with a frequency of 1 flash/2 sec. Small ink marks were made in a pre-defined pattern at the osteotomy line and on the femoral head as reference points. On the video screen the deflection at the osteotomy site and the rotation of the femoral head were measured with highly sensitive (± 0.01 mm) electronic calipers, and adjusted for magnification errors. The degree of rotation Θ (degrees) of the femoral head was calculated from the formula $\sin \Theta = s/r$, where $s$ is the distance on the video screen that a central ink mark on the femoral head moved in relation to the load transmission stamp during the loading sequence, and $r$ is the radius of the femoral head. The loads were registered continuously on a x-y plotter, and the load at 2 and 5 mm deflection of the proximal fragment, and at fracture, were plotted in a load-deflection curve (Figure 2).

The specimens were loaded until fracture. The screws were then removed and the cross-sectioned areas at the osteotomy site analyzed with respect to defects in the cancellous bone due to displacement of the screws. The option to stop and magnify the videopicture enabled us to measure displacement with an accuracy of ± 0.4 mm.

The fractures produced all involved the femoral calcar, occasionally with a fracture line in the posterior cortex, and with a similar pattern in both groups. After fracture of the specimens, the screws were still firmly anchored within the femoral head and could be removed only with the aid of a spanner. Bending of the distal screws was seen in 2 specimens, 1 in each

**Table 1. Loads at 2- and 5-mm deflection and at fracture. Group A: Osteotomies fixed with posterior cortical support for the proximal screw. Group B: Osteotomies fixed with cancellous bone support for the proximal screw. Values are mean kN *SD***

| | 2-mm deflection | | 5-mm deflection | | Fracture | |
|---|---|---|---|---|---|---|
| Group | n | Load | n | Load | n | Load |
| A | 15 | 0.83 *0.40*[a] | 4 | 0.89 *0.52* | 15 | 0.95 *0.42* |
| B | 15 | 0.57 *0.23*[a] | 11 | 0.90 *0.33* | 15 | 0.92 *0.33* |

[a] A vs B, $P < 0.05$, Student's *t*-test

group. Defects in the cancellous bone due to a posterior dislocation of the proximal screw in the femoral neck were recorded in 2 specimens in Group A and in 11 specimens in Group B; the proximal segment had rotated posteriorly before fracture. No defects due to displacement of the screws were seen in the femoral heads. The reproducibility of the measurements was determined from 10 repeated measurements of the same loading sequence. The variation in load at 2 mm deflection was 0.047 (SD 0.015) kN. Paired *t*-test, chi-square test with Yates' correction, and linear regression analysis were used.

## Results

The loads at 2 mm deflection at the osteotomy site were higher when the proximal screw had a posterior cortical support (Group A) compared to the group where the proximal screw was placed centrally (Group B) ($P < 0.05$, paired *t*-test) (Table 1). Deflection 5 mm before fracture of the specimen occurred in 4 cases in Group A and in 11 cases in Group B ($P < 0.05$, chi-square test). There were no differences in loads between the groups at fracture of the specimens.

Posterior rotation (5–25 degrees) of the proximal fragment before fracture occurred in 2 specimens in Group A and in 11 specimens in Group B ($P < 0.01$, chi-square test). Anterior rotation of 5 degrees before fracture occurred in 1 specimen in Group A. Closure of the posterior cortical defect before 2 mm deflection at the osteotomy site was seen in 4 specimens in Group A and in 1 specimen in Group B.

The mean (SD) BMD of all specimens was at the femoral neck 0.63 (0.13) g/cm$^2$, at Ward's triangle 0.49 (0.14) g/cm$^2$, and at the trochanter region 0.67 (0.13) g/cm$^2$. No difference in BMD was observed between the groups. The correlation was high between the two groups with respect to the neck and the trochanter regions ($r^2$ 0.75–0.80), but less pronounced regarding Ward's triangle, ($r^2$ 0.62)

No difference between the 2 groups was observed when the bone density values (BMD-neck and BMD-Ward) for the specimens with 5 mm deflection before fracture were compared to the specimens with fracture before 5 mm deflection. Nor was there any difference in bone density between specimens where the proximal fragment had rotated before fracture compared with the specimens where the fracture occurred before rotation of the proximal fragment.

## Discussion

The 0.57–0.90 kN loads at 2 and 5 mm deflection in our study were similar to those reported by Husby et al. (1987) for 2 von Bahr screws. We used the same slow load increase as Husby et al. (1987) to ensure correct measurements of < 1 mm degrees of deflection on the videofilm. van Audekercke et al. (1979) has reported considerably higher load values (~5 kN) at 10 mm deflection of the femoral head, fixed with 3 Knowles pins. Their method was, however, quite different from the one used by us and Husby et al. (1987); the mean loading time was 700 ms and the force was measured at 10 mm deflection of the femoral head. In addition, the mean age in our study was high, 79 years, which is probably higher than in the study by van Audekercke et al. (1979) which included people in their 60s. Reports of bone density measured with dual-photon absorptiometry in studies of femoral neck fractures are, however, scarce. In our study the average bone density of the femoral neck was lower than that reported by Clark et al. (1990); 0.63 compared to 0.81 g/cm$^2$.

We used 2 screws for fixation of the osteotomies since this is the number of screws commonly used for fixation of femoral neck fractures in Scandinavia. Increasing the number of screws to 3 or more can change the stability of fixation. Husby et al. (1987) found lower load values at 2 and 5 mm deflection for specimens fixed with 3 Knowles pins compared to specimens fixed with 2 von Bahr screws. van Audekercke et al. (1979), however, found no difference in strength for specimens fixed with 3, 5, or 7 Knowles pins.

Rotation of the femoral head after fixation of femoral neck fractures *in vivo* was studied with the RSA-technique by Ragnarson et al. (1989) who reported that rotation of the femoral head was common and occurred early after mobilization of the patient, and to a higher extent than varus-valgus displacement. In our study, posterior rotation of the proximal fragment occurred more often in Group B, where the proximal screw was placed centrally in the femoral neck, compared to Group A, where the proximal screw had a posterior cortical support.

Closure of the posterior cortical defect before 2 mm deflection occurred only in a small number of specimens and was not correlated to the degree of deflection. In the present study, however, there was no control group without a posterior wedge resection. In contrast to many clinical failures we found the screws firmly anchored within the femoral head. The screws in our study were placed in or close to the subchondral bone, predrilling was done once, and no backing out or repositioning of the screws was done.

The low values for BMD-neck in our study are typical of patients at risk for hip fractures. We found no difference in bone density between the specimens where the proximal fragment displaced or rotated before fracture, compared to the specimens where the fracture occurred first, indicating that the quality of the cancellous bone in the femoral neck in this group of elderly patients is too poor to provide support for a loaded screw and that the stability of fixation depends upon the presence of cortical support for the screws. A posterior cortical support for the proximal screw in internally fixed femoral neck osteotomies substantially improves the stability. We assume this is true also of fractures.

## Acknowledgement

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