CLOSED KÜNTSCHER NAILING OF FEMORAL SHAFT FRACTURES

A SERIES OF 100 CONSECUTIVE PATIENTS

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One hundred and two fractures of the femoral shaft, including eighteen pathological fractures, in 100 patients were internally fixed by closed Küntscher nailing. Sixty-eight fractures resulted from motor vehicle accidents; ten were compound. Seventy-five patients were under the age of thirty years and thirty-four had multiple injuries.

Sixty-nine fractures were nailed on the day of the accident and the operative technique is described. Complications during and after operations were few. Fifty-eight patients left hospital within four weeks and 77 per cent of those working returned to work in less than four months. There were no wound or bone infections.

The results are discussed and it is concluded that, with the correct equipment and careful attention to detail, closed nailing is a straightforward procedure with few complications. Advantages include the wide range of fractures that can be nailed, the short hospitalisation, the rapid return of function to the knee, the early return to work and the absence of infection.

In 1940 Küntscher first described the use of the clover-leaf nail for fixation of fractures of long bones (Küntscher 1940). He used a closed technique with fluoroscopic control. During World War II German surgeons used the technique on a large scale and the results, particularly with femoral shaft fractures, were so impressive that the method rapidly gained popularity throughout the world (Watson-Jones *et al.* 1950; Bick 1968). By 1950 the high incidence of reported complications, such as failure to reduce the fracture, jamming of the nail, splitting of the distal fragment and damage to arteries and nerves, as well as high radiation exposure, prompted leading surgeons in Britain and America to declare that closed nailing was dangerous and that, when intramedullary nailing was indicated, the open method with exposure of the fracture, should be used (Watson-Jones *et al.* 1950).

The development of the mobile x-ray image intensifier with a television monitor, and a fracture table that combines efficient traction with access to the fracture site for the image intensifier, has eliminated the technical difficulties and dangers originally associated with the closed technique. Nevertheless, the potential advantages of closed nailing have not been widely recognised and the technique is practised in relatively few centres. In Dunedin closed Küntscher nailing was introduced in June 1972; it was rapidly accepted by all the surgeons and is now the treatment of choice for fractures in the middle two-quarters of the femoral shaft.

This paper presents the first 100 patients with 102

femoral shaft fractures; the follow-up period ranges from nine months to five years.

CLINICAL MATERIAL

The age range was from thirteen to ninety-two years, but seventy-five patients were under the age of thirty; seventy-one were male and twenty-nine female.

Sixty-eight fractures resulted from motor vehicle accidents, fourteen from other trauma and eighteen were classified as

Table 1. Associated injuries in thirty-five patients

Fracture of tibia	9	Fracture around the ankle	2
Fracture of pelvis	8	Dislocation of hip	1
Fracture/soft tissue injury around the knee	7	Dislocation of shoulder	1
Fractures of forearm	7	Rupture of urethra	1
*Closed head injury	6	Brachial plexus lesion (permanent)	1
Fracture of mandible or maxilla	4	Crushed chest	1
Abdominal injury	3		

*Requiring postponement of operation by at least 24 hours

pathological fractures. The pathological group included ten with senile osteoporosis, five with Paget's disease and three with metastatic carcinoma. Thirty-five patients had fifty-one significant associated injuries; fractures of the tibia, pelvis and patella predominated (Table 1). The presence of other injuries was regarded as a strong indication for early nailing.

Table II. Type and site of fracture

Type		Site	
Transverse	53	Middle third	78
Oblique	17		
Spiral	9	Proximal third	12
Comminuted	23		
Compound	10	Distal third	12

The type of fracture and its site are shown in Table II. The proximal limit for nailing was accepted as the junction of the proximal one-quarter with the distal three-quarters and the distal limit, the junction of the proximal three-quarters with the distal one-quarter.

METHOD

It was decided to aim at very early nailing. In sixty-nine cases the fracture was nailed on the day of injury, and all except one were nailed within fourteen days.

Blood gases are checked before operation and, when the patient is fit enough, the operation is begun. A Marquet table and Philips Portable Image Intensifier are used (Fig. 1). The patient is positioned

Fig. 1

The patient is placed on his side on a Marquet table, with the T-piece through the perineum. The hip of the fractured leg is flexed 90 degrees around the centre post and traction applied through the foot stirrup. The foot itself is placed in neutral rotation, that is parallel to the floor. The mobile image intensification system has complete access to the fracture site.

with the hip on the fractured side flexed around the centre post and with the T-piece in the perineum. Traction is applied through a closely fitting boot connected to a strain gauge and windlass. The uninjured leg is kept out of the way on the special support. Correct positioning is critical. By applying traction, and in some cases direct manipulation, the fracture is reduced and the position checked on the image intensifier in two planes. It is essential to be able to reduce the fracture before incising the skin.

A short incision is made proximal to the tip of the greater trochanter, splitting the glutei to expose the piriform fossa at the base of the femoral neck. The femoral neck is then broached. The proximal

shaft is reamed using solid hand reamers until limited by cortical bone. In fractures of the proximal one-third, the reamer must be advanced into the distal fragment. A guide wire is then introduced and advanced across the fracture; at this stage it may be necessary for an unscrubbed assistant to manipulate the thigh and align the fragments. A nail is threaded over the guide into the proximal fragment; this provides a useful lever for manipulation and facilitates the passage of the guide wire across the fracture. With the guide wire in position the Küntscher nail, which must be the correct length, is advanced across the fracture site. The traction is released and the nail hammered home under radiographic control to ensure correct positioning of the nail in relation to the knee joint.

Because we had decided not to ream cortical bone, the average diameter of the nails we used was only 11 millimetres (range 9–15). Multiple nails were needed in two patients.

Operative complications. In four patients the fracture could not be reduced and open reduction through a small second incision was necessary. In two cases a spike of bone prevented reduction; in the other two muscle was interposed between the bone ends. Early in the series there were problems with unsatisfactory hand reamers which fractured where the cutting head was brazed to the shaft; this was overcome by using solid single-piece reamers.

With faulty reduction the distal fragment may be split while advancing the nail; this occurred once.

Postoperative management. After operation a Thomas's splint was used for seven to ten days during which static quadriceps exercises were encouraged. After release from the splint, more active flexion and extension exercises were begun. Once the patient could bend his knee to a right angle he was allowed to walk using crutches and taking no weight through the injured leg. He was then discharged from hospital. On this regime 58 per cent of patients were home in less than four weeks and 89 per cent were discharged from hospital by six weeks. Most of the remaining patients were those with pathological fractures.

Partial weight-bearing was allowed at six to eight weeks, progressing to full weight-bearing by ten to twelve weeks, by which time there was usually radiological evidence of bony union. In thirteen patients who had either comminuted femoral fractures or an ipsilateral tibial fracture, cast-bracing was used for additional support.

Postoperative complications. In eight patients a clinical diagnosis of fat embolism syndrome was made and was supported by finding a PO_2 of less than 55 millimetres of mercury; all recovered completely. Four patients had non-fatal pulmonary emboli, three developed pneumonia, one urinary retention requiring suprapubic drainage, and one developed a transient palsy of the ulnar nerve. In one patient a 9 millimetre nail bent soon after operation; it was straightened by manipulation under anaesthesia. There were three deaths in hospital all in senile patients with osteoporosis.

RESULTS

Twelve patients had clinically detectable shortening due to the femoral fracture but in only one was this greater than 2.5 centimetres. Five patients had minor rotational deformities, two had marked deformity of lateral rotation (40 degrees) although in neither was this apparent when walking; both these patients had multiple injuries which prevented the use of traction after operation.

Only five patients lacked full flexion of the knee at follow-up; the restriction ranged from 10 to 40 degrees. In all five there had been associated injuries of the knee.

Ninety-one fractures in eighty-nine patients proceeded uneventfully to clinical and radiological union within six months. In three patients union was delayed, but their fractures were united by one year. Two

fractures required bone grafting for non-union at one year and eighteen months respectively; one was in a leg flail from poliomyelitis, the other in a patient with multiple fractures, including a severe head injury. Six patients with pathological fractures died before union was established.

There were no cases of infection, early or late, superficial or deep. Antibiotics were not routinely used either during or after operation.

Fifty-five of the Küntscher nails have so far been removed, because the upper end of the nail was causing minor symptoms. The policy of removing asymptomatic nails varies with the individual surgeon.

Sixty-four of the patients were working before the accident; of these 43 per cent had returned to work by three months and 77 per cent by four months. All but two had returned to work by six months.

In addition to the three deaths in hospital there were five further deaths during the follow-up period. All were in the pathological group and the deaths were unrelated to the operation.

DISCUSSION

As shown in several other series (Gross and Giebink 1967; Böhler 1968; Clawson, Smith and Hansen 1971; Rascher *et al.* 1972; Gherlinzoni, Vasciaves and Murena 1975; Kwan and Ma 1975; Winkquist, Hansen and Clawson 1977) intramedullary nailing of femoral shaft fractures may have distinct advantages over more conventional methods of conservative treatment or over open nailing. It is now established as a safe procedure and the technical requirements and pitfalls are well documented (Küntscher 1967; Böhler 1968; Clawson *et al.* 1971; Rascher *et al.* 1972; Gherlinzoni *et al.* 1975). It must be emphasised that the correct equipment is essential and careful attention to the positioning of the patient on the table is mandatory. The advantages of closed nailing are as follows:

Short hospital stay. The short period of time in hospital, which is a feature of other reports (Gross and Giebink 1967; Rokkanen, Slätis and Vankka 1969; Rascher *et al.* 1972; Gherlinzoni *et al.* 1975) is further supported in the present series. The rapid turnover has made a big difference to the availability of hospital beds as well as having clear economic and social benefits for the patients.

Rapid recovery of knee function. Flexion of the knee to a right angle was required before the patient was allowed up on crutches. The fact that 58 per cent of patients had been discharged within four weeks shows how quickly this range was usually attained. Only five patients, all with associated injuries of the joint, failed to regain full movement. Similar results are less likely after open nailing, because of muscle scarring and adherence to bone (Nichols 1963; Rokkanen *et al.* 1969; Rush 1970; Rascher *et al.* 1972), or after conservative treatment when the knee may become stiff from prolonged

immobilisation (Nichols 1963; Rokkanen *et al.* 1969).

Low risk of infection. This is one of the most important advantages of closed nailing. Reported rates of deep infection for open nailing range from 1 to 11 per cent (Böhler 1951; O'Brien 1963; Dencker 1965; Wickstrom and Corban 1967; Carpenter and Couk 1970; Rush 1970; Miller, Kovacs and Richard 1974). The rates for closed nailing range from 0 to 3 per cent (Gross and Giebink 1967; Böhler 1968; Cloke 1970; Clawson *et al.* 1971; Rascher *et al.* 1972; Gherlinzoni *et al.* 1975; Kwan and Ma 1975; Winkquist *et al.* 1977). Prolonged morbidity, long hospitalisation, multiple operations and often an unsatisfactory final outcome which may include amputation, is the sequence of events all too frequently described in patients with secondary osteomyelitis (Dencker 1965; Wickstrom and Corban 1967; MacAusland 1968; Kostuik 1971; Miller, Kovacs and Richard 1974). Any technique which minimises the risk of

Fig. 2

Fig. 3

Fig. 4

Figure 2—A thirty-six-year-old fireman sustained this grossly comminuted fracture of the left femur in a fall from a ladder. Figures 3 and 4—The appearance one year later. The fracture is soundly united with 1 centimetre of residual shortening. A cast brace was worn for four months following nailing; the patient then returned to light duties, resuming full duties at five months.

Fig. 5

Fig. 6

Fig. 7

Figure 5—A twenty-one-year-old worker in a freezing plant sustained this transverse fracture of the distal shaft when a heavy drum fell on to his leg. Figures 6 and 7—The anteroposterior and lateral radiographic appearance one year later showing the fracture soundly united with no residual shortening. He returned to work at twelve weeks.

infection but retains the advantages of internal fixation deserves close scrutiny.

Stabilisation of a greater variety of fractures. It is widely accepted that mid-shaft transverse or short oblique fractures with a minimum of comminution are those best suited to open Küntscher nailing (Böhler 1951; Küntscher 1965; Wickstrom and Corban 1967; Rokkanen *et al.* 1969). However, this present series (and others) show that adequate fixation can be achieved in a much wider variety of fractures, including comminuted fractures, long spiral or oblique fractures, segmental fractures, and fractures involving the proximal and distal one-thirds of the shaft (Figs. 2 to 9). We believe that this is possible with the closed method because the musculo-periosteal sheath surrounding the femur is left undisturbed and can act as an "external splint".

Other advantages. The surgical incision required is no more than 10 centimetres long and is easily hidden, even under a bikini. The absence of a scar, often an ugly one, is greatly appreciated by younger patients, particularly women.

Open nailing dramatically decreased time lost from work after fractures of the femoral shaft (Nichols 1963; Rokkanen *et al.* 1969). Closed nailing can decrease it still further; this is borne out by other series (Rokkanen *et al.* 1969; Gherlinzoni *et al.* 1975) as well as our own.

Greater stability of the fracture, rapid return of function to the knee and early mobilisation are undoubtedly contributing factors.

Comparison with other closed nailing series

In several respects this series differs from others reporting closed nailing.

Early nailing. The policy established very early in this series was to nail the fracture on the day of injury whenever possible; this applied even to compound fractures. We achieved this objective in sixty-nine patients; other surgeons, including Charnley and Guindy (1961), Lam (1964) and Smith (1964), have reported that union was slower with immediate internal fixation than if it was done a few days later. But in our series, with early fixation, there were only two cases of non-union and three of delayed union. Rush (1970) also found that delaying internal fixation did not significantly improve the rate of fracture union; moreover delay was associated with a higher incidence of infection, a finding reported also by Wickstrom and Corban (1967) and by Miller *et al.* (1974). One advantage of early nailing is that reduction is usually easy, so that skeletal traction or

Fig. 8

Fig. 9

Figure 8—An eighty-five-year-old man with severe osteoarthritis of both hips fell and sustained this long spiral fracture of the proximal shaft. Figure 9—Five months later the fracture is soundly united with 2.5 centimetres of shortening. He began taking weight one week after the accident and is still walking with elbow crutches three and a half years later.

distraction devices (Küntscher 1965; Clawson *et al.* 1971) need not be used. If nailing had to be deferred, then skeletal traction with slight overdistraction of the fragments was employed. This policy of early nailing contributed significantly to shortening the length of hospital stay.

Fig. 10

Fig. 11

Figure 10—A seventy-eight-year-old retired medical practitioner with painful Paget's disease fell and sustained this midshaft transverse fracture of the right femur. Figure 11—Eighteen months later the fracture is soundly united. The bowing is corrected and his bone pain has disappeared.

It is commonly stated that operation should be deferred until the risk of fat embolism syndrome diminishes (Dencker 1965; Küntscher 1965; Gross and Giebink 1967; Wickstrom and Corban 1967; Böhler 1968; Clawson *et al.* 1971; Rascher *et al.* 1972; Gherlinzoni *et al.* 1975) but the 8 per cent incidence of non-fatal cases in this series compares favourably with those that advocate delay. Furthermore we believe that the initial intensive resuscitation of the patient plus the careful monitoring of blood gases after operation are sound prophylactic measures.

Reaming the medullary canal. In this series reaming was used to determine the width of the medullary canal in its narrow segment and a Küntscher nail of the same diameter and of appropriate length was then used for internal fixation. Hence the small average diameter of the nail. Unlike other surgeons (Küntscher 1967; Clawson *et al.* 1971; Rascher *et al.* 1972; Gherlinzoni *et al.* 1975; Winkquist *et al.* 1977) we do not believe it is necessary to ream cortical bone up to a diameter of 14 to 17 millimetres; the possible advantage of more rigid fixation is offset by the higher risk of causing a fracture, particularly of the distal segment (Rascher *et al.* 1972). This view is supported by Böhler (1968), Cloke (1970) and by Kwan and Ma (1975). Furthermore, a cast brace can be used as additional support with unstable fractures.

Pathological fractures. In this series 18 per cent of the fractures were pathological. With such patients nursing and early mobilisation are much easier after internal fixation (Küntscher 1967). It is interesting to note that in two of the patients with Paget's disease, significant correction of the bowing was achieved and bone pain was relieved (Figs. 10 and 11). The high mortality (44 per cent) during the follow-up period is probably inevitable.

CONCLUSION

With modern equipment closed Küntscher nailing has become safer and easier than formerly. With scrupulous attention to details of technique, complications are few.

We believe that the results of this and other series show that closed nailing has distinct advantages over other methods of treatment and therefore deserves serious consideration as the method of choice for treatment of fractures of the femoral shaft.

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