COMPRESSION SCREW FIXATION FOR DISPLACED SUBCAPITAL FRACTURE OF THE FEMUR

SUCCESS OR FAILURE?

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We report a prospective study of 198 cases of subcapital fracture of the femur treated by closed reduction and fixation with a sliding compression screw-plate. This was done without regard to the patient's age or the Garden stage of the fracture. Early weight-bearing was encouraged.

Of the displaced fractures 23% failed in the first year because of non-union or infection. Of the fractures which united 27% had developed avascular necrosis after three years. Despite this we believe that the sliding compression screw-plate, of proven value in the treatment of intertrochanteric fractures, is also useful for the fixation of subcapital fractures.

Over the years, many fixation devices have been used to treat subcapital fractures of the femur (Tronzo 1974), and it is accepted that virtually any method of fixation will give satisfactory results for undisplaced fractures. For displaced fractures, however, a simple triffin nail is unreliable because it provides insufficient resistance to lateral rotation. In 1961, Garden proposed low-angle fixation to overcome this problem by providing a firm grip in the lateral cortex of the femoral shaft, but this method has resulted in a 2.4% incidence of fracture of the femoral shaft at the point of entry of the screw (Howard and Davies 1982).

Putti was reported by Charnley, Blockley and Purser in 1957 to be among the early investigators who proposed fixation by a device with a side plate attached to the femoral shaft. He believed that lateral rotation forces at the fracture site could be neutralised by a rigid device which entered the firm subchondral bone of the femoral head and was fixed to the strong cortical bone of the femoral shaft. Charnley developed this concept with a screw-plate which provided compression at the fracture, yet allowed for sliding of the lag screw to accommodate any bone resorption. This device failed to gain wide acceptance because the lag screw tended to cut out of the femoral head (Hargadon and Pearson 1963). The sliding nail-plates of Pugh and Tulloch-Brown have proved to be more successful (Brown and Abrami 1964; Fielding, Wilson and Ratzan 1974).

In the 1950s, the Richards Manufacturing Company developed a sliding screw-plate for the fixation of intertrochanteric fractures which was an improvement on several earlier designs. The current version of this device (Fig. 1) provides rigid fixation, and allows the screw to "back out". Because of the positive grip of the screw threads in the head, it also allows compression to be applied to impact the fracture at operation.

Mackechnie-Jarvis (1983) compared the rigidity of several fixation methods in the laboratory. He found the rigidity of fixation provided by a sliding compression screw-plate to be superior to that of Moore's pins, a triffin nail, or Garden crossed screws, although none of the devices resisted continued cyclical loading *in vitro*.

Fig. 1

Radiograph three years after compression screw-plate fixation of a Garden Stage IV subcapital fracture. There has been slight impaction of the lag screw within the barrel of the plate.

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Despite the apparent suitability of the sliding compression screw-plate for the fixation of subcapital fractures, there have been few reports of clinical studies of its use for injury at this level (Cassebaum and Parkes 1973; MacDiarmid 1981; Rau, Manoli and Morawa 1982).

MATERIAL AND METHODS

We studied all 198 patients with a subcapital fracture of the femur admitted to King's College Hospital between January 1980 and December 1983 under the participating surgeons. Pathological fractures were the only exclusion from the series, which otherwise included all grades of fracture in patients with a mean age of 72.3 years, ranging from 29 to 98 years (Fig. 2). Women formed 77% of the series. Operation was performed as soon as permitted by the patient's general condition, the majority within 48 hours of admission. Most operations were performed by members of the resident staff.

Technique of operation. Displaced fractures were reduced by closed methods and standard guide-wire techniques were used. The length of screw was selected to allow its tip to be placed within 5 mm of the joint line. At the surgeon's discretion, a second guide-wire was used to prevent rotation of the femoral head during reaming and screw insertion. A lag screw with a short threaded segment (19 mm) was usually used in order to avoid bridging the fracture with its thread. It was necessary to tap the screw track only in patients with unusually dense bone. Two or three-hole plates with 135° or 140° angles were used in all cases. When the plate had been fixed to the femoral shaft, the compression screw was tightened; impaction was seen in many cases. The compression screw was then removed in some and retained in other cases at the discretion of the surgeon.

Fig. 2

To show the age distribution of the patients (five were not recorded).

Postoperative management. After operation radiographs were taken to assess the quality of reduction and screw placement. The angulation and the displacement of the fracture, and the position of the screw, were measured in two planes as reported in previous papers. Patients were encouraged to bear weight 48 hours after operation, and to progress from partial weight-bearing to full weight-bearing as soon as this was comfortable; they left hospital when it was thought that they could manage independently.

Follow-up. Of 198 patients entered into the study, 66 were lost to follow-up and 17 died within three months of operation, leaving 115 who were followed for 3 to 48 months (mean 22 months). At review all patients were asked about pain and mobility, and were examined. Their mobility was not analysed in detail, since we agree with other authors that there are too many variables in this age group. Standard anteroposterior and lateral radiographs were taken at each visit.

Statistical analysis. Previous reports on subcapital fractures of the hip have presented their results in one of two ways: either after a mean follow-up of a certain number of months, or by assessment of all patients at a certain time, say 36 months, after operation. We believe the first method can mislead since all patients may not have been followed long enough to develop the later complications, while the second method ignores those patients that died or were lost to follow-up without evidence of failure before the review assessment. We have, therefore, in addition used the actuarial method of Armitage (1971) to present our results. This method takes account of patients having different periods of follow-up and of those patients who die or are lost to review. This statistical method was well described by Dobbs (1980) when he assessed the survivorship of Stanmore hip replacements, and by Tew and Waugh (1982) in comparing knee replacements. It enables calculation of the annual failure rate and the cumulative success rate at say three to four years after operation. To allow comparison of the various methods and the different results that they produced, we present the results of our study by all three methods in Table I.

Assessment of results. A number of authors (D'Arcy and Devas 1976; Miller 1978) have stressed that for subcapital fractures the time to obtain union and the incidence of avascular necrosis are of secondary importance to the high mortality and loss of mobility of the elderly patients being treated. We have therefore assessed the results of all patients who survived three months after operation as "success" or "failure".

Failure was defined at two levels since some patients with non-union or avascular necrosis had few symptoms and were mobile. Those cases in which further surgery was required formed a subgroup of all those with radiological evidence of non-union or avascular necrosis with or without pain.

Union was defined by the presence of trabeculae across

Fig. 3

Radiograph showing obvious collapse of the femoral head six months after fixation of a Garden Stage III fracture. This was classified as a case of non-union because no trabeculae are seen to cross the fracture line.

an obliterated fracture line. This can be difficult to assess less than 12 months after operation. *Non-union* was diagnosed when there was redisplacement of the fracture (it had "fallen apart") or when there was collapse of the femoral head within 12 months.

Avascular necrosis was diagnosed from the radiological appearance of segmental or whole-head collapse later than 12 months after operation. This chronological distinction between non-union and avascular necrosis avoids the difficulty of assessing union when the head is collapsing (Fig. 3).

RESULTS

Mortality. The postoperative mortality was 13% within three months and 22% within 12 months with a continuing annual mortality of about 10%. There was 64% survival at four years (Fig. 4). These mortality rates are similar to those reported in other series (Miller 1978).

Undisplaced fractures. All eight patients with minimally displaced fractures had successful results. Garden Stage I fractures all united by six months and Stage II fractures by 12 months. None of the five patients reviewed after a mean follow-up of 24 months had developed avascular necrosis.

Displaced fractures. Of 107 patients with displaced fractures 28 cases had failed by the time of latest review because of non-union, infection or avascular necrosis, though not all of them had symptoms. When this definition of failure was used the failure rate from non-union and infection was 23% in the first year (Table II). After

Table I. The results of compression screw fixation of 107 displaced subcapital fractures using three different methods of assessment

Method	Number of patients assessed	Union (per cent)	Avascular necrosis (per cent)	All failures* (per cent)
After a mean follow-up of 22 months	107	82	10.2	27
After 36 months' follow-up in each case	39	69	18.5	44
By the Armitage method after 0 to 4 years	107	77	27.1	42

* Failure defined as pain, removal of the device, or radiological evidence of non-union or avascular necrosis

Table II. The annual failure rate and cumulative success rate of 107 displaced subcapital fractures, when failure is defined as pain, removal of the device, or radiological evidence of non-union or avascular necrosis

Years since operation	Number at start of period	Result of last review		Number at risk throughout period	Annual failure (per cent)	Cumulative success rate (per cent)
		Success	Failure			
0-1	107	38	20	88	22.7	77.3
> 1 2	49	18	6	40	15	65.7
> 2 3	25	15	2	17.5	11.4	58.2
> 3 4	8	8	0	4	0	58.2

this the annual failure rate from avascular necrosis in the next two years was 15% and 11.4% respectively. The cumulative success rate on these criteria between three years and four years was 58%. However, if patients with few symptoms are excluded, and the need for a further operation is the definition of failure, then the annual failure rate falls to around 14% and the cumulative success at three to four years is 64%.

Separate survivorship tables have been constructed for Garden Stage III and Stage IV fractures; the results are summarised in Table III. As in previous series the failure rate from non-union was significantly higher in Garden Stage IV fractures.

Infection. Prophylactic antibiotics were not used routinely; the infection rate in this series is similar to that reported by Burnett *et al.* (1980). Five patients developed deep infection; all required a further operation. One patient died from sepsis but the other four had total hip replacement and after 8, 24, 24 and 42 months, respectively, can walk satisfactorily.

Non-union. Eight fractures redisplaced ("fell apart") within three months and a further seven cases showed established non-union within 12 months of operation. The rate of non-union was 30.5% in Stage IV fractures and 10.3% in Stage III fractures (Table III). If, as in many previous series, infection is included with non-union, then the failure rate within the first year was 15.4% and 37.3% respectively for Stage III and Stage IV fractures.

Three of the 15 patients with non-union have not required further operation; one died after 18 months but two are asymptomatic and walking. Of the 12 requiring a second operation, eight have had a total hip replacement, successful at a mean follow-up of 19 months, and four are able to walk after simple removal of the screw.

Avascular necrosis. Radiological signs of collapse of a

Table III. Percentage of various modes of failure in 107 displaced subcapital fractures of the hip related to Garden stage. Failure defined as pain, removal of the device, or radiological evidence of non-union or avascular necrosis

Garden stage	Number of patients	Infection	Non-union	Avascular necrosis
III	73	4.1	10.3	20.5
IV	34	5.8	30.5*	44.5†
	107	4.7	17.1	27.1

* Significant difference between Stage III and Stage IV fractures ($P < 0.05$)

† No significant difference between Stage III and Stage IV fractures

Table IV. Percentages of failures reported for the use of different fixation devices for displaced subcapital fractures of the hip

Author and device	Infection or non-union		Avascular necrosis Stages III and IV
	Stage III	Stage IV	
Barnes <i>et al.</i> (1976)			
Smith-Petersen trifin nail	43	50	} 27.6
Garden cross-screws	26	25	
Sliding nail-plate	23	32	
Skinner and Powles (1986)			
Compression screw-plate	15.4	37.3	24.3

segment or the whole head developed in eight patients between 12 and 36 months postoperatively. The incidence was 24.3% for those at risk through the four-year period, with no significant difference between Stage III and Stage IV fractures (Table IV). Only half of the patients with radiological avascular necrosis have required re-operation, and if this is the definition of failure then the late failure rate in united fractures falls to 15%.

The four patients requiring further operation all had total hip replacement; one has since died and three are successful at 6, 12 and 24 months after revision. Of the patients with avascular necrosis that have not required revision, one died after 30 months, two are asymptomatic at 18 and 24 months, and one requires occasional analgesics 36 months after fracture.

Age of patient. No differences in failure rate were found when patients were grouped by age and standardised for the stage of the fracture; patients younger than 65 years fared no better than the older ones. In the 43 patients under 65 years of age, three undisplaced fractures united without avascular necrosis after 24 to 48 months. Of the 31 patients with displaced fractures, seven have required further surgery for non-union and one for avascular necrosis. Two patients have radiological signs of avascular necrosis 18 and 36 months respectively after the fracture, but have little or no pain.

Causes of failure. The quality of reduction and the position of the lag screw was assessed in all failures and in those who survived three years' follow-up. An optimal reduction, as in previous series, showed under 30° of angulation in either plane and no displacement. Displacement of the calcar in the horizontal plane by more

Fig. 4

Percentage survival curve of the 132 patients whose fate was known, excluding those who died in the first three months.

than 3 mm led to certain failure. The optimal position for the screw tip was within 10 mm of the articular surface, but not through it, and not in the anterior third of the femoral head.

The cause of failure in each case was then assessed using these parameters. Poor screw placement, even after a good reduction, tended to lead to the fracture falling apart within three months, whereas good screw placement after a poor reduction tended to lead to avascular necrosis after 12 months. In the cases in which both reduction and screw position were good only two Garden Stage IV fractures failed to unite and three Garden Stage III fractures developed avascular necrosis. Mechanical failure of the device did not occur and there were no fractures through a screw hole.

DISCUSSION

Sliding compression screw-plates of various designs are now used widely to fix intertrochanteric fractures, but there are few reports of their use for subcapital fractures, perhaps because of discouraging earlier papers. Rau *et al.* (1982) reported three failures in five Garden Stage II fractures, three failures in 10 Stage III fractures, and eight failures in nine Stage IV fractures, giving a total failure rate of 14 in 24 cases followed for 6 to 36 months (mean 22 months). They found difficulty in controlling rotation of the femoral head during tapping and insertion of the lag screw. In our experience this occurred infrequently, and when seen, could be overcome by the insertion of additional guide-wires. Small rotational movements are likely during the insertion of the lag screw, but these must also occur when a nail is hammered in or a Garden screw is inserted.

The largest proportion of our failures, as in other series, was caused by the fracture "falling apart" in the first three months postoperatively. In most of our cases this was due to either a poor reduction, or to poor placement of the screw, or to both. In only two cases with accurate reduction and screw placement was there failure of fixation.

Accurate reduction of the fracture remains the most important part of the operative technique, and also the most difficult. We now recognise that when a fracture cannot be accurately reduced by closed means, it is not acceptable to fix it in an unreduced position, while Sikorski and Barrington (1981) have reported a high mortality when attempted fixation is abandoned for immediate prosthetic replacement. Open reduction of the fracture may therefore be preferable (Trickey 1981). This can be achieved by extending the incision proximally to approach the hip anterolaterally, without altering the patient's position on the orthopaedic table.

We agree with D'Arcy and Devas (1976) that the object of operating on these patients is to avoid prolonged recumbency and we therefore encouraged weight-bearing 48 hours after operation in all cases. Our results

appear to be better than those reported for the trifin nail, and similar to those reported by several investigators using sliding nail-plates and Garden screws (Table IV). The failure rate for Stage IV fractures remains high for the reasons we have discussed. There is a more compelling argument for primary prosthetic replacement in this group than in Stage III fractures, but further controlled clinical trials are required.

A particular advantage of the sliding compression screw-plate is that it can be used for the fixation of both subcapital and intertrochanteric fractures of the femur. The uniformity of operative technique and instrumentation allows the rapid accumulation of experience, which is particularly important for junior surgeons, operating theatre staff and for the patients.

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