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Internal fixation of femoral neck fractures

Compression screw compared with nail plate fixation

In a prospective, randomized study of femoral neck fracture operations, a newly developed compression-screw device was compared with the McLaughlin nail-plate. One hundred and twenty-eight fractures were treated with the compression screw and 127 with a nail plate. The patients were followed up for 3 years.
All undisplaced fractures healed in both groups. Eleven per cent of displaced Garden 3 and 4 fractures did not heal in the compression-screw group compared to 25 per cent in the nail-plate group. Late segmental collapse occurred in 15 per cent of the healed displaced fractures in the compression-screw group, compared to 21 per cent in the nail-plate group. Fixation of femoral neck fractures using the new compression-screw device gave fewer failures without concomitant disadvantages compared to nail plate fixation.

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A new compression screw device (Figure 1) for fixation of femoral neck fractures was developed by A. Haukebø, MD, Surgical Department, Ullevål University Hospital, Oslo, in cooperation with the senior author of this report (P.B.). The construction of this device partly aimed to simplify the insertion of compression hip screws, reducing the exposure of the femur. This report presents the results of the 3-year follow-up of a prospectively planned study of femoral neck fractures randomly treated with the new compression-screw or nail-plate fixation.

Patients and methods

From October 1977, all patients with femoral neck fractures admitted to the Orthopaedic Department were randomized as follows:

1. All patients below 70 years of age were treated with either the compression screw (CS) or the nail plate (NP). Also, patients older than 70 years with undisplaced fractures (Garden stage 1 and 2, Garden 1961) were treated with CS or NP.
2. Patients over 70 with displaced fractures (Garden stage 3 and 4) were treated by three different methods: CS, NP or primary prosthesis (PP).

The randomization was completed in January 1980; of the total series comprising 314 fractures in 312

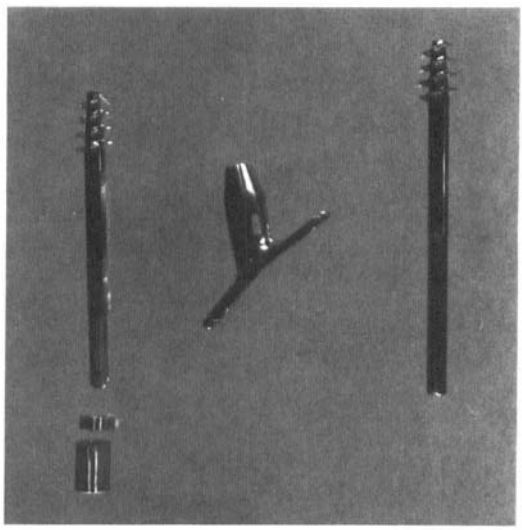

Figure 1. Components of the compression screw device; the lag screw tap to the right.

Table 1. The total series of femoral neck fractures treated with compression screw (CS), nail plate (NP) or primary prosthesis (PP)

Garden stage	Over 70 years			Under 70 years		Total
	CS	NP	PP	CS	NP	
1	13	20		17	10	60
2	8	3		5	6	22
3	37	37	39	17	21	151
4	17	19	20	14	11	81
	75	79	59	53	48	314

Table 2. Hips observed until definite healing or failure following femoral neck fracture

	Compression screw	Nail plate
Total	128	127
Dead before healing	16	20
Lost to follow up	3	4
Number of evaluated hips	109	103

Mean observation time 2.6 years (6 months–3 years).

Table 3. Healed femoral neck fractures observed 3 years postoperatively for evaluation of late segmental collapse

	Compression screw	Nail plate
Healed fractures	101	86
Dead	17	10
Lost to follow up	3	5
Number of hips available for evaluation	81	71

patients, 128 fractures were treated by CS, 127 by NP and 59 by PP (Table 1). There were 238 women and 76 men, with no difference in sex distribution in the various groups. The total number of patients evaluated for up to 3 years was 109 CS and 103 NP (Table 2). The number of healed fractures followed up for 3 years for evaluation of the rate of late segmental collapse was 81 and 71, respectively (Table 3). The mean age of the patients was 71 years, the age distribution being equal in the two groups. A comparative study of internal fixation versus treatment with hemiprosthesis will be presented in a separate report.

Compression screw

The stainless steel CS device (manufactured by Benoist Girard) used in this study (Figure 1) consists of a cannulated sliding lag screw and a barrel-plate combination, with the barrel angled 130° to the inferior branch of the plate. The plate continues proximal to the barrel. A hole in this part of the plate enables insertion of a cancellous screw across the fracture. The lag screw is available in various lengths, the shaft diameter being 7 mm, maximal thread width 14 mm, and thread length 20 mm. Compression is obtained by application of a cylindrical nut at the outer end of the lag screw and this nut fits into the barrel of the barrel-plate combination. A second nut prevents loosening of the compression nut, whereas the hexagonal shape of the shaft of the screw and the inner part of the channel prevents rotation of the screw.

Insertion technique. After reduction of the fracture, a guide-pin is inserted through a fixed angle device (angled 130°) into the lower central part of the femoral head. A second pin is then inserted proximal and parallel to the first to prevent rotation of the femoral head during tapping and insertion of the lag screw. A hole for insertion of the lag screw tap is prepared by a special cannulated reamer. The wider hole needed for insertion of the barrel is prepared by use of a barrel reamer. The hole for the lag screw is then tapped. Unless the bone substance is very firm, only the middle-sized tap of the three available is used.

After insertion of the barrel, compression is obtained as previously described. The plate is fixed to the subtrochanteric region of the femur with one cortical screw. Finally, a cancellous screw is inserted through the proximal hole of the plate to enhance rotational stability of the fracture.

Figure 2 shows a fracture fixed by the compression screw.

Nail plate

The Thornton trifin nail combined with the McLaughlin plate (McLaughlin 1947) was used for NP fixation. The nail was intended to be inserted at a steep angle through the femoral neck into the central lower part of the femoral head. Sagittally, it was attempted to position the nail centrally or slightly posteriorly.

The operation

Most of the patients were treated by tibial pin traction prior to operation, which was usually performed

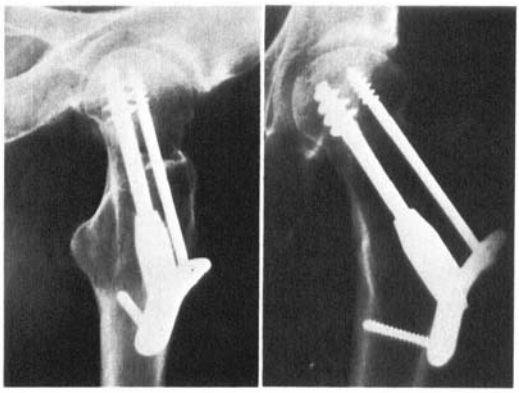

Figure 2. Femoral neck fracture operated with the compression screw.

the day after admittance. During the last part of the study, surgery was preferably performed as an emergency.

Epidural anaesthesia was applied in 179 of the operations, spinal anaesthesia in 42 and general anaesthesia in 34. There was no significant difference as to the type of anaesthesia in the two groups. The reduction of the fracture was performed on a traction table and the position of the screw or nails was checked with two-plane fluoroscopy ("Saab-jig") and by use of an image intensifier. The operations were performed by a total of 17 surgeons, all trainees in orthopaedic surgery. Full weight-bearing was encouraged as early as possible after operation. Subcutaneous heparin injections, 5000 IU three times daily, were given from the day of admittance in patients over 60 years of age, except on the day of operation, when 5000 IU were given only twice. This thrombosis prophylaxis was stopped 10 days after operation. Prophylactic antibiotics were not used.

Evaluation of the results

The fractures were divided according to Garden's (1961) classification. The level of the fracture (CS/AB, Barnes et al. 1976) and the shearing angle were measured on the postoperative radiographs. The reduction of the fractures was evaluated by measurements of the Garden angle and the lateral angle (Garden 1961).

The position of the screw or nail in the femoral head was classified as follows:

1. Central in both views.
2. Posterior and/or inferior.
3. Anterior and/or superior.

The duration of the operations, blood transfusions, fall in the haemoglobin level 1 week postoperatively, postoperative complications, mortality rate and length of hospitalization were recorded and compared within the two groups.

Failure of healing was defined as follows:

1. Recurrence of the fracture deformity or progressive displacement requiring a second operation.
2. No radiographically visible trabeculation across the fracture line at the last follow-up.

Late segmental collapse was not classified as failure.

The patients were examined clinically and radiographically at 3 months, 6 months and at 1, 2 and 3 years after the operation. The results were recorded on a special form.

Statistics

Standard statistical tests were used. Differences with P-values lower than 0.05 were regarded as significant.

Results

Duration of the operation

The mean duration of the operation was 43 min and 38 min ($p < 0.01$) in the CS and the NP groups, respectively. There was no difference in blood transfusions and fall in haemoglobin level 1 week postoperatively between the two groups.

Postoperative complications

There was no difference between the two groups in general complications. Deep vein thrombosis was seen in only one patient in both groups.

There were three superficial infections, two in the CS group and one in the NP group. They were all successfully treated with antibiotics. Deep infection occurred in three hips in both groups. The compression screw was removed in all three patients; in one, the secretion then stopped and the fracture healed. In the two other cases the femoral head had to be removed and a secondary total hip replacement

performed. In the nail-plate group one was successfully treated with antibiotics. In the other two patients, the implant had to be removed, and secondary total hip replacement was performed.

Mortality

No patient died during the operation. The mortality rate at 1 year was 14 per cent in the CS group and 16 per cent in the NP group.

Hospitalization

When five patients with extremely long hospitalization due to other diseases and to special social circumstances were excluded, the mean stay was 15 days, without any difference between the two groups.

Fracture healing

All undisplaced fractures healed in both groups. In displaced fractures there were eight failures in 70 CS fractures, compared to 17 failures in 68 NP fractures ($p < 0.05$; Table 4).

There was no difference between the fracture level and the shearing angle in the two groups, nor did these parameters influence the rate of healing significantly.

There was no difference in the rate of failure related to the position of the screw or nail. Six fractures had been fixed with the implant anteriorly and/or superiorly in both groups, which is considered bad by Barnes et al. (1976). Two of these were failures, both in the NP group.

Table 4. Failures of healing in the two treatment groups

		Number of hips	Failures
Total series	CS	109	8
	NP	103	17
Garden stage 3	CS	46	6
	NP	46	10
Garden stage 4	CS	24	2
	NP	22	7
Garden 3 + 4	CS	70	8
	NP	68	17

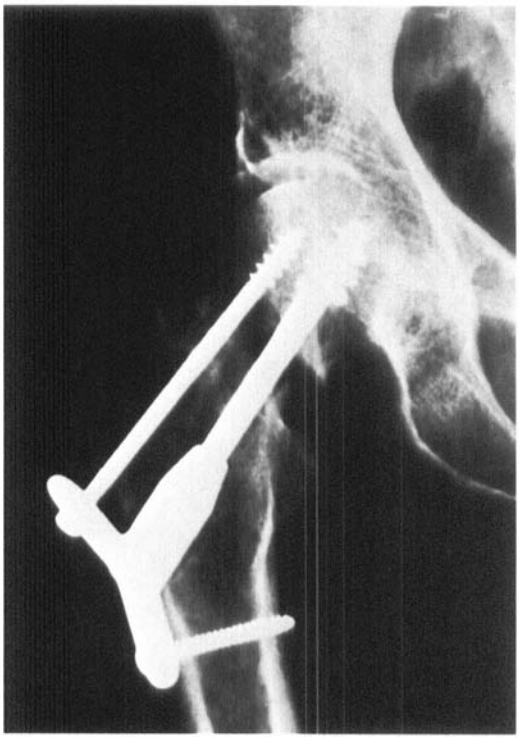

Figure 3. A femoral neck fracture operated with a compression screw in which the sliding mechanism failed; healing did not occur.

Fracture healing related to reduction

Six fractures had been fixed in varus position (Garden angle below 160 degrees); only three of these fractures healed. Fractures reduced in valgus position (Garden angle over 180 degrees) healed better ($p < 0.025$).

There were nine fractures with anterior or posterior tilt exceeding 20 degrees; only one of these did not heal. No difference in the rate of failure was found by comparison of fractures with lateral angles below and above 20 degrees.

When comparing fractures treated with CS or NP, no difference was seen in deviation of Garden-angles from 160 degrees (mean 13 degrees versus 15 degrees), nor did the post-reduction lateral angles differ (7 degrees versus 8 degrees).

In the fractures treated with CS, the sliding mechanism jammed in two of the eight

Table 5. Late segmental collapse in healed fractures 3 years postoperatively

		Number of hips	Late segmental collapse
Garden stage 1 and 2	CS	27	2
	NP	28	2
Garden stage 3 and 4	CS	54	8
	NP	43	9

failures. This was the main reason for the lack of healing in one of these (Figure 3).

Late segmental collapse

The rate of late segmental collapse (Table 5) in undisplaced fractures was 7 per cent in both groups. In healed, displaced fractures the rates were 15 per cent in CS fractures, compared to 21 per cent in NP fractures ($0.25 < p < 0.50$).

We did not find a higher incidence of late segmental collapse in fractures reduced in valgus with a Garden angle over 180 degrees. Eighty-six per cent of all fractures which developed late segmental collapse showed radiographic evidence of the collapse within 2 years.

Half of the patients with late segmental collapse had acceptable function, and no indication for further surgery was found 3 years postoperatively.

Removal of the implant

Removal of the implant due to pain in the trochanter region was performed as an isolated procedure in 14 CS patients and in 23 NP patients.

Discussion

Healing of femoral neck fractures impacted in valgus position and fractures without displacement does not usually pose any problem after internal fixation. However, the failure rate in healing of displaced fractures is still a severe problem. It has long been a matter of discussion which type of fixation device is the most reliable: single or multiple screws or nails, crossed screws or nails, nail plates or sliding nails (Tronzo 1974).

During recent years, various hip compression screw systems have been developed. The aim of this type of fixation is to obtain compression of the fracture at surgery, and the sliding mechanism is supposed to secure interfragmentary contact even if resorption of the fracture ends should occur.

The disadvantage of using the various hip compression screw systems available at the beginning of the study was the need for an extensive exposure of the subtrochanteric region to secure insertion of a relatively long plate parallel to bone. The developed compression screw used in this study was designed to overcome this disadvantage by shortening the length of the plate. It was assumed that the main function of the plate-barrel combination was to obtain compression of the fracture at surgery, and that firm fixation of the plate to the femur was of minor importance. Furthermore, the thread of the lag screw was slightly increased compared to that of some commonly used compression screws, and the plate was continued proximal to the barrel, with a hole for insertion of a cancellous screw across the fracture to enhance rotation stability.

There have been several reports on the use of compression screw fixation in intertrochanteric femoral fractures (Clawson 1964, Jensen et al. 1980). To our knowledge, however, no comparative study of compression screw fixation versus other types of fixation has been performed in femoral neck fractures.

In the present prospective, randomized study, a significantly lower rate of failure was seen in displaced fractures treated with the compression screw device compared to fractures treated with the McLaughlin nail plate. The rate of failure was 11 per cent versus 25 per cent.

This failure rate after fixation with the hip compression screw compares favourably to recent studies of other fixation devices. Barnes et al. (1976) recorded a failure rate of 28 per cent in a large prospective multicenter study where various fixation devices were applied. Smith-Petersen nailing was found inferior to crossed screws, low angle screws and nails and to sliding nails. Frandsen & Andersen (1981) re-

ported 25 per cent failures in fractures treated with the sliding nail plate compared to 38 per cent in fractures treated with the Smith-Petersen nail. Søreide et al. (1979) found 22 per cent failures following fixation with von Bahr screws. The failure rates of these methods of fixation, with the exception of Smith-Petersen nailing, are approximately equal to that of nail plate fixation in the present study.

There was no significant difference in the rate of failure related to the level of the fracture and the shearing angle. Barnes et al. (1976) found that high level fractures showed a greater failure rate than those at lower levels. They, too, found that the shearing angle has no influence on the rate of failure.

The position of the screws or nails did not significantly influence the rate of failure. However, less than 10 per cent of the displaced fractures had been fixated with the implant in a "bad" position.

Varus positioning of the femoral head is commonly held to be a predisposing factor for failure of healing (Garden 1961, Barnes et al. 1976, Frandsen & Andersen 1981). This was also confirmed by the present study.

It has not been determined whether the development of late segmental collapse in healed fractures can be influenced by the choice of fixation device. Some authors claim that more rigid fixation will reduce the rate of segmental collapse (Bøhler 1978, Deyerle 1980), and others that a less traumatizing osteosynthesis device may reduce the development of avascularity of the femoral head (Bauer et al. 1980, Strømquist et al. 1983).

The rate of late segmental collapse of healed fractures in our study was not significantly different in the two treatment groups and is consistent with that reported in several other studies (Barnes et al. 1976, Fielding 1980, Frandsen & Andersen 1981).

One disadvantage with the McLaughlin nail plate is the protruding nail-plate junction, which often causes pain in the trochanteric region. The compression screw protrudes less and required removal due to pain in the trochanteric region in only 14 patients, compared to 23 patients in the nail-plate group.

The compression screw method is somewhat more complicated than nail-plate fixation, but the mean duration of the operation was only 5 min longer in the compression-screw group. The postoperative course, including the fall in haemoglobin level and the need for blood transfusions, the rate of complications and mortality did not differ between the two groups.

The sliding mechanism was the main reason for only one of the eight failures in the total series of 109 fractures, including 70 displaced fractures, indicating that the sliding mechanism had functioned adequately in most cases. The device is now also produced with higher screw-plate angles, since higher angles may improve the sliding mechanism (Kyle et al. 1980).

No case of failure could be attributed to loosening of the plate in the present series. This indicates that the advantage gained from using a shorter plate does not increase the risk of failure.

In conclusion, the result when using the new hip compression screw device was favourable compared to the McLaughlin nail plate, with a lower rate of failure in displaced fractures.

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