Fixation of femoral neck fractures

Comparison of the Uppsala and von Bahr screws

Lars Rehnberg and Claes Olerud

In a prospective randomized study, a newly developed so-called Uppsala technique for internal fixation of femoral neck fractures was compared with the von Bahr technique. The series consisted of 222 consecutive patients, 167 women and 55 men, with a mean age of 80 years. Half of the patients were randomized to each treatment group. During the first postoperative year, 18 failures occurred in the Uppsala group, compared with 39 in the von Bahr group ($P < 0.01$). Of 128 patients without pain at 4 months, 9 developed failures, compared with 29 of the 37 that had pain at this time ($P < 0.001$). We conclude that the new technique gives better results during the first postoperative year and that most failures occur among those with pain at 4 months. Follow-up radiography is indicated only in patients with pain at 4 months.

We have compared a newly developed technique for internal fixation of femoral neck fractures[1]—utilizing the subchondral bone of the femoral head to increase the stability—with our traditional technique, the von Bahr method[2]. The study was conducted as a prospective, randomized trial, approved by the ethics committee at the University of Uppsala.

Materials and methods

The series consisted of 222 consecutive patients admitted for a femoral neck fracture to our department from March 1986 to July 1987. During the time of the study, 5 patients were treated with primary arthroplasty because of an inability to reduce their fractures; further, 5 patients had pathologic hip fractures, 1 patient had a severe coxarthrosis, and 10 patients had fractures that were older than 1 week. These 21 patients were not included in the series.

Totally, 111 patients were randomized, e.g., allocated to each treatment group by a table of random numbers, and they were also matched with respect to age, fracture type, and living condition (Table 1). There were totally 167 women and 55 men in the study, and their mean age was 80 (55–98) years. Fifty-two of the fractures were undisplaced (Garden[3] Stages I and II) and 170 were displaced (Garden Stages III and IV). There were no differences between the two treatment groups as regards preinjury living condition and need for walking aids.

Operative techniques. The Uppsala technique uses two cannulated screws with a 6-mm shaft diameter and an 8-mm thread diameter. The screws are inserted over guide pins. The tip of the screws are self-tapping to avoid damage to the cancellous bone of the femoral head. The screws are inserted parallel and fixed in the subchondral bone of the femoral head. The distal screw lies on the calcar femorale and the proximal screw as high up in the femoral neck as possible (Figure 1). In the lateral plane, the screws are placed centrally in the femoral neck and head. The insertion device allows introduction of the screws without wobbling, and assures a snug fit of the screw in the lateral cortex of the trochanter.

The von Bahr technique, which has been used at our department since 1965, uses two parallel screws (shaft diameter 5.5-mm, thread diameter 7 mm) placed in the same manner in accordance with the technique recom-

Table 1. Age, sex, and fracture type distribution in the two treatment groups

	Age mean *SD*	Sex F/M	Undisplaced/ displaced
Uppsala	80 *9*	84/27	27/84
von Bahr	80 *8*	83/28	25/86

Department of Orthopedics, University Hospital, S-751 85 Uppsala, Sweden

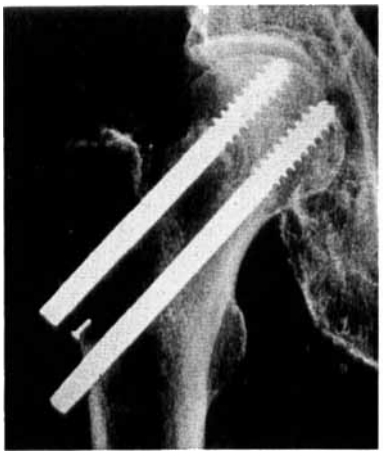


Figure 1. Uppsala technique (small screw in the lateral cortex is for measuring purposes).

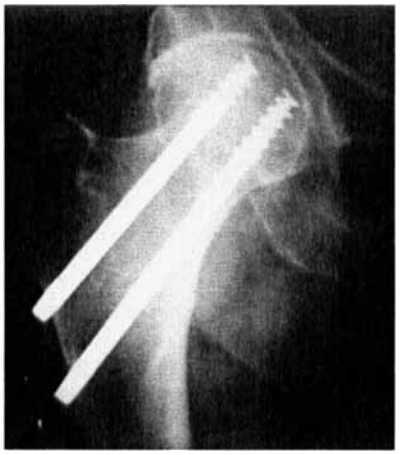


Figure 2. von Bahr technique.

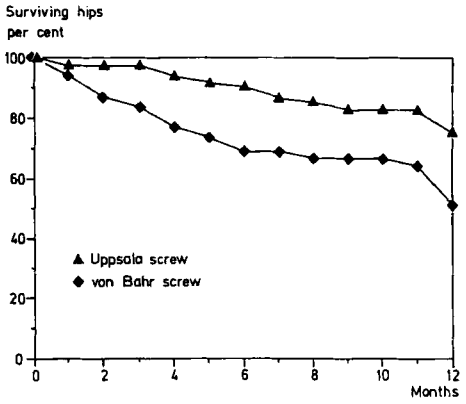


Figure 3. Life-table analysis comparing the Uppsala and the von Bahr technique. After the first month, the difference is significant ($P < 0.001$).

Table 2. Number of accumulated complications in the two treatment groups at the 12-month follow-up

	Penetration	Early loosening	Non-union	Late segmental collapse
Uppsala	2	1	10	5
von Bahr	1	12	23	3

mended by the manufacturer. The tips of the screws were left a couple of millimeters from the subchondral bone of the femoral head (Figure 2).

In both treatment groups, internal fixation was performed through a small lateral exposure with the aid of fluoroscopy. Mobilization was allowed with full weight bearing from the first postoperative day. The operations were performed by 29 different surgeons.

Evaluation. A reduction of Garden's angle to between 155° and 180° on the AP projection and less than 20° on the lateral view was considered a good reduction[4]. The position of the internal fixation in the AP projection was considered good if the distal screw was introduced at the level of the lesser trochanter and was lying on the calcar femorale and if the proximal screw was introduced at least 2 cm apart from and parallel to the distal one (the angle between the screws being less than 5°). In the lateral view the position of the screws was considered good if they were parallel and placed in the central one third of the femoral neck and head. The tips of the screws should be less than 5 mm from the junction between the bone and cartilage in the femoral head.

Follow-up was performed with a clinical and a radiographic examination 4 and 12 months after surgery. The following data were recorded: pain, need for walking aids, and living condition. The radiographs were analyzed for signs of complications. In addition, all the failures were recorded. The following complications were considered: penetration of the fixation

device into the joint, early loosening (loss of reduction and/or loosening of fixation devices within 2 months after the operation and painful movements of the hip joint), nonunion (open fracture gap with or without resorption of the femoral neck later than 6 months after the operation in combination with painful weight bearing), and late segmental collapse (deformation of the femoral head after union).

According to the applied criteria, 202/222 of the patients had good reduction of the fractures—103/111 in the Uppsala group versus 99/111 in the von Bahr group. Totally, 203/222 of the patients had a good position of the internal fixation devices—104/111 in the Uppsala group versus 99/111 in the von Bahr group.

Fifty-seven patients (26 per cent) died during the first postoperative year—30 in the Uppsala group and 27 in the von Bahr group.

Statistics. A life-table analysis rating uncomplicated survival of the hip was used, as well as t - and chi-square tests, contingency tables, and multiple variance analysis. In the life-table analysis, the date when a complication was diagnosed was considered the end point for that particular hip. Patients that died during the observation period were counted as uncomplicated with regard to the hip for the time they were alive and followed in the study. $P < 0.05$ was considered significant.

To evaluate if a learning curve had an impact on the outcome in this series, a regression analysis was performed where the fraction of performed von Bahr operations was used as the dependent variable and the number of performed operations in the study was used as the independent variable.

Results

In the Uppsala group, 18 patients had failures, compared with 39 in the von Bahr group ($P < 0.01$). In the Uppsala group, all 18 failures occurred among the 84 displaced fractures. In the von Bahr group, three of the failures occurred among the 25 undisplaced fractures, compared with 36 among the 86 displaced fractures. (Table 2, Figure 3).

At 4 months, the patients in the Uppsala group had less pain ($P < 0.001$) and less need for walking aids ($P < 0.01$ than the von Bahr group. At 12 months after the injury, the patients in the Uppsala group had less pain ($P < 0.01$) than the von Bahr group, but there was no difference in the need for walking aids (Table 3). There was no difference in living conditions between the two groups 4 and 12 months after the injury (Table 4).

Table 3. The level of pain and need for walking aids in the two groups 4 and 12 months after the injury[a]. Mean *SD*

	4 months		12 months	
	Pain	Walking aid	Pain	Walking aids
Uppsala	1.12 *0.36*	1.52 *0.64*	1.02 *0.12*	1.48 *0.64*
von Bahr	1.40 *0.59*	1.96 *1.35*	1.24 *0.42*	1.70 *0.66*

[a]Both variables are recorded on a point scale. No pain gives 1 point, pain on weight bearing gives 2 points, and constant pain gives 3 points. No walking aids or one cane gives 1 point, need for more walking aids than one cane gives 2 points, and nonambulatory gives 3 points

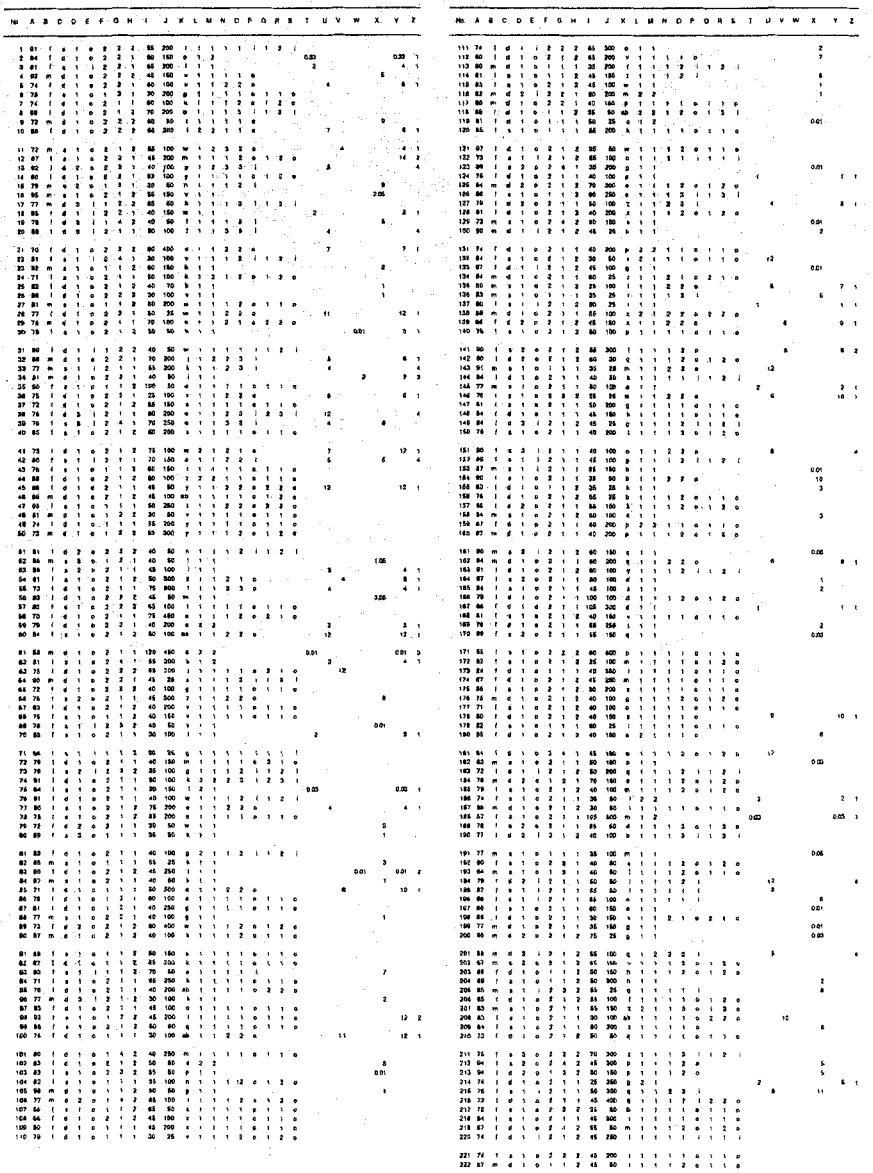
Table 4. Living conditions for the patients in the two groups 4 and 12 months after the injury. No significant difference can be detected (chi-square 0.75 and 1.60, respectively)

	4 months		12 months	
	Institution	Own home	Institution	Own home
Uppsala	20	68	15	49
von Bahr	23	54	8	43

In all, 128 patients were free from pain at the 4-month follow-up. In this group, 9 patients subsequently became failures (6 nonunions and 3 late segmental collapses). Six of these 128 patients had deteriorated clinically and had developed pain on weight bearing at the 12-month follow-up. Thirty-seven patients had pain at the 4-month follow-up. Twenty-nine of these 37 became failures (24 nonunions and 5 late segmental collapses). No patient with pain at the 4-month follow-up had spontaneously become free from pain at the 12-month follow-up (Table 5). The difference in risk of developing complications between the group that had pain and the group that did not have pain at 4 months was significant ($P < 0.001$).

The most important factor for the 1-year outcome was whether or not the internal fixation device was in a good position ($F = 11.4$, $P < 0.0009$), followed by the applied method ($F = 8.7$, $P = 0.035$), whether or not the fracture was displaced ($F = 7.3$, $P = 0.076$), and peroperative blood loss ($F = 4.0$, $P = 0.046$). The experience of the surgeon came close to significance ($F = 2.5$, $P = 0.085$). The regression analysis revealed that the slope was -0.709 with $P = 0.470$, the regression squared was 1.95 percent, and thus there was no tendency for the more experienced surgeons to perform a higher proportion of either one or the other of the procedures.

Table 5. Patient´s data



A age
B sex
C side: s sinister, d dexter
D preinjury need for walking aids
1 no walking aids or one cane
2 two canes or more walking aids
3 not ambulatory
E preinjury living conditions
i institution
o own home
F fracture type
1 undisplaced
2 displaced
G anesthesia
1 spinal
2 epidural
3 general
4 ethamine
H operative procedure
1 von Bahr
2 Uppsala.
I duration of operation, minutes
J bleeding, milliliters
K identity of surgeon L reduction
1 good
2 not good
M position of internal fixation devices
1 good
2 not good
N pain at 4 months
1 no pain
2 pain on weight bearing
3 constant pain
O need for walking aids at 4 months, see "D"
P living conditions at 4 months, see "E"
Q pain at 12 months, see "N"
R need for walking aids at 12 months, see "D"
S living condition at 12 months, see "E"
T early loosening, months after operation.
U nonunion, months after operation.
V late segmental collapse, months after operation.
W penetration of screws into the joint, months after operation.
X death, months after operation.
Y reoperation, months after operation
Z reoperation procedure
1 arthroplasty
2 removal of screws
3 other
4 patient not operable

Discussion

Stability is an important factor for the outcome after treating femoral neck fractures with reduction and internal fixation[5–9]. This concept is also supported by the fact that the position of the fixation device, which is important for the stability, turned out to be the most important factor for the 1-year outcome. Surprisingly, the quality of the reduction did not have a significant impact on the outcome, which was probably due to the low number of poorly reduced fractures in the series.

The results of the von Bahr series in this investigation is the same as we have had with the method since 1965. With the results of the in vivo stability test[9] in mind, a more effective procedure than the von Bahr method for femoral neck fractures should be sought.

When compared with the von Bahr technique, the new Uppsala technique has improved the stability on the basis of the design of the screws and the application technique. The tip of the screw is designed to insure a firm grip in the hard subchondral bone of the femoral head. The insertion technique provides a concentric canal for the screws without damaging the soft cancellous bone of the femoral head and neck and provides a snug fit of the screw in the lateral cortex of the proximal femur.

The present study shows that the rate of mechanical complications, i.e., early loosening and nonunion, can be reduced by the improved technique. Reflecting the increased stability, there were differences between the two treatment groups regarding pain and need for walking aids at the 4-month follow-up despite the fact that all the patients who became failures prior to this follow-up had already been excluded. Almost all the patients (29/37) with pain at this time were, or subsequently became, failures, whereas only a very few patients (9/128) became failures among those that were free from pain at this time. In fact, in no instance did radiographs reveal any complication that required any action from the surgeon without the patient having symptoms. We therefore consider that radiography is only indicated in patients with pain at 4 months to determine what type of complication they have. The difference in pain and need for walking aids did not affect the patient's living condition at 4 or 12 months, indicating that other factors have a greater impact on the patient's ability to live in his or her own home[10].

In this series, there were very few late segmental collapses. However, we expect more of these to develop during the next 2 or 3 of years [7,11–14]. We also expect a somewhat higher incidence of late segmental collapse in the Uppsala group than in the von Bahr group. Due to the higher incidence of nonunion in the latter group, several femoral heads destined for late segmental collapse will never heal to prove their lack of viable bone.

Life-table analysis[15,16] has been very useful in studying this series. The fact that the curves of both treatment groups showed a sudden drop toward the end of this study is due to the design of the study. We have recorded all the complications as they have occurred, but only patients with symptoms have presented themselves between the planned follow-ups. The dip in the curve represents the nonsymptomatic complications that were disguised at the 12-month follow-up.

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