Biases in a randomized comparison of three types of screw fixation in displaced femoral neck fractures

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We studied fixation of displaced femoral neck fractures prospectively in a randomized multicenter study, comparing 2 Olmed screws, 2 Tronzo screws and 3 Ullevaal hip screws. The study population consisted of 482 women and 125 men, of whom 432 women and 100 men were older than 65 years of age. Their median age was 80 (54–97) years. Despite agreement on criteria, the rates of reoperations for pain and failure—salvage (prosthesis replacement) and other reoperations (removal of implant)—differed significantly between the 3 hospitals regardless of type of fixation. In total, the percentages of salvage operations were: Olmed screw 17/175, Tronzo 17/130 and Ullevaal screw 11/302 (n.s.) ; the percentages of other reoperations were 11, 6 and 13, respectively (n.s.). In the whole series, the 2-year rate of salvage operations was 14%. No differences between the implants were found in patients older than 65 years of age.

We conclude that an agreed, common definition of a hard end-point (reoperation) does not ensure comparability of results, because of differences in clinical decision making.

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Fixation with multiple screws is currently a common treatment for displaced femoral neck fractures (Brown and Court-Brown 1976, Madsen et al. 1987, Husby et al. 1989, Sernbo et al. 1990). Although the differences between different screw designs may not be essential, the interest in comparing implants has focused on an important orthopedic problem, which is the fracture itself. In many reports of new fixation methods, the number of failures is remarkably low, because of good fracture reduction and exact adherence to technical details (Strömqvist et al. 1984, Rehnberg and Olerud 1989, Alho et al. 1992). However, these results have not always been reproduced in apparently similar conditions in other institutions (Holmberg et al. 1990, Sernbo et al. 1990, Benterud et al. 1997).

We compared a new screw system with two currently used screw fixations in recent, displaced femoral neck fractures in a prospective randomized multicenter study having a 2-year follow-up.

Patients and methods

In 1991–1993, 662 patients were included in the study in 3 Norwegian hospitals, Ullevaal Hospital, Oslo, Akershus Central Hospital, Nordbyhagen, and Rogaland Central Hospital, Stavanger. These hospitals were the only ones treating fracture patients in their respective catchment areas. The study was approved by the Ethics Committee of Health Region I. The study group met 8 times to plan the study and agree about the criteria to be registered and to monitor it.

Methodological guidelines for clinical trials were used (Raskob et al. 1985, Laupacis et al. 1989). The criteria for inclusion were: a ≥ 54-year-old patient, a displaced fracture in a previously unaffected femoral neck, having occurred less than 3 days before the operation. All patients who met the criteria entered the study consecutively.

After inclusion, the patients were randomly allocated to fixation with either the implant in current use in the hospital or with the test implant (Ullevaal Hip Screw®) by using random numbers in closed envelopes. In 2 hospitals (Ullevaal and Rogaland), patients were allotted to use of Ullevaal Hip Screws® (Howmedica, Sweden) or Olmed® screws (Olmed, Sweden) and in the third hospital (Akershus) to use of either Ullevaal Hip Screws® or Tronzo® screws

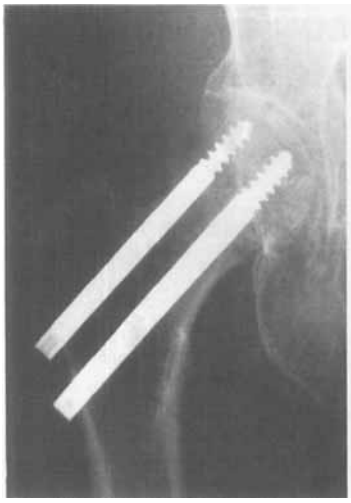

Figure 1. A displaced medial femoral neck fracture treated with 3 Ullevaal Hip Screws®. Their parallel insertion is guaranteed by a centralized guide. 2 screws on the calcar are projected as 1.

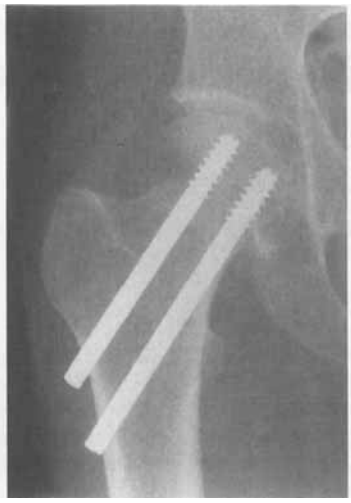

Figure 2. A displaced medial femoral neck fracture fixed with 2 Olmed® screws by free hand technique.

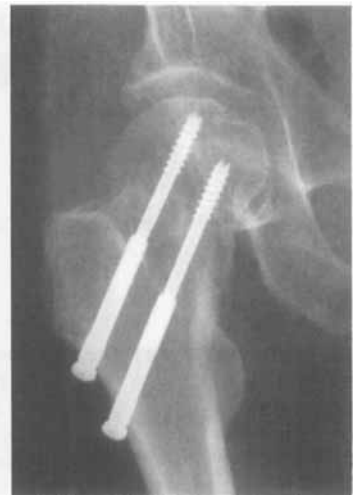

Figure 3. 2 Tronzo® screws in the fixation of a displaced medial femoral neck fracture.

(Biomet, England). The Ullevaal Hip Screw has a diameter of 7 mm, the wing diameter being equal to the shaft diameter. Three parallel screws were inserted at a 130° angle in relation to the femoral shaft, two of them in the calcar region and the third cranially on top of them (Figure 1). The parallelism of the screws was obtained using a guide pin centered in the femoral neck. The Olmed screw has a wing diameter of 8.5 mm and a shaft diameter of 6 mm; 2 screws were inserted, one in the calcar region and the other parallel and cranial to the first one. The instructions by the company were followed (Figure 2). The Tronzo screw has a wing diameter of 6.5 mm, the outer diameter of the telescoping shaft is 6.5 mm; 2 parallel screws were inserted (Figure 3).

The following data were registered on admission: demographic data, radiographic characteristics of the fracture (dislocation, comminution), activities of daily life, and walking ability before injury. Postoperative radiographs were recorded concerning the reduction obtained and the position of the screws (parallelism, position in the neck, tip distance from the joint). Radiographic data were monitored by the authors in each hospital separately.

Postoperatively, the patients were allowed to bear weight, as much as tolerated. Low-molecular-weight heparin was used for thrombosis prophylaxis, but no prophylactic antibiotics were given. After discharge, the patients were advised to contact the hospital in case of increasing pain, deteriorating function or any unexpected event. Three follow-up examinations, at 3, 12, and 24 months, were scheduled.

The treatment protocol included an option for salvage operation, hemiarthroplasty or total hip replacement, for failure of fixation and pain, because of nonunion or late segmental collapse. Failure of fixation was defined as loss of reduction, change in position of the screws in relation to each other and/or to the original position by > 10°, backing out of screws by > 20 mm, as a sign of fracture collapse, or perforation of the femoral head by screws (Alho et al. 1992). In cases where pain was considered to be caused by protruding screws only and the former criteria were not met, one or several screws were removed, usually under local anesthesia on an out-patient basis.

11 of the randomized 662 patients were younger than 54 years of age and were thus excluded from the analysis. 29 undisplaced fractures were also excluded. In 9 more excluded cases, the fracture could not be reduced and a primary hemiarthroplasty was performed, after the patient had been randomized. 6 patients were lost to follow-up. 607 patients, 482 women and 125 men, formed the study population. Their median age was 80 (54–97) years. 532 patients, 432 women and 100 men, were older than 65 years of age, with a median of 81 years. At the time of the injury, 71% of the patients lived at home and 70 % walked without aid.

The patients in Ullevaal Hospital were older ($p = 0.04$, Kruskal-Wallis one-way ANOVA) than those in the other two hospitals (Table 1). The patients in Rogaland lived more often in institutions at the time of fracture (35%) than in Oslo and Akershus (25%) ($p = 0.02$, χ^2-test). There were no differences between the

Table 1. Reoperated patients during the 2-year follow-up period [a]

	Rogaland Central Hospital		Akershus Central Hospital		Ullevaal Hospital	
	Ullevaal screw	Olmed screw	Ullevaal screw	Tronzo screw	Ullevaal screw	Olmed screw
N	102	89	119	130	81	86
Age (median and range)	79 (54–97)		78 (54–96)		81 (56–97)	
Female : male	149 : 42		203 : 46		130 : 37	
Hemiarthroplasty	1	1	15	19	10	23
Total hip replacement	6	4	1	3	0	2
Removal of screws	17	16	15	8	2	2
New internal fixation	2	1	1	0	1	0

[a] Each patient is recorded only once; removal of implants in 2 cases followed by hemiarthroplasty and in 4 cases by THR is recorded as hemiarthroplasty and THR, respectively.

Table 2. Patients older than 65 years of age reoperated during the 2-year follow-up period [a]

	Rogaland Central Hospital		Akershus Central Hospital		Ullevaal Hospital	
	Ullevaal screw	Olmed screw	Ullevaal screw	Tronzo screw	Ullevaal screw	Olmed screw
N	89	80	106	112	71	74
Age (median and range)	80 (66–97)		79 (66–96)		82 (66–97)	
Female : male	134 : 35		182 : 36		116 : 29	
Hemiarthroplasty	1	1	14	18	10	20
Total hip replacement	5	3	1	2	0	0
Removal of screws	12	15	11	7	2	2
New internal fixation	2	1	1	0	1	0

[a] Each patient is recorded only once; removal of implants in 2 cases followed by hemiarthroplasty and in 3 cases by THR is recorded as hemiarthroplasty and THR, respectively.

latter two populations. The pre-injury walking abilities of the patients in the three regions were similar: 70% of them walked without support, 24% needed a walking aid, 4% needed another person for support and 2% were bedridden.

The follow-up data on each examination included habitat, walking ability, activities of daily life and pain. Based on radiographs, healing of the fracture was evaluated as: united fracture, united fracture with segmental collapse of the femoral head, nonunion or salvage by reoperation. There was no statistically significant difference in the numbers of patients in the randomized groups from the expected 50% and no differences in the age or sex distribution in any of the hospitals.

Results

In total, more reoperations were done in Rogaland and Akershus Central Hospitals than in Ullevaal Hospital ($p < 0.001$) (Table 1). The percentages of salvage operations were 6 in Rogaland, 15 in Akershus, and 21 in Ullevaal Hospital. The only significant differences in the cumulative 2-year results between 2 randomized groups were found in Ullevaal Hospital, where more salvage operations ($p = 0.02$) and more reoperations in total ($p = 0.02$) were performed in the Olmed than in the Ullevaal screw group. When all hospitals were considered together, more salvage operations (n 52, 17%) were performed in groups where 2 screws (Olmed or Tronzo), instead of 3 screws (Ullevaal) (n 33, 11%), had been used ($p = 0.03$). The rates of screw removal were higher in Rogaland and Akershus than in Ullevaal Hospital ($p < 0.001$). The percentages of removal of the screws, according to type, were: Olmed screws 10, Tronzo screws 6, and Ullevaal screws 13 (n.s.). The figures for patients older than 65 years of age are given in Table 2.

The radiographic criterion for an adequate reduction in the a-p view was proximal fragment engaged or flush. This criterion was met by 81% of the patients in Rogaland, 76% in Akershus, and 94% in Ullevaal Hospital. The criterion for an adequate reduction in the side view was less than 5° angulation of the head from the neutral head-neck axis. This criterion was met by 90%, 91%, and 76% of the patients, respectively. There were no significant differences between

Table 3. Reoperations within 3 months, later during the 1st year and during the 2nd year

	Rogaland Central Hospital		Akershus Central Hospital		Ullevaal Hospital	
	Ullevaal screw	Olmed screw	Ullevaal screw	Tronzo screw	Ullevaal screw	Olmed screw
Within 3 months						
Hemiarthroplasty	1	0	11	14	5	10
Total hip replacement	0	2	0	3	0	0
Removal of screws	3	1	3	2	0	0
New internal fixation	2	1	1	0	1	0
Debridement	0	0	0	0	0	1
Later during the 1st year						
Hemiarthroplasty	0	1	2	5	4	8
Total hip replacement	2	2	0	0	0	0
Removal of screws	12	10	14	6	2	3
Debridement	0	0	1	0	0	0
During the 2nd year						
Hemiarthroplasty	0	0	2	1	1	5
Total hip replacement	4	0	1	0	0	2
Removal of screws	5	5	0	1	0	0

the implant groups in any hospital.

63% of the patients in Rogaland Central Hospital with retained femoral head had no pain on the 1-year examination, while the percentages in the two other hospitals were in the order of 79 ($p = 0.008$). 86% of the former and 90% of the latter patients had uneventful fracture healing, without signs of late segmental collapse or nonunion (n.s.). On the 2-year examination, the percentage of patients with no was 52 in Rogaland and 86 in the other two hospitals, respectively ($p < 0.001$). The percentages of uneventful fracture healing were 75 and 91, respectively ($p = 0.02$).

Within 3 months, 9 reoperations (5%) had been performed in the Rogaland Central Hospital, 34 (14%) in Akershus Central Hospital, and 17 (10%) in Ullevaal Hospital ($p = 0.01$); 3, 28, and 15 of them, respectively, being salvage operations (Table 3). 5 reoperations were performed because of a trochanteric fracture through the screw insertion site, 4 after Ullevaal and 1 after Olmed screw fixation. These fractures were treated by sliding hip screw plate fixation. There were no significant differences between the implant groups.

Later during the first year, the numbers of salvage operations were 5, 7, and 12 and the numbers of removal of screws were 22, 21, and 5, respectively ($p = 0.003$). Again, no significant differences were found between the randomized groups. During the second year, the numbers of salvage operations were 4, 4, and 8, respectively, and the numbers for "other removal of screws" were 10, 1, and 0, respectively ($p < 0.001$). All these were differences between the hospitals, there were no significant differences between the randomized groups during any of the three observation periods. While the indication for 3 reoperations during the first year was late segmental collapse, the number during the second year was 12, i.e., 44% of all reoperations.

There were local differences in the walking ability. In the 1-year examination in Rogaland, 43% of the patients walked without aids, in Akershus, 54% and in Oslo, 38%. The corresponding percentages for the 2-year examination were 41, 62, and 37, respectively.

The general complications were 16 deep venous thromboses, 1 non-fatal pulmonary embolus, 13 pneumonias, and 22 urinary tract infections. The local complications were 6 superficial (1.0%) and 4 deep infections (0.7%). 1 of the latter required a debridement.

Discussion

Considering the present randomized multicenter study as a whole, the rate of salvage operations—4%—compares favorably with other studies (Lu-Yao et al. 1994, Elmerson et al. 1995). When the outcomes are studied institution by institution, the results of 2 different fixations differed significantly in one of them only. At Ullevaal Hospital, 3 Ullevaal screws yielded better results than 2 Olmed screws, in respect to salvage and all reoperations, whereas no similar differences were found at Rogaland or Akershus Central Hospitals.

Our study shows interesting findings which may explain differences in previous studies with similar implants, similar patients and apparently similar decision-making. The randomization procedure resulted in comparable groups. However, the patients in Oslo were significantly older than in 2 less urbanized com-

munities, Rogaland on the western coast of Norway and Akershus adjacent to Oslo. Remarkable differences in habitat were also found. In Rogaland, more patients lived in institutions pre-injury than in the 2 East-Norwegian areas, although the functional abilities of the patients were similar. Habitat may have affected the choice of screw removal as a minor operation, instead of a salvage operation in Rogaland. Thus, demographic and social factors differed in a restricted geographic area and affected the populations to be included in a study.

Bias may also result from differing familiarity with the methods used. Sliding screw plate fixation was a more difficult operation to perform on duty than separate screw fixation (Benterud et al. 1997). Such differences may have existed between the new 3-screw fixation and the 2-screw fixations. Pretrial routines and level of training of the participants affect the outcomes (Linden 1980, Strömqvist et al. 1992).

Various end-points, subjective and objective, may be used to evaluate outcomes of treatment (Raskob et al. 1985, Laupacis et al. 1989). We chose to use a hard end-point—reoperation—to compare the randomized groups (Dobbs 1980). Despite agreed rules for salvage operations, the decision to perform a hemiarthroplasty was done earlier and more often in Oslo and Akershus than in Rogaland. Screw removal as a minor rescue operation in cases of pain and without obvious failure was used more often in Rogaland and Akershus than in Oslo. The relativity of a "hard" endpoint has been shown in studies comparing pain and reoperation (Nilsson 1989, Britton et al. 1997).

These observations make it hard to compare orthopedic studies. Further examples may be found in the literature. While Sernbo et al. (1990) and Holmberg et al. (1990) found no differences in the results yielded by hook-pins and a single 4-flanged nail in displaced femoral neck fractures, Strömqvist et al. (1984) obtained better results with the former implant, in terms of salvage arthroplasty ($p = 0.008$, chi-square-test). The results found by Strömqvist et al. were inferior to those of Sernbo et al. ($p = 0.04$) when using the 4-flanged nail. The decision to make a salvage operation is a complex procedure and no blinding is possible at the time of decision.

Multicenter studies are performed to collect sufficient numbers of patients and to level out local differences. The aim of our study was to compare different screw fixations. However, the inter-institution differences were so dominating that drawing common conclusions is more or less meaningless. Instead, it becomes important to find measures to reduce the obvious biases generated by resource factors, treatment tradition, and by favoring certain procedures. Making different procedures in different institutions, using an unbiased monitor throughout the study, blinding the outcome evaluation, and using several end-points in the evaluation may be such measures.

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