Acta orthop. scand. 44, 323–334, 1973

Surgical Department II and III, Ullevål Hospital, Oslo, Norway.

INTRAMEDULLARY NAILING OF TIBIAL SHAFT FRACTURES

KAARE SOLHEIM & OLAV BØ

Accepted 6.ii.73

For a long time intramedullary nailing has been used in the treatment of shaft fractures. In 1950, Küntscher (1962) introduced reaming of the medullary cavity prior to insertion of the nail – one of the greatest advantages in modern operative fracture treatment. Furthermore, the use of the TV image intensifier has made nailing easier and safer and considerably improved closed nailing.

For tibial shaft fractures, closed nailing has great advantage because accurate reduction is possible without exposing the fracture, thus avoiding compromising further the soft tissues, which may already have been severely damaged at the accident. Rigid fixation is usually achieved, giving the best conditions both for healing of the fracture and the soft tissues.

In our general surgical department intramedullary nailing has been used to an increasing extent, especially after 1967, when we started using the AO instrumentarium. We have reviewed the case histories and x-rays of the patients treated with intramedullary nailing for tibial shaft fractures in the period 1952–71 and performed a clinical and roentgenological follow-up.

MATERIAL AND METHODS

In all, 81 patients (61 males and 20 females) had intramedullary nailing for 85 tibial shaft fractures; 4 patients had bilateral fractures. Younger males predominated but nailing was also performed in older patients (Figure 1). Traffic accidents accounted for about 85 per cent (Table 1); consequently associated injuries were common (73 per cent) (Table 2).

The *fracture types* are summarized in Table 3. The fracture was located in the middle third of the shaft in 65 cases. The majority were comminuted (Figures 2–5) and/or open, but a distinction has to be made between a small puncture wound caused by dislocated fragments penetrating from inside and the larger soft tissues

Table 1. Circumstances of injury.

	No.
Road traffic accidents	69
Accidents at work	4
Sport injuries	4
Others	4
Total	81

Table 2. 91 associated injuries in 60 patients.

Type		No.
Head		40
Thoracic injury		3
Pelvic fracture		5
Fracture of upper limb		8
Fracture of ipsilateral femur		15
Fracture of contralateral lower limb		20
femur	8	
tibia	12	
Total		91

Table 3. Fracture type.

Type		No.
Comminuted		35
Segmental	4	
Transverse	16	
Transverse		28
Oblique		9
Segmental		7
Other		6
Total		85

injury commonly produced by direct trauma. Of the 35 open fractures, 18 were open through puncture wounds and 17 had larger wounds.

The *treatment* is summarized in Table 4. As a routine, the patients are operated upon under general or epidural anaesthesia, preferably on a traction table with the

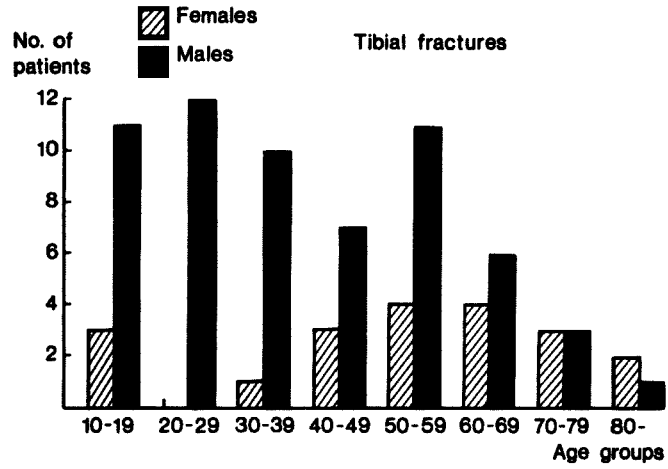

Figure 1. Distribution by age and sex.

knee flexed to 90° or more. A small skin incision is made slightly proximal to the tibial tuberosity. With an awl a hole is made in the cortex and the first part of the canal is made. Thereupon the guide wire is introduced under visual control by the TV image intensifier. Most fractures are easily reduced by traction and manipulation. Reaming is thought essential. When the nail has been driven home, traction is released and a few heavy but considerate blows will impact the fragments. Vacuum drainage is sometimes used. The leg is elevated on a frame for 2–3 days. After this time the patient may start active exercises and is up and around on crutches in 4–5 days. In stable transverse fractures, weight bearing is allowed after 2 weeks.

The treatment of choice is primary nailing, e.g. within 8 hours. This was performed in 22 patients, 6 of whom had open fractures. In patients with multiple injuries, the tibial fracture was deemed of secondary priority and skeletal traction or plaster applied. The same applies to most of the open fractures. Among the patients primarily treated by traction, many were nailed within one week of the accident and all within 4 weeks. In patients primarily treated with plaster, nailing was postponed for periods varying from 2 weeks to 5 months. In 8 patients other types of osteosynthesis (e.g. plates, Parham's band, etc.) had primarily been performed up to 2 years previously.

Open nailing was performed in 25 cases and in 6 of these supplementary cerclage was found necessary because of butterfly fragments. In later years closed nailing has been preferred. Reaming was done in 71 fractures but was not performed in some cases from the earlier part of the period, nor was this always done in segmental fractures. In 23 patients a post-operative plaster was applied, either because the osteosynthesis was not deemed exercise stable or the patient deemed non-cooperative (chronic alcoholics, etc.). In about 10 per cent of the cases the osteosynthesis was deemed rigid enough to allow primary weight bearing (e.g. transverse fractures after 2 weeks). Among the other patients full weight bearing was allowed within a mean of 4 months after the operation.

Figure 2. Male, aged 26 years, run over by his own car. (a) Typical comminuted fracture with butterfly fragment, caused by direct trauma. (b) Six weeks after nailing.

Complications are listed in Table 5. There were 3 deaths, 2 from head injury and one from pulmonary embolism. Among *operative* complications, comminution predominated, either during the reaming or the hammering of the nail. In no case was the healing of the fracture impaired. We included smaller fragmentation and only one case of larger fragmentation was encountered. Penetration of the guide wire and locking of the same was uncommon and had no harmful effect. All these complications are avoided by adhering to a strict technique and by using adequate instrumentarium.

Postoperative complications were similar to those that may occur after any operative procedure and were not particular numerous. No case of deep infection was encountered.

Re-operation was found necessary in 9 patients (Table 6), mostly in the earlier part of the period. Re-nailing was the usual procedure, in most cases because too thin a nail had primarily been inserted. In some of these patients reaming had not

Figure 3. Male, aged 20 years, injured in a car accident. (a) Typical transverse fracture with small butterfly fragment, caused by direct trauma. (b) Eight months after nailing.

been performed as mentioned above (in the first part of the period, in some segmental fractures, etc.). Two cases of non-union occurred: (1) A comminuted, open severely displaced fracture had been nailed with a V-formed nail without reaming. The fixation was supplemented by 2 Parham's bands and a plaster; re-nailed with reaming 9 months later. (2) A severely comminuted segmental fracture was nailed and 2 wires and plaster also used; 20 months later re-operation with a sliding graft without removal of the nail. Both fractures healed. One patient was re-nailed because of a refracture after premature removal of the primary nail.

Follow-up

Of the 78 patients, 2 could not be traced. The remaining 76 patients were followed up clinically and roentgenologically with a mean observation period of 2½ years

Figure 4. Male, aged 60 years. A rolling stone hit his leg. (a) Direct trauma caused a comminuted fracture with butterfly fragment. (b) Primary nailing. (c) Sixteen months after nailing.

(range, 8 months to 19 years). The results are summarized in Table 7. Only one patient had a lasting poor result: the above-mentioned patient who was renailed due to nonunion; healing occurred but stiffness and pain incapacitated him. One patient with re-fracture and one with a varus deformity had an uneventful healing and ultimately good result after re-nailing.

DISCUSSION

The present series indicates that intramedullary nailing after reaming is the treatment of choice in selected tibial shaft fractures. Although the series comprised a 20-year period and the osteosynthesis had been performed by several surgeons, many of whom were in their surgical training period, the overall results were excellent. The majority of the fractures were of the "severe" type, e.g. comminuted and/or open, caused by heavy direct trauma and often associated with severe soft tissue injury. These fractures have a bad reputation and rightly so,

Figure 5. Male, aged 16 years, crashed on motorcycle with a lorry. (a) Severely displaced fracture caused by direct trauma. (b) Eleven months after nailing. The fracture healed in spite of the use of too thin and too short a nail. Note abundant callus formation.

because of a prolonged healing time and a high incidence of complications.

Furthermore, in this series a standardized technique and a perfectionized instrumentarium have not been used until the last few years. Our results nevertheless compare favourably with the best reports available from the last years (Tscherne et al. 1967, Zimmermann 1967, Lemaire & Poucet 1968, Decoulx et al. 1969, Marty 1969, Arzinger & Riedeberger 1969, Zucman & Maurer 1969, Lemaire 1969, Kempf et al. 1970, Bombart et al. 1970, Schwingt et al. 1969, Hamza et al. 1971).

Table 4. Primary treatment.

Primary treatment	No.
Skeletal traction	46
Intramedullary nailing	22
Plaster	9
Other osteosyntheses	8
Total	85

Table 5. Complications.

Complication		No.
Operative		10
Comminution	8	
Penetration of guide wire	1	
Locking of guide wire	1	
Postoperative		12
Local		
Wound infection	3	
Wound hematoma	2	
Leg thrombosis	2	
General		
Serum hepatitis	1	
Bronchopneumonia	1	
Pulmonary embolism	3	
Total		22

Table 6. Re-operations.

Type		No.
Re-nailing		8
Nail too thin	5	
Non-union	1	
Varus malunion	1	
Re-fracture (original nail removed too early)	1	
Sliding graft operation		1
Total		9

Table 7. Follow-up results.

Evaluation	No. of patients
Good (healing in normal alignment, no symptoms or signs)	67
Fair (slight symptoms or signs, not incapacitated for work or everyday life	6
Poor (non-union, marked deformity, incapacitated for work or everyday life	3
Total	76

Although admirable results may be achieved with intramedullary nailing of tibial shaft fractures without reaming (Zucman & Maurer 1970) and with supplementary plaster immobilization, we prefer nailing after reaming, in accordance with the present-day technique elaborated by Küntscher (1962). In most cases, this will secure an absolute rigid immobilization of the fracture, thus making plaster superfluous. The patient then gains the enormous advantage of being able to exercise his muscles and joints while the fracture heals. Furthermore, reaming will markedly diminish or even abolish the risk of comminution of the bone when the nail is hammered home, and also eliminates the complication of jamming the nail. In addition, a most important point is that the reaming will make it possible to use a *thick* nail which will prevent bending and thereby counteract malunion. This was stressed by Küntscher (1962) and again by Böttger et al. (1970).

Reaming may not always be advisable in segmental fractures, as it may result in rotation or twisting of intermediate fragments, thus depriving them of their blood supply. These fractures are also difficult to treat with closed methods, and even operative procedures are liable to a high frequency of complications, i.e. when using plates, screws, wires, and Parham's bands. In such cases a thin intramedullary nail may be used, in some cases supplemented by plaster (Figure 6). Zucman & Maurer (1969) claim good results with this method. Re-nailing with reaming after 6–8 weeks may be considered.

The discussion whether to perform the osteosynthesis primarily or secondarily, i.e. after healing of the skin wound, has not yet been settled. Many authors now strongly recommend primary nailing of open fractures and claim excellent results (Staudacher 1962, Tscherne et al. 1967, Decoulx et al. 1969, Scheuba 1969, Arzinger & Riedeberger

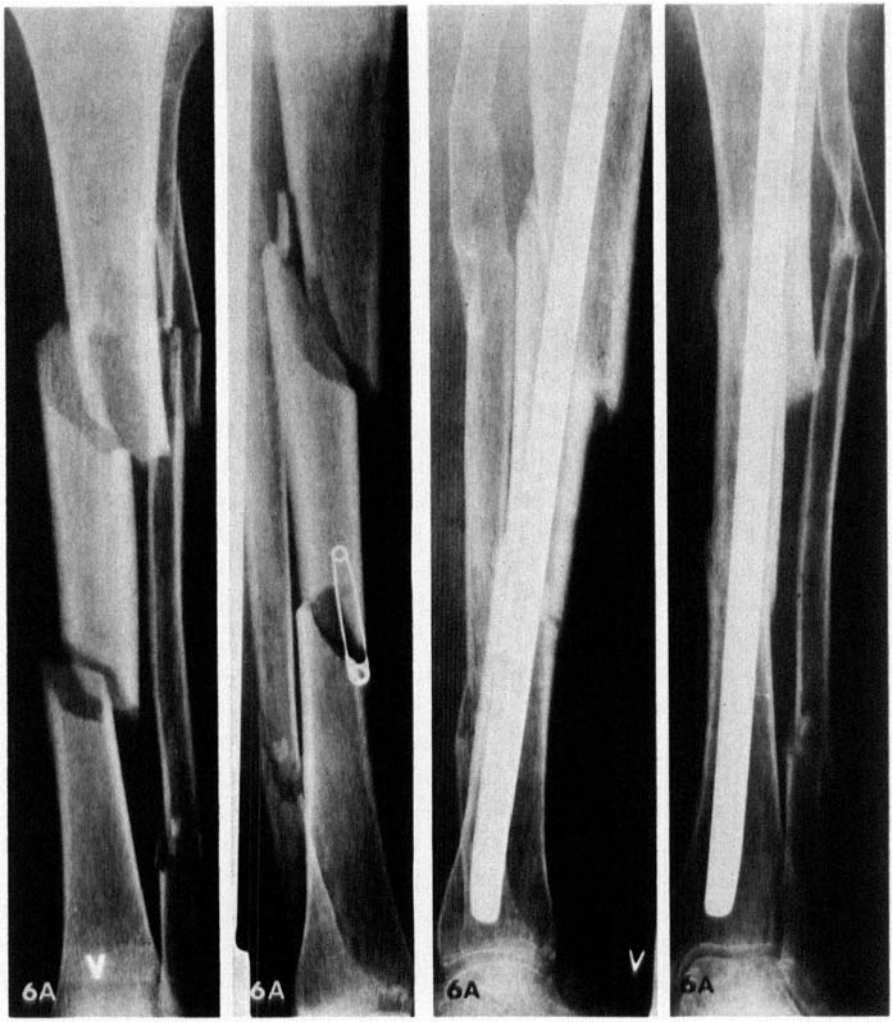

Figure 6. Female, aged 69 years, pedestrian knocked down by a car. Cerebral contusion. (a) Segmental fracture caused by direct trauma with severe soft tissue injury. Closed nailing without reaming; plaster. (b) Full weight bearing allowed after 3 months.

1969). We have previously resorted mostly to secondary nailing in open fractures, but probably primary nailing should be more commonly used if performed within 6–8 hours of the accident. The rigid fixation of the fracture fragments will also accelerate the healing of the soft tissue injury. In addition, it must be stressed that 90 per cent of the micro-

organisms found in open infected fractures are hospital bacteria which invade the wound from ambulance personnel, nurses, doctors and *not* organisms found primarily in the contaminated wound (Arzinger & Riedeberger 1969). This fact underlines the necessity of treating open fractures according to the strictest aseptic rules, i.e. the wound should be covered with a sterile dressing at the scene of the accident and not removed until the patient is in the operating theatre.

SUMMARY

The good results of intramedullary nailing of tibial shaft fractures are illustrated in a series of 81 patients who were either primarily or secondarily nailed. Reaming was performed in most cases. A rigid fixation was secured in most patients.

At the follow-up of 76 patients, the results were good or fair in 96 per cent. In addition, 2 patients had a good result after re-nailing; only one patient had a poor functional end result.

REFERENCES

Arzinger, H. & Riedeberger, J. (1969) Die primäre Versorgung offener Unterschenkelschaftfrakturen. *Zbl. Chir.* **94**, 217–223.

Bombart, M., Decoulx, J., Dubousset, J., Kempf, I. & Zucman, J. (1970) Enclouage à foyer fermé des diaphyses tibiales et fémorales. *Rev. Chir. orthop.* **56**, 775–786.

Böttger, G., Strik, W. & Mahmoudi, J. (1967) Über osteosynthesebedingte Achsenfehlstellungen bei der versorgung von Unterschenkelbrüchen durch Küntschernagelung. *Mschr. Unfallheilk.* **70**, 337–345.

Decoulx, P., Decoulx, J. & Duquennoy, A. (1969) Present day treatment of open fractures of tibial shaft. *Wiederherstellungschir. u. Traum.* **11**, 104–117.

Hamza, K. N., Dunkerley, G. E. & Murray, C. M. M. (1971) Fractures of the tibia. *J. Bone Jt Surg.* **53**-B, 696–700.

Kempf, I., Gonzalo-Vivar, F., Copin, G. & Jaeck, D. (1970) L'enclouage centro-médullaire avec ou sans alesage: traitement de choix des fractures récentes diaphysaires ouvertes et fermées de jambe—incidences de ce traitement sur la durée et la qualité de la consolidation osseuse. *Ann. Chir.* **24**, 303–309.

Küntscher, G. (1962) *Praxis der Marknagelung.* Friedrich-Karl Schattauer-Verlag, Stuttgart.

Lemaire, R. (1969) L'enclouage médullaire dans le traitement des fractures diaphysaires récentes du tibia. *Acta chir. belg.* **68**, 31–56.

Lemaire, R. & Poucet, C. (1968) L'enclouage médullaire dans les fractures ouvertes et les pseudarthroses du tibia. *Rev. Méd. (Paris)* **23**, 737–743.

Marty, A. (1969) Zur geschlossenen Marknagelung der Unterschenkelfrakturen. *Helv. chir. Acta* **36**, 136–139.

Scheuba, G. (1969) Zur primären Marknagelung der offener Unterschenkelfraktur. *Mschr. Unfallheilk.* **72**, 252–259.

Schwingt, E., Weill, D., Otteni, F. & Katzner, M. (1969) Le traitement des fractures diaphysaires du tibia d l'adulte par la méthode de Küntscher. *J. Chir. (Paris)* **97**, 351–368.

Staudacher, F. X. (1962) Die primäre Marknagelung offener Unterschenkelfrakturen. *Chir. Praxis* **6**, 509–520.

Tscherne, H., Magerl, F. & Feischl, P. (1967) Die Marknagelung frischer offener und geschlossener Unterschenkelfrakturen. *Langenbecks Arch. klin. Chir.* **317**, 209–218.

Zimmermann, H. (1967) Beitrag zur offener und geschlossenen Marknagelung von Unterschenkelschaftfrakturen. *Arch. orthop. Unfall-Chir.* **62**, 205–224.

Zucman, J. & Maurer, P. (1969) Two-level fractures of the tibia. *J. Bone Jt Surg.* **51**-B, 686–693.

Zucman, J. & Maurer, P. (1970) Primary medullary nailing of the tibia for fractures of the shaft in adults. *Injury* **2**, 84–92.

Correspondence to:

Dr. Kaare Solheim
Sentralsjukehuset
3700 Skien
Norway