Acta Orthop Scand 56, 138–144, 1985

Ender nailing of pertrochanteric fractures

Complications related to technical failures and bone quality

In a series of 127 consecutive patients with trochanteric femoral fractures treated with Ender nailing, bone quality and technical failures were analysed. Of the fractures, 35 per cent were stable and 65 per cent unstable according to the definitions of Evans. There were no implant failures. Technical failures occurred in 16 cases. These could be referred to unsuitable location of the nails in the femoral head and/or to an insufficient fixation of the nails in the medullary cavity, especially in patients with poor bone quality and unstable fractures. Technical failures should therefore be preventable. When a correct surgical technique is used with a sufficient number of nails in femurs with low bone quality and a wide medullary canal, the method seems to be a simple and safe treatment for most pertrochanteric fractures, with elimination of many of the problems often associated with this injury.

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The majority of the devices for internal fixation of trochanteric fractures of the femur have been of the nail- or screw-plate type (Thornton 1937, Jewett 1941, McLaughlin 1947, Pugh 1955, Holt 1963, Clawson 1964). A different principle of fixation was introduced by Küntscher (1970). He presented the condylar cephalic approach followed by Ender & Simon-Weidner (1970), who advocated intramedullary multiple elastic nails. Harris (1980) described fixation with a single solid but elastic rod, a technique which is not yet widely used.

In the treatment of trochanteric femoral fractures, attention has mainly been focused on the choice of implant and its biomechanical consequences. Little attention has been paid to the question of bone quality in relation to mechanical failures.

The purpose of the present study was to investigate the importance of bone quality in the occurrence of technical failures with the Ender technique. Further, the results in a series of elderly patients treated by this method were compared with those of other authors who have used the same technique, with respect to technical factors.

Patients and methods

Between January and December 1980, 127 patients with unilateral trochanteric femoral fractures were treated with the Ender technique at our hospital. Seventy-six per cent were women, with a mean age of 80 years, and 24 per cent were men, with a mean age of 75 years. The mean age of the total series was 79 (59–104) years. According to the system of Evans (1949), 35 were classified as stable types A and B and 65 as unstable types C and D (Figure 1).

The operation was carried out as described by Ender & Simon-Weidner (1970), with anteverted nails (Kuderna et al. 1976, Olerud et al. 1979). The patients were encouraged at least to stand on their legs 1 day postoperatively, and immediate, full weight-bearing was allowed. However, four patients could not follow the instructions, two for medical reasons and two because of intraoperative supracondylar fractures. Clinical and radiographic follow-up was performed in all patients every 3 months for 1 year postoperatively or until death. No patients were lost to follow-up.

The bone quality was evaluated from AP radiograms as described by Barnett & Nordin (1960) and expressed as a femoral score (FS, Figure 2). The diameter of the femoral medullary canal (FMD) was measured at its narrowest part. According to the FS and FMD, the patients were then divided into three groups of bone quality (Table 1).

The reduction of the fracture was assessed. Good reduction was defined as a position with at least some valgus and cortical contact medially on AP radiograms as well as correct alignment on lateral views with no or only minimal anterior or posterior gaps. When assessing the results at different stages after operation, two main points of fixation were taken into consideration: (1) the femoral head, (2) the medullary canal. The position of the nails in the

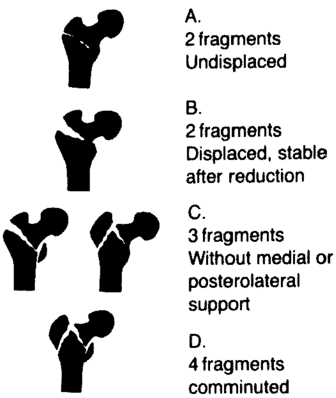


Figure 1

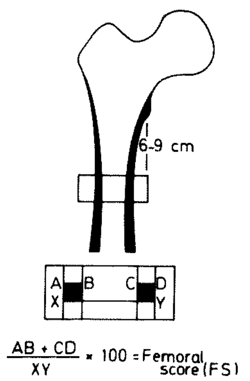


Figure 2

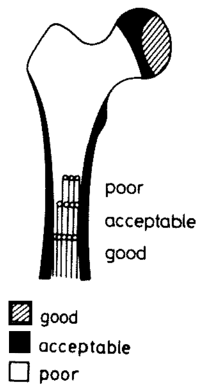


Figure 3

Figure 1. Evans' (1949) classification of pertrochanteric femoral fractures. A and B stable, C and D unstable.

Figure 2. Evaluation of bone quality (femoral score) according to Barnett & Nordin (1960).

Figure 3. Definitions of good, acceptable and poor nail placement and fixation in the femoral head and in the medullary canal (the two main points of fixation).

femoral head and the filling of the canal with nails was classified as good, acceptable or poor (Figure 3).

Early or late technical failures were identified from the clinical and radiographic examinations and classified as:

a) Penetration through the femoral head and neck;
b) Slipping of rods distally with clinical manifestations – pain, limitation of movements and secondary fracture displacement;
c) External malrotation.

Finally, a correlation was sought between technical failures, FS and FMD, and type of fracture.

Results

Technical failures were found in 16 of the 127 fractures (Table 2); there was no case of implant failure. The mortality during the first year was 15 per cent.

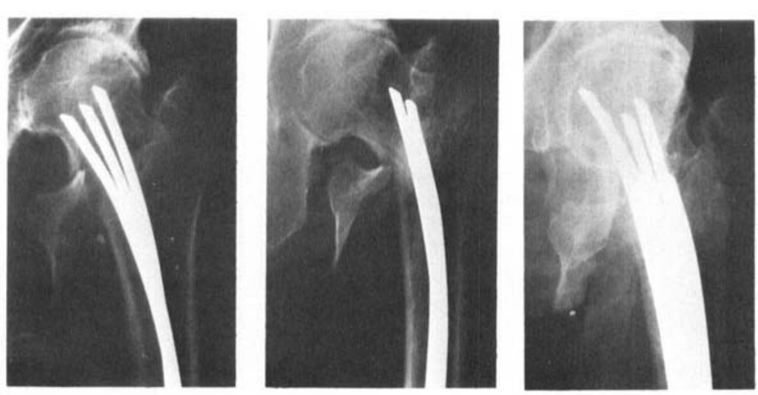
Group 1 (FS > 44, FMD < 18 mm)

There were 45 fractures in this group, 32 stable and 12 unstable. Good reduction was achieved in all but one, a fracture of type C. The mean impaction at the fracture site was 5 (3–5) mm. The fractures united in 12–16 weeks. Superficial wound infection occurred in one patient. No varus deformities, delayed

Table 1. Definitions of bone quality

Group	No. of patients	Bone quality	FS	FMD
I	45	Good	>44	<18
II	51	Moderate osteoporosis	33–44	18–22
III	31	Advanced osteoporosis	<33	>22

FS Femoral score (Barnett & Nordin (1960), Figure 2).
FMD Narrowest part of femoral medullary canal.



A B C

Figure 4. Unstable type C fracture.
A. Poor position of nails in the femoral head and insufficient stabilization in the medullary cavity with only three rods.
B. Early nail migration and varus deformity.
C. Excellent result after reoperation with osteotomy of the trochanter and renailing with seven rods.

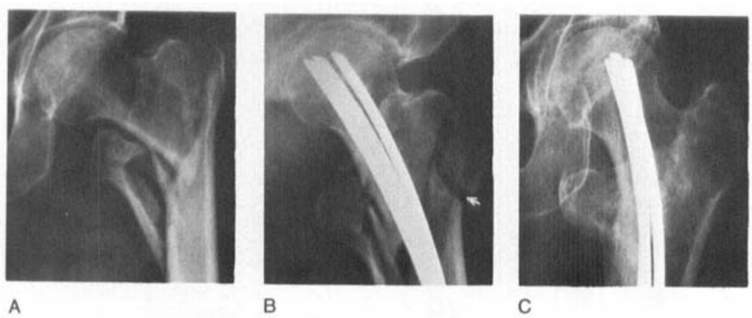


Figure 5.
A. Unstable fracture of type C.
B. A slight overreduction in valgus possible after osteotomy of the greater trochanter (see arrow). Four nails secured a good fixation of the diaphyseal fragment.
C. Excellent union of the fracture as well as the osteotomy.

union or other complications impaired the clinical end results.

The positions of the nails at both main points were good or satisfactory in all but four fractures (Figure 4). In two fractures of the stable types A and B, the fixation was inadequate at both main points. After the nails had slipped distally and caused pain in the knee region, they were extracted at 4 and 5 months with excellent clinical result. In another two fractures – a stable type A and an unstable type C – the fixation was adequate at one of the main points only, but the fractures united without any problems with excellent end results.

Group II (FS 33–44, FMD 18–22 mm)

There were 51 fractures in this group, eight stable and 43 unstable. Reduction was achieved in all but one fracture, according to definition, with an intentional valgus position, in two of them with the aid of trochanteic osteotomies. In the remaining fracture, of type D, the gap at the fracture site was more than 10 mm. Fixation at the first point was secured in 48 fractures, and at the second point in 47 fractures. Two early and three late failures occurred in one stable and four unstable fractures. There were two fractures of types C and D with poor fixation in both the femoral head and the medullary cavity. In both cases the nails slipped distally, and secondary fracture displacement occurred. Ender nailing was again performed after 9 and 12 days postoperatively; the medullary cavity was filled with the optimal number of nails of the right length and the position of the nails was secured at both main points. Both fractures healed without further complications. In the other three cases (one stable and two unstable fractures) with adequate placement of the nails in the femoral head or a sufficient number of nails in the medullary canal, the nails protruded at the knee region in the late postoperative period. All the nails were extracted after 6, 7 and 9 months respectively and the fractures healed

Table 2. The distribution of technical failures in each type of fracture in relation to bone quality and the two main points of fixation

Type of fracture (Figure 1)	Bone quality (Table 1)								
	I			II			III		
	No. of patients	Failure in the femoral head	Failure in the medullary cavity	No. of patients	Failure in the femoral head	Failure in the medullary cavity	No. of patients	Failure in the femoral head	Failure in the medullary cavity
A	25	F^a	F^{a}F	6	–	–	2	–	–
B	8	F^a	F^a	2	F	–	1	–	–
C	9	F	–	32	f^a	f^{a}F	11	f^a	f^{a}F
D	3	–	–	11	f^a	f^{a}F	17	f^{a}f^{a}F^{b}F^b	f^{a}f^{a}F

f = Early failure, F = Late failure, a = Failure in the femoral head as well as in the medullary cavity in same patient, b = Lateral position of nails in the femoral head.

with satisfactory end results. The average time of healing in this group was 16 (14–16) weeks. The neck-shaft angle was 140–145 degrees. The mean impaction at the fracture site was 12 (8–15) mm. External rotation of 10°–15° in comparison with the contralateral extremity was recorded in four patients; it was of no clinical significance. Limb shortening of about 2 cm was observed in one patient, and of less than 2 cm in another four patients. In the remaining patients of Group II the impaction at the fracture site was compensated by a valgus position.

Group III (FS < 33, FMD > 22 mm)

There were 31 fractures in this group. Only three were of stable types while 28 were unstable. Reduction was achieved in 29 cases. A good or acceptable position of the nails in the femoral head and adequate filling out of the medullary canal with nails were noted in 26 cases.

In this group three early and four late technical failures were recorded, all in unstable fractures. In two unstable fractures there was a gap of 2 and 5 cm. When the fractures were impacted, the rods in these two patients migrated into the hip joint and also protruded at the knee region. All were extracted after the fracture had united in a valgus position with less than 1 cm shortening of the limb. In another three fractures, all of unstable types, poor positioning of the nails in the femoral head and insufficient filling of the medullary cavity with nails were the reasons for early major technical failures. The rods in these cases slipped distally and the fracture became displaced. Ender nailing was repeated immediately and instead of three nails, seven or eight were inserted (Figure 4). All fractures united successfully without further complications.

In two cases (unstable D-fractures), the nails were placed in the lateral sector of the femoral head. The nails cut through the head, and both fractures united in a varus position. Both patients were confined to bed.

The fractures in this group united in an average of 18 (14–26) weeks. There was no case of non-union. All united in the valgus position, except the two above-mentioned fractures that united in a varus position. Two supracondylar fractures occurred intraoperatively, and both were attributed to a faulty technique. These fractures united after cast-brace treatment.

Limb shortening of about 30 mm was recorded in two patients. Both were able to walk well with the aid of a stick. In another patient with previous below-knee amputation in the same, fractured limb, external malrotation of 30 degrees was recorded. In another two cases there was external malrotation of 10–15 degrees. A major postoperative complication occurred in an 88-year-old woman with known arteriosclerosis and diabetes. She had previously undergone below-knee amputation in the other, non-fractured limb. A few days postoperatively she developed arteriosclerotic gangrene in the fractured limb, necessitating below-knee amputation.

Summary of technical failures

Of the 16 technical failures, two did not lead to reoperations or an unsatisfactory end result. Twelve of the patients with technical failures had satisfactory end results after renailing (five patients) or extraction of the nails after fracture healing (seven patients). There were no failures among the patients with correct placement of the nails in the femoral head and with a sufficient number of nails in the medullary canal. Only in two cases did the fractures unite with varus deformity and a poor end result.

Discussion

The total correspondence between FS and FMD within the three groups of bone quality may be a coincidence, and in a material of a less homogeneous population some overlapping could be expected. However, a correlation between bone quality and the FMD is always probable as the exterior as well as the interior diameter continuously expands with age (Smith & Walker 1964, Nordin et al. 1970).

In this series Ender nailing was used only in elderly patients. Younger patients with trochanteric fractures were treated with open reduction and rigid internal fixation, which to a greater extent can guarantee an anatomical end result with preserved limb length and rotational alignment.

In a critical analysis of different systems for classification of pertrochanteric fractures, Jensen (1980) found that the classification according to Evans (1949) is the most suitable one when treatment results are studied. On that account we chose to use this classification in the present study.

The biomechanical advantage of Ender nailing has been pointed out in several reports (Poigenfürst & Schnabl 1977, Corzatt & Bosch 1978, Aprin & Kilfoyle 1980, Hall & Ainscow 1981). With respect to the low degree of operative stress and infection, the low rate of postoperative complications, and the early functional recovery, our results correspond to those of several other authors (Kuderna et al. 1976, Raugstad et al. 1979, Russin & Sonni 1980, Chan et al. 1982, Nilsson 1984). External malrotation has been regarded as one of the disadvantages of Ender nailing (Raugstad et al. 1979, Levy et al. 1983). In other reports the frequency of this problem has been low and without clinical significance (Russin & Sonni 1980, Lund et al. 1981, Chan et al. 1982). In the present series in which nails torqued in anteversion were used (Kuderna et al. 1976, Olerud et al. 1979), there was one case of external malrotation of clinical importance (30°) and in 7 per cent it ranged from 5 to 15 degrees.

An objection has been raised to the use of the Ender method in unstable types of trochanteric femoral fractures, on the basis of the high rate of technical failures – up to 46 per cent in these cases (Jensen & Sonne-Holm 1980, Levy et al. 1983). The reasons for this may be lack of sufficient reduction, lack of proper position of the nails within the femoral head as well as an inadequate number of nails in the often widened medullary cavity – all causes of instability after Ender nailing of so-called unstable types of fractures. Compared with these figures, the relatively low failure rate in the present series comes out as rather favourable. Only 11 technical failures in 83 unstable fractures (13 per cent) influenced the healing course or end result. The reliability of the internal fixation is also reflected in the fact that only four patients were unable to put full weight on the injured extremity on the first postoperative day.

Only in two cases did penetration of nails into the hip joint require reoperation. However, such failures should be preventable. If a diastasis in the fracture still exists, after insertion of the first one or two nails, it is imperative to attain impaction by reducing the traction. Another risk of late perforation is created when a peroperative perforation is followed by only a slight backing out. Such a technique is not optimal: instead, the nail needs to be placed in a completely new position.

This study indicates that technical failures after Ender nailing are intimately related to the adequacy of the positioning of the rods in the femoral head and the filling of the medullary canal with a sufficient number of rods. When the trochanter prevents a reduction in valgus, osteotomy of the greater trochanter may be essential in certain unstable fractures, so that the nails can be placed in the right position in the femoral head (Figure 5). Otherwise, after the passage of the nails through the medullary canal, the curvature of the nails has often become too slight for them to achieve a good position in the femoral head (Böhler 1972, Kuderna et al. 1976). Without the osteotomy, there is also in certain fractures a risk of creating a cortical defect in the calcar region.

After reduction, it is essential that the proximal ends of the rods are placed in the posteromedial portion of the femoral head, to prevent torsion and to maintain normal rotation. Good depth of the nails in the centre of the femoral head will secure the best possible fixation and also compensate the tendency of the nails to cut out of the femoral head. It should also be an aim to create the best possible fixation within the proximal part of the medullary cavity. This is done by filling the medullary cavity with several nails; as many as seven or eight nails might be needed. A good fixation in this respect will reduce the motion in the fracture between the nails and the endosteal surface of the femoral shaft, which will prevent nail migration as well as outward malrotation, and will also minimize postoperative pain. Our results confirm that in early technical failures, an inadequate position of the nails, together with an inadequate number of nails in the medullary canal is responsible. When the fault is only at one main point, late technical problems can be expected.

We have previously demonstrated an increased rate of unstable fractures in patients with decreased bone stock, with similar domestic types of trauma (Zain Elabdien et al. 1984). Thus the unstable fracture is more common among patients with low bone quality. An adequate procedure considering every technical aspect is therefore essential when Ender nailing is the choice of treatment, as the risk of failure is most obvious in these fractures.

It is evident that the results of more recent prospective studies are superior to those of the early 1970s, indicating that more experience has been gained in the method, as Nilsson (1984) has clearly shown. It was also concluded by Pasoff & Schein (1980), who reviewed 100 consecutive fractures after Ender nailing, that there are no pertrochanteric fractures that cannot be treated by this method. Our results in this series seem to confirm this statement.

Conclusions

Ender nailing can eliminate many of the problems associated with pertrochanteric fractures:

1. Immediate mobilization with full weight-bearing is possible for most patients after an adequately performed operation.
2. An appropriate surgical technique with due regard to the position and fixation of the nails in the femoral head as well as in the medullary cavity will give a low failure rate.
3. The risks of failure mainly threaten osteoporotic patients with unstable fractures.
4. Ender nailing is a suitable method of treatment for almost all types of intertrochanteric femoral fractures in elderly patients.

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