

THE USE OF ENDER NAILS IN TIBIAL SHAFT FRACTURES

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The results of 31 fractures of the tibial shaft treated with closed Ender nailing and early weight-bearing are reported. Twenty-five of these fractures were closed and six open. All fractures united between 6 and 16 weeks after operation. No case of deep wound infection was encountered. Comminuted fractures of the proximal and distal third were prone to angular deformities and needed cast protection post-operatively. Nail reinsertion became necessary in two patients. Delay of operation renders closed reduction very difficult.

The advantages of this method are: 1) normal knee and ankle movements are possible during healing and 2) there is a relatively rapid restoration of bone continuity.

Key words: fracture; fixation; tibia

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The evaluation of methods of fracture treatment has been based mainly on the results of union and complications, ignoring how acceptable the method is to the patient, who has to endure a disability as long as the treatment lasts and for a considerable time thereafter (Önnerfält 1978).

Cast immobilization often results in joint stiffness and circulatory disturbances. A high rate of complications following open methods are repeatedly encountered in everyday practice and in the literature. Hopes that the problem had found its solution with rigid compression fixation have not been fulfilled (Bradley et al. 1979).

In recent years the good results of closed plaster treatment and early weight-bearing, presented by Dehne et al. (1961), Brown & Urban (1969) and Sarmiento (1967), stress the importance of functional treatment in tibial shaft fractures (Burkhalter & Protzman 1975).

The purpose of our paper is to present the results of functional treatment (intramedullary Ender nail fixation and early weight-bearing) of 31 fractures of the tibial shaft.

MATERIAL AND METHODS

In order to ascertain how stable the reduction of the fracture site is after Ender nailing we tested the method on tibiae from cadavers. We created ten experimental models with transverse, oblique and short oblique fractures of the tibial shaft.

The reduction of the fracture was secured with the intramedullary insertion of two Ender nails, one on each side of the tibial tuberosity.

The tibiae were fixed at both ends in epoxy resin and subjected to compressional and rotational forces with an Instron machine and an M.A.N.S. apparatus, respectively.

It was observed that during compression with forces averaging 2046.26 N an audible crack was produced suggesting breakage of the cortex without significant disturbance of bone alignment.

When rotational forces were applied (up to 0.8 kg) a rotational deformity of 45° was produced but when the force was released the fragments returned to their original position. It is assumed that fractures of the proximal and distal third of the tibial shaft are less stable because the fracture site is between two points of fixation of the Ender nails and not three, as in the fracture of the middle third (Figure 1).

During an 8-month period from January 1979, 30 patients with 31 tibial shaft fractures were admitted to our Department and treated by this method.

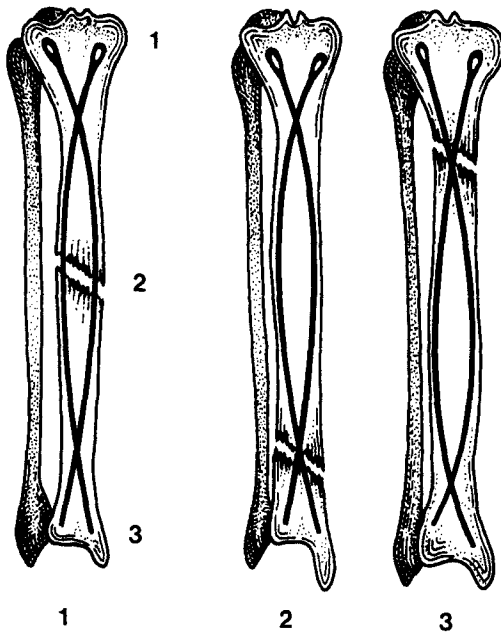


Figure 1. The stability of the fracture is enhanced when it is included between the three points of fixation of the Ender nails.

Prior to the operation the length of the appropriate Ender nail is estimated by measuring the distance from a point 2 cm proximal to the tibial tuberosity down to the tip of the medial malleolus, on the intact leg. The nailing is usually performed by two surgeons. One keeps the fracture reduced by manipulation and traction while the other drives the nails across the fracture site, one at a time.

Two oblique skin incisions, 2 cm long are made on both sides of the tibial tuberosity down to the tibial cortex. The cortex is perforated with an awl. After insertion of the first nail the fracture is tested for stability and X-rays are taken. When both nails are secured in a good position (usually after two or three attempts) the

wounds are closed and a below-knee plaster splint is applied.

The mean operative time using the conventional X-ray method is 40 minutes. The average interval between the injury and the operation is 6 days and after admission 4 days.

Twenty-two patients were males and eight females. Their ages ranged from 15 to 73 years (average 37 years).

For our classification we used Edward's 1965 anatomical and etiological parameters.

A) Anatomical parameters

I) *Location*. There were 3 fractures in the proximal third, 21 in the midshaft, 5 in the distal third and 2 double fractures.

II) *Pattern*. There were 20 transverse fractures (9 simple transverse, 4 short oblique, 5 comminuted, 2 double fractures) (Önnerfält 1978) (Table 1).

III) *Displacement*. There were 26 displaced and 5 undisplaced fractures.

IV) *Soft tissue injury*. There were, according to Ellis' definition (Ellis 1956), 5 minor compound injuries and 1 major compound injury.

B) Etiological parameters

Of these the most important is the nature of the breaking forces defined as high energy and low energy violence.

The correlation between the anatomical and etiological parameters is demonstrated in Tables 2-7 (Edwards 1965, Önnerfält 1978).

Patients with minor compound injuries included in this study had initially the usual surgical debridement, followed by application of a long-leg plaster splint. The fracture was nailed after the wound healed.

Stitches and splint were removed at 2 weeks post-operatively. Next day the patients were allowed to walk with crutches, bear as much weight as they could tolerate and return home. Thereafter the fracture was

Table 1. Classification of fractures

Type of fracture	Closed	Open	Proximal	Mid Shaft	Distal
Transverse	7	2	—	9	—
Oblique	4	1	2	2	1
Short oblique	3	1	1	3	—
Comminuted	3	2	—	4	1
Spiral	6	—	—	3	3
Double	2	—	—	—	—
Total	25	6	3	21	5

Table 2. Anatomical classification of fractures of the shaft of the tibia

Anatomic classification	No.
Displaced longitudinal closed	7
Displaced longitudinal open	
Undisplaced longitudinal open	
Undisplaced longitudinal closed	4
Displaced transverse closed	13
Displaced transverse open	6
Undisplaced transverse open	
Undisplaced transverse closed	1
Total	31

Table 3. Cause of injury in 31 tibial fractures

	No.
<i>High energy violence</i>	
Traffic accidents	
Pedestrian	10
Motorcyclist	3
Cyclist in collision with a car	2
Car passenger	1
Fall from a height of more than 3 metres	3
Blow from a heavy object	1
Total	20
<i>Low energy violence</i>	
Fall at ground level or from a low height	8
Sport (soccer) injury	1
Single bicycle accident	2
Total	11

checked for union at monthly intervals in the outpatient clinic. In comminuted fractures of the proximal and distal third the patients were fitted with a patella tendon-bearing cast for 1 month.

Four compound and two closed fractures were submitted to open reduction, because for various reasons the operation had been delayed more than 10 days, rendering reduction by the closed method impossible.

RESULTS

The results are evaluated as regards the time until union of the fracture and the postoperative complications.

The patients in our series were followed for a period ranging from 9 to 13 months postoperatively, average 10 months.

Six patients showed union at the fracture site between 6 and 8 weeks after operation, 13 between 8 and 12 weeks and 10 between 12 and 16 weeks. The average healing time is 14 weeks (Figure 2).

The criteria used for fracture healing referred to radiological maturity of the callus and obliteration of the fracture line in at least three quarters of the bone circumference (Figure 3).

The general and local complications are listed in Table 8. Superficial infection occurred in two cases following open reduction of the fracture. They developed redness of the wound edges, swelling and mild fever without discharge. The infection cleared with antibiotics 1 week after the operation. No case of deep wound infection was encountered. Pulmonary embolism occurred in one case 20 days postoperatively.

Valgus angulation was observed in patients with comminuted fractures of the distal third of the tibia, while posterior angulation was observed

Table 4. Cause of injury related to classification of the fractures

	Trans-verse	Longi-tudinal
<i>High energy violence</i>		
Traffic accidents		
Pedestrian	9	1
Motorcyclist	3	
Cyclist in collision with a car	1	1
Car passenger	1	
Fall from a height of more than 3 metres	2	1
Blow from a heavy object	1	
Total	17	3
<i>Low energy violence</i>		
Fall at ground level or from a low height	2	6
Soccer injury		1
Single bicycle accident	1	1
Total	20	11

Table 5. Cause of injury and further classification of the transverse fractures

	Transverse	Short oblique	Comminuted	Double
<i>High energy violence</i>				
Traffic accidents				
Pedestrian	5	1	2	1
Motorcyclist	1	2		
Cyclist in collision with a car	1			
Car passenger		1		
Fall from a height of more than 3 metres			1	1
Blow from a heavy object				
Total	7	4	3	2
<i>Low energy violence</i>				
Fall at ground level or from a low height	1	1		
Soccer injury				
Single bicycle accident		1		
Total	8	6	3	2

Table 6. Size of the wound associated with transverse fractures related to the cause of injury

	Minor compound injuries No.	Major compound injuries No.
Pedestrian	2	
Motorcyclist	2	
Car passenger	1	
Cyclist in collision with a car		1
Total	5	1

in one patient with a big butterfly fragment on the anterior aspect of the fracture site (Figure 4).

In two patients we tried to reduce the fracture with fixed traction on the orthopedic table. These patients developed rotational deformity. Probably, the deformity existed before the insertion of the nails and became permanent afterwards.

Reoperation became necessary in one patient. The nail was replaced with a shorter one because of penetration of the distal articular surface of the tibia.

All patients had minor discomfort in the knee joint especially when climbing stairs but normal

knee movements were not affected as a result of the discomfort.

Two patients had stiffness of the ankle joint.

DISCUSSION

Laurin et al. (1963) and Bradley et al. (1979) in a recent experimental study concluded that mechanical stimulation (stress and movement) at the fracture site is beneficial to the healing process.

McKibbin (1978) emphasized that the external callus provides rapid restoration of continuity and strength to a fractured diaphysis. A certain amount of motion at the fracture site is required for the formation of this external callus. These

Table 7. Cause of injury in high energy transverse compound fractures (all compound fractures were transverse)

	Simple transverse	Short oblique	Comminuted
Pedestrian	1		1
Motorcyclist			2
Car passenger		1	

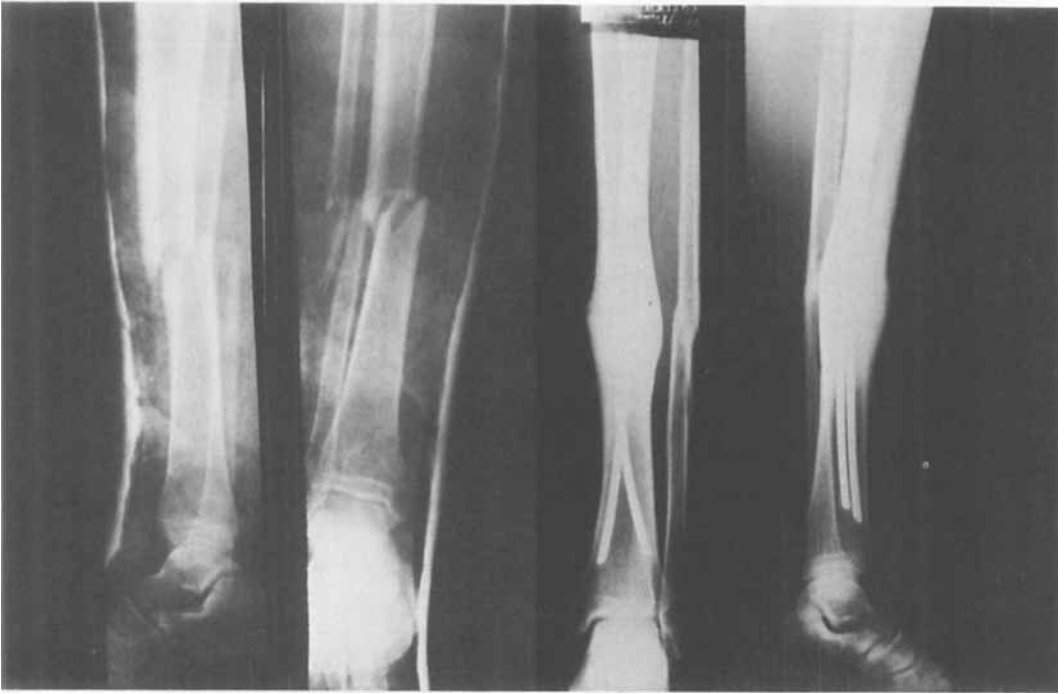


Figure 2. A transverse fracture before and 3 months after Ender nailing.

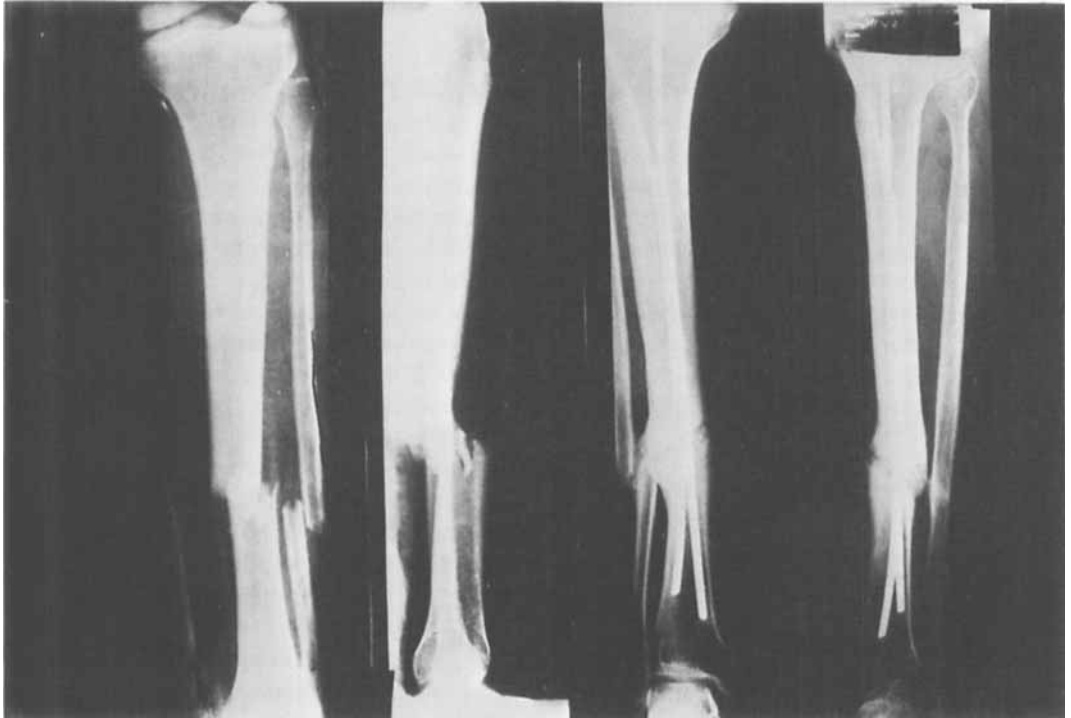


Figure 3. A tibial fracture before and 2 1/2 months after Ender nailing.

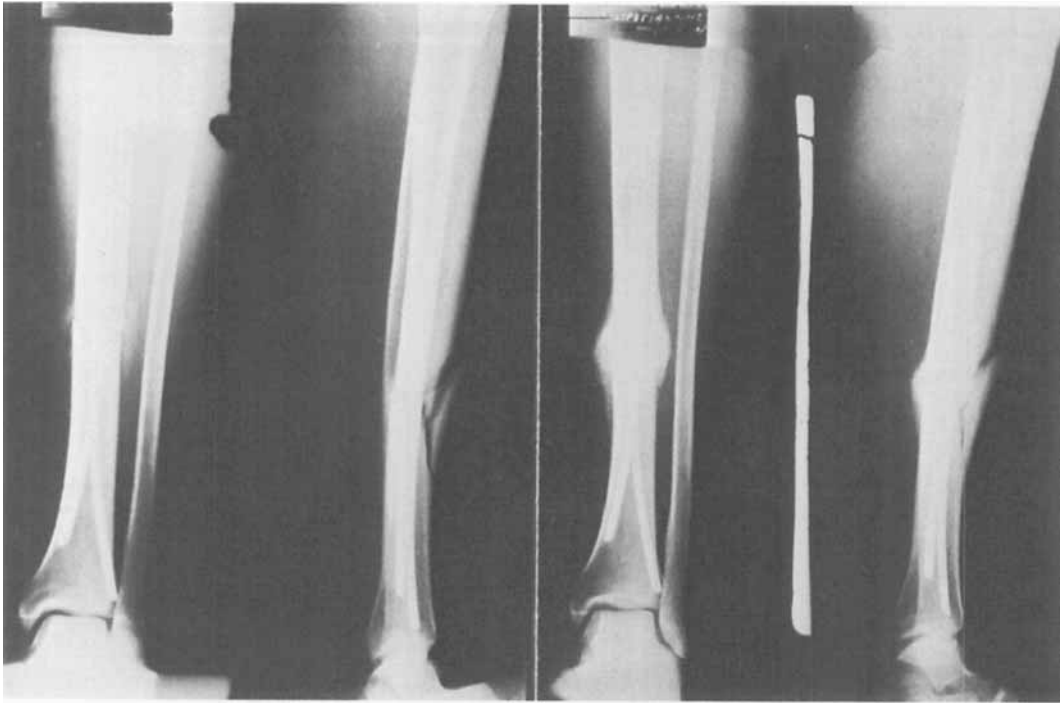


Figure 4. The large butterfly fragment is responsible for the development of a few degrees of posterior angulation of the fracture.

beneficial factors for the healing of tibial shaft fractures are enhanced by Ender nailing and were responsible for the early fracture healing observed in our series, where all fractures healed within 20 weeks. This can be compared with the figures given for fracture healing in the series of Van Der Linden & Larsson (1979).

The nails allow for a dynamic controlled motion at the fracture site which is probably responsible for the early formation of callus. In some of our cases callus appeared as early as 2 weeks after

operation. The method requires no reaming of the medullary canal. Further stripping of the periosteum or muscle attachments is avoided. This results in minimal damage to the capillary bed and possibly favors increased blood flow essential for calcium delivery in the region of a healing fracture (Hughes et al. 1979).

How important the intact periosteum and muscular attachments are for fracture healing was obvious in the six cases of our series undergoing open reduction. Despite minimal interference with soft tissues, all fractures failed to show callus formation on the anterior aspect of the fracture site where the incision was placed.

Comminuted fractures of the proximal and distal third of the tibia are prone to angular deformity during weight-bearing, because stability is not secured by this method. These fractures need plaster protection and we recommend application of a P.T.B. cast for at least 1 month after operation. The rest of the fractures in our experience are sufficiently stable and do not require

Table 8. General and local postoperative complications

<i>General</i>		
Superficial infection		2
Pulmonary embolism		1
<i>Local</i>		
Valgus angulation	<10°	2
Posterior angulation	<10°	1
Rotational deformity	15°	2

plaster support postoperatively. No case of tibial shortening was noticed.

The practical advantage of the method described is the possibility of normal knee and ankle movements during healing, and thus greater comfort for the patient. Even in cases requiring a P.T.B. plaster the mobile knee is of great importance to the patient, allowing him to carry out his activities of daily living without difficulty. Also weight-bearing is an important factor causing impaction of the fragments without loss of alignment, promoting early union.

In conclusion the method described is recommended for all types of diaphyseal fractures of the tibia. The advantages of the method are: 1) The relatively rapid restoration of bone continuity, 2) The minimal number of postoperative complications and 3) The maintenance of almost normal limb function during the period of treatment.

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