INTERTROCHANTERIC FEMORAL FRACTURES

MECHANICAL FAILURE AFTER INTERNAL FIXATION

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In a prospective study we assessed the causes of mechanical failure in a series of 230 intertrochanteric femoral fractures which had been internally fixed with either a sliding hip screw or a Küntscher Y-nail.

The overall rate of mechanical failure was 16.5%; cutting-out of the implant from the femoral head was the cause in three-quarters of the instances. Implants placed posteriorly in the femoral head cut out more often (27%) than those placed centrally (7%). The cut-out rate was also determined by the quality of the fracture reduction, but age, walking ability and bone density (assessed by the Singh grade and metacarpal indices) had no significant influence.

We conclude that these fractures should be reduced as accurately as possible and it is imperative that the implant is placed centrally within the femoral head.

Internal fixation of unstable intertrochanteric fractures is not always successful. Failure rates of 5% to 10% have been reported with sliding screw devices (Jensen, Tøndevold and Mossing 1978; Kyle, Gustilo and Premer 1979; Wolfgang, Bryant and O'Neill 1982; Bannister and Gibson 1983). Cutting-out of the implant from the femoral head was the most common cause of mechanical failure. The incidence of cutting-out is determined by the fracture subtype (Jensen 1980), the quality of the fracture reduction and the type of implant (Jensen, Sonne-Holm and Tøndevold 1980). Reduced bone density may also be a relevant factor (Laros and Moore 1974).

Although a number of authors believe that the cut-

out rate is determined by the position of the implant in the femoral head, the ideal location is controversial (DeLee 1984). Central placement of the implant is recommended by some authors (Mulholland and Gunn 1972) while others recommend posterior placement (Laskin, Gruber and Zimmerman 1979). Jensen et al (1978) recommend that the tip of a sliding screw should be at least 10 mm from the articular surface, while Kyle et al (1979) advocate that it is placed within 10 mm of this surface.

In our study the causes of mechanical failure were investigated prospectively in a consecutive series of patients with particular attention to the roles of reduced bone density and the position of the fixation device.

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PATIENTS AND METHODS

At Sunderland District General Hospital and Dryburn Hospital, Durham from June 1983 to May 1985, every patient over the age of 50 with an intertrochanteric fracture was included, provided that they were considered fit for anaesthesia.

Operative technique. Using image intensification a closed reduction was performed to as near an anatomical position as possible. Medial displacement (Dimon and Hughston 1967) or valgus osteotomies (Sarmiento and Williams 1970) were not performed. Each fracture was internally fixed with either a sliding hip screw (Richards Fig. 1) or a Küntscher Y-nail (Fig. 2). The choice of implant was determined pre-operatively by random

Fig. 1

AP and lateral radiographs of a sliding hip screw.

Fig. 2

AP and lateral radiographs of a Küntscher Y-nail.

Table I. Incidence and method of fixation of different types of trochanteric fracture

	Küntscher Y-nail	Sliding hip screw	Total	
			Number	Per cent
2-part displaced	22	13	35	15
3-part lateral	28	22	50	22
3-part medial	18	7	25	11
Complex	35	56	91	39
Associated subtrochanteric	9	11	20	9
Basi-trochanteric	4	5	9	4
Total	116	114	230	

Table II. Frequency of mechanical complications

	Küntscher Y-nail (n = 116)	Sliding hip screw (n = 114)	Total (n = 230)
Cutting-out	12 (2)*	17 (3)*	29 (5)*
Implant fracture or bending	2	1	3
Implant loosening from femoral shaft	1	4	5
Implant uncoupling	1	0	1

*cases with implant tip in joint space

Table III. Frequency of cutting-out, related to age, sex and mobility

	Number	Per cent
Age < 80 years	14 of 92	15
Age > 80 years	10 of 133	8
Male	2 of 40	5
Female	22 of 185	12
Pre-fracture mobility		
Good	17 of 115	15
Poor	7 of 110	6

allocation. The method for inserting the Küntscher Y-nail was as described by Cuthbert and Howat (1976). Weight-bearing, using walking aids, was encouraged from 48 hours after the operation.

Patient assessment. The age and prefracture walking ability of each patient were recorded pre-operatively. Walking ability was classed as poor if the patient was housebound and good if he or she was able to walk outside with or without a walking aid.

Radiographs of the patient's contralateral hip and of the right hand were obtained pre-operatively, and used to make two simple estimations of bone density. The state of the trabecular bone in the proximal femur was assessed using the Singh grading method (Singh, Nagrath and Maini 1970) and the state of the cortical bone of the second metacarpal was assessed by measurement of the cortical area ratio (Horsman and Kirby 1972). The Singh grading and metacarpal morphometry were performed by one experienced observer (MS) who did not know the outcome of the fracture fixation. When the trabecular pattern of a proximal femur had characteristics which were intermediate between two consecutive Singh grades it was allocated to an intermediate half-grade. Observer error was minimised by assessing each film on two separate occasions and using the mean of the two results. The results for those patients where the fixation device cut-out of the femoral head (cut-out group) were then compared with the results of 40 control patients who were matched for age, sex, fracture subtype and prefracture mobility, in whom union occurred without fixation failure.

2-part Displaced

3-part, lateral fragment

3-part, medial fragment

Complex (4-part)

Associated Subtrochanteric

Basal

The classification of intertrochanteric femoral fractures.

Fig. 3

Fig. 4

The assessment of postoperative radiographs. A, AP diastasis; B, lateral diastasis; C, distance from implant tip to the nearest articular cortex.

Fracture assessment. Using the pre-operative radiographs, each fracture was classified by one of the authors (TRCD) using Jensen's (1980) modification of Evans' classification (1949). This recognises six types of fracture as shown in Figure 3. The immediate postoperative radiographs were used to assess the accuracy of the fracture reduction and the position of the implant in the femoral head. The amount of displacement between the two main fracture fragments was measured on the anteroposterior (AP diastasis) and lateral (lateral diastasis) radiographs (Fig. 4) and the neck-shaft angle was compared with that of the contralateral femur. The position of the implant in the coronal plane (AP

radiograph) was classed as superior, central or inferior and in the sagittal plane (lateral radiograph) as anterior, central or posterior. The distance between the tip of the device and the nearest articular surface was also measured (Fig. 4).

Radiographs of the fractures of surviving patients, obtained at 6 weeks, 3, 6, and 12 months postoperatively, were used to demonstrate any failure of fixation. The one-year survival was 61%. Failure of fixation was defined as migration of the device within the head; cutting-out from the head; loosening, bending, fracture or uncoupling of the implant.

Statistical analysis. Unless stated otherwise, we used the chi-squared test for statistical analyses.

RESULTS

In all, 230 patients entered the study, including 40 men and 190 women. Their average age was 80.6 years, and the number with each type of fracture is shown in Table I. A total of 116 Küntscher Y-nails and 114 sliding hip screws were inserted.

The overall rate of mechanical failure was 16.5%, and cutting-out of the implant from the femoral head was the cause in 76% (Table II). Other causes of mechanical failure were infrequent and have been excluded from further analysis.

Cutting-out. Of the 29 cases with this complication five were shown on immediate postoperative radiography to have the implant placed with its tip penetrating into the joint space; these were excluded from further consideration. The cut-out rate for the Küntscher Y-nail was 8.8%

Fig. 5

The distribution of Singh grades in the cut-out and control groups of patients. There is no significant difference between the groups.

Fig. 6

The frequency of cutting-out in relation to the position of the implant in the femoral head, excluding 2-part fractures. Percentages are given in parentheses.

Table IV. The mean (s.d.) ages and cortical area ratios of the cut-out and control groups. The difference between the groups is not significant

	Age (years)	Metacarpal cortical area ratio
Cut-out group (n = 24)	81.6 (6.5)	0.627 (0.095)
Control group (n = 40)	83.0 (7.8)	0.577 (0.097)

and for the sliding hip screw it was 12.6%. This difference, which is not significant, may possibly be explained by the uneven distribution of 2-part (stable) fractures (Table I) and by the quality of the fixation.

General factors. Although cutting-out appeared to be more common in women, patients under 80 years old and those with good prefracture walking ability (Table III), these differences were not significant. The apparent correlations with lower age and greater walking ability may simply reflect the facts that these two subgroups of patients had a longer average survival rate than the remainder; and that a higher proportion of them were able to stress their fracture fixation by weight-bearing.

The mean cortical area ratios of the second metacarpal in the cut-out group and the control group were compared using the unpaired *t*-test; they did not differ significantly (Table IV).

Table V. Frequency of cutting-out for each of the six fracture subtypes

Fracture type	Cut-out rate	
	Number	Per cent
2-part displaced	0 of 35	0*
3-part lateral	7 of 49	14
3-part medial	1 of 24	4
Complex	12 of 89	13
Associated sub-trochanteric	2 of 19	11
Basi-trochanteric	2 of 9	20

*the difference between the rates for 2-part fractures and the remainder is significant ($p < 0.05$)

The differences between the two assessments of the Singh grade for each patient were minimal. In 27 cases the two assessments were identical; in 30 cases the difference was half a grade, and in only one instance was there a difference of one whole grade. Three patients from the cut-out group and three from the control group had previously sustained a fracture of the contralateral proximal femur. The Singh grades in the remaining 21 patients of the cut-out group (median = 3.75) were generally slightly less than those for the remaining 37 patients of the control group (median = 4.25); this difference was close to significance ($0.1 < p < 0.05$, two-tailed Mann-Whitney U test) (Fig. 5).

Fracture factors. There were no instances of cutting-out in 2-part fractures (Table V); these 35 stable fractures were excluded from further analysis.

The cut-out rate was significantly higher ($p < 0.01$) in those fractures which had been fixed with more than

5 mm of AP diastasis (Table VI). Lateral diastasis and restoration of the normal neck-shaft angle were not significant determinants of cutting-out (Table VI).

Implants placed posteriorly in the femoral head (Fig. 6) had a significantly higher ($p < 0.001$) cut-out rate (13 of 46 = 28%) than those placed centrally in the coronal plane (9 of 121 = 7%). This was so for both the Küntscher Y-nail ($p < 0.05$) and the sliding hip screw ($p < 0.01$). Provided that the implants were centrally positioned on the lateral radiograph, the cut-out rate was not significantly affected by either a superior or an inferior placement as seen on the AP view.

For the Küntscher Y-nail alone, there was a significantly higher ($p < 0.01$) rate of cutting-out when the perceived distance between the implant tip and the femoral articular surface was less than 10 mm (Table VII). For the sliding hip screw this distance did not appear to be critical.

Table VI. Frequency of cutting-out related to quality of reduction, excluding 2-part fractures

Reduction	Cutting-out	
	Number	Per cent
Varus $> 10^\circ$	3 of 19	16
Valgus $> 10^\circ$	5 of 28	18
Varus and valgus	8 of 47	17
Anatomical	16 of 143	11
Displacement on AP radiograph		
< 5 mm	8 of 108	7*
> 5 mm	16 of 82	20*
Displacement on lateral radiograph		
< 5 mm	10 of 78	13
> 5 mm	14 of 112	13

*difference significant at $p < 0.01$

Table VII. Cutting-out related to the distance between implant tip and joint surface excluding 2-part fractures

Implant-cortex distance (mm)	Küntscher Y-nail		Sliding hip screw		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
0 to 4	4 of 13	21	1 of 13	8	5 of 26	19
5 to 9	4 of 21	19	4 of 34	12	8 of 55	15
10 to 14	1 of 30	3*	7 of 34	21	8 of 64	13
> 15	1 of 28	4	2 of 17	12	3 of 45	7

*there is a significant difference ($p < 0.01$) in the frequency of cutting-out of Küntscher Y-nails placed over 10 mm and under 10 mm from the joint surface

DISCUSSION

Our most important finding is that the position of the fixation device is a highly significant determinant of the probability that the implant will cut out.

Mulholland and Gunn (1972) recommended central placement (as visualised on both AP and lateral radiographs) and Kyle et al (1979) reported that posterocentral placement also resulted in a low failure rate (5%). Laskin et al (1979) always placed the sliding hip screw posteriorly in the femoral head and reported no cases of cutting-out in their series of 236 intertrochanteric fractures. This contrasts with our finding that both the sliding hip screw and the Küntscher Y-nail had a higher rate of cutting-out when placed posteriorly in the femoral head. The reason for this difference is not apparent and cannot be explained by differences in postoperative mobilisation.

Regarding the position of the tip of the device, Jensen et al (1978) advise placement *over* 10 mm from the articular surface and Kyle et al (1979) *within* 10 mm. We found that this distance was not critical for the sliding hip screw. However, five implants were accidentally

placed with their tips penetrating into the joint space. As this error was thought to result from misinterpretation of the peroperative images, it would seem sensible not to aim to place the implant too close to subchondral bone. As the Küntscher Y-nail cannot telescope, it is not surprising that there was a higher incidence of cutting-out when its tip was placed within 10 mm of the joint surface.

Simple measures of bone density (metacarpal cortical area ratio and Singh grade) could not be demonstrated to influence the cut-out rate. This contrasts with the findings of others (Laros and Moore 1974), but the difference may be due to their use of older implants, now recognised to be biomechanically unsound. At present these simple indices are the only measures of bone density which can easily be performed pre-operatively in a district general hospital.

Our findings agree with those of previous studies which showed that cutting-out was rare in stable fractures (Jensen, Tøndevold and Sonne-Holm 1980) and that the cut out rate was determined by the quality of the fracture reduction (Jensen, Sonne-Holm and Tøndevold 1980).

We have shown that the mechanical failure rate of

the fixation of intertrochanteric femoral fractures can be minimised by reducing the fracture as accurately as possible and by placing the implant centrally within the femoral head. The success of fixation is dependent much more on the technical expertise of the surgeon than on the bone quality of the patient.

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