134 tibial shaft fractures managed with the Dynamic Axial Fixator

Roger G Checketts[1], Christopher G Moran[2] and Andrew G Jennings[1]

We have reviewed the results of 134 tibial shaft fractures treated with the Dynamic Axial Fixator. In 86 closed fractures, the average union time was 4 months. 76 fractures had united by 5 months; delayed union occurred in 7 cases. 3 closed fractures failed to unite.

In 48 open fractures, the union time was related to the severity of soft tissue trauma. The average union time was 5 months for grade II and 6 months for grade III open fractures. 33 open fractures had united by 5 months and delayed union occurred in 11 fractures. 4 open fractures failed to unite.

The commonest complication was minor pin site infection, which was seen in 34 percent. These responded rapidly to treatment and external fixation continued. Major pin site infections were uncommon (5 percent) and none led to any serious sequelae. We have found the Dynamic Axial Fixator a safe and reliable device for treating fractures of the tibial shaft.

[1]Department of Orthopaedics, Sunderland General Hospital, Kayll Road, Sunderland SR4 7TP, [2]Freeman Hospital, Newcastle-upon-Tyne, U.K. Tel +44 91-5656256. Fax -5653973
Submitted 94-02-20. Accepted 94-12-23

The treatment of tibial shaft fractures remains controversial. External fixation is now widely used for the management of open fractures (Edwards et al. 1988, Bach and Hansen 1989), and has been advocated also for the treatment of closed injuries (Burny 1979). The major problems associated with external fixation are pin-related infections and non-union, particularly with rigid frame configurations (Austin 1977). The Dynamic Axial Fixator (Orthofix Srl, Bussolengo, Italy) is a single-bar device with a telescoping facility to allow conversion from rigid to dynamic fixation. Dynamization allows increased axial movement at the fracture site in the hope of promoting external bridging callus (McKibbin 1978). There are few reports on the use of the Dynamic Axial Fixator. We have reviewed our experience in treating tibial shaft fractures by this method.

Patients and methods

We used the Dynamic Axial Fixator (DAF) to treat a consecutive series of 134 adult, tibial shaft fractures. The mean age of the patients was 43 (16–89) years; there were 95 men and 39 women with a bimodal age/sex distribution; 2 male patients had bilateral fractures. The tibial shaft fractures were all displaced sufficiently to require reduction under anesthesia and 84 percent were in the middle and distal thirds. The injury was closed in 86 cases and open in 48. The open fractures were graded using the classification of Gustilo and Anderson (1976). 42 patients had a simple fracture configuration, while 92 had significant comminution. The classification of Winquist et al. (1984) (Table 1) was adopted to grade these fractures (Table 2).

The majority (72 percent) of closed fractures were due to low energy trauma, such as sports injuries or simple falls. In contrast, 82 percent of open fractures were the result of high energy trauma from road traffic accidents or industrial injury.

Open fractures were extensively debrided and the external fixator was applied within 6 h of injury. All patients received a prophylactic, third-generation cephalosporin. The wounds were left open and delayed primary closure, or skin grafting, was usually performed between 24 and 72 hours.

Table 1. Classification of fracture comminution (Winquist et al. 1984)

Grade	
I	Minimal comminution
II	Butterfly fragment, > 50% cortex intact
III	Butterfly fragment, rotational instability
IV	Gross comminution, rotational and longitudinal instability

Table 2. Fracture type

			Grade of comminution [a]				
		Simple	I	II	III	IV	Total
Closed		32	18	21	10	5	86
Open [b]	Grade I	0	6	0	0	0	6
	Grade II	10	2	4	6	2	24
	Grade III	0	2	0	11	5	18
Total		42	28	25	2	12	134

[a] Winquist et al. 1984
[b] Gustilo and Anderson 1976

Table 3. Cumulative union rate, number and *percentages*

Months after fract.	Closed fractures n 86		Open fractures n 48		Total	
3	15	*17*	3	*6*	18	*13*
4	54	*63*	17	*35*	71	*53*
5	76	*88*	33	*69*	109	*81*
6	76	*88*	34	*71*	109	*81*
7	76	*88*	34	*71*	109	*81*
8	78	*91*	36	*75*	114	*85*
9	80	*93*	39	*81*	119	*89*
10	83	*97*	44	*92*	127	*95*

When adequate soft tissue cover was established, the treatment regimens were similar for both open and closed fractures. Partial weight bearing was encouraged after 48 h and intensive physiotherapy commenced.

Patients were discharged home once they had obtained a full range of knee and ankle movement; outpatient physiotherapy was not necessary. Full weight bearing was allowed as soon as the patient felt comfortable. The fixator was dynamized when callus appeared on the radiographs (average 2 months). A fracture was considered united when there was clinical and radiographic evidence of union allowing removal of the fixator and full, unprotected weight bearing. Delayed union was defined as a fracture that had failed to unite within 5 months. Non-union was defined as a fracture that had not united by 10 months.

Results

Union

Closed fractures. There were 86 closed fractures. The average union time was 4 months; 76 fractures had united by 5 months (Table 3) and delayed union occurred in 7 cases. There were only 3 non-unions. The union time was similar for all fracture sites and was related to the severity of the bony injury: simple closed fractures united at an average of 3.5 months. All 7 patients with delayed union had severe comminution of the fracture.

Open fractures. There were 48 open fractures. The union time was related to the severity of soft tissue trauma (Table 3). The average union time was 5 months for grade II and 6 months for grade III open fractures. 33 open fractures had united by 5 months (Table 3); delayed union occurred in 11 fractures. 4 patients developed non-union. 9 of the delayed unions had grade III open fractures with severe comminution. No patient developed deep infection at the fracture site.

Nonunion

Nonunion occurred in 7 patients. 2 of these were women over 80 years of age, who had been struck by motor vehicles. One patient sustained a simple closed fracture, whilse the second had a grade III open fracture. In both cases the fixators were removed and treatment delayed for 1 month until the pin sites had healed completely.

Rigid internal fixation was performed using AO plates with autogenous bone graft. The fractures have united without complications. In the other 5 cases, when it became clear from the radiographs that union was not proceeding, Phemister bone grafting was performed with the fixators in position. In each case, union then occurred and the fixators were finally removed when consolidation was judged to be complete.

Pin-site infection

Minor infections. These are infections that settle with local treatment plus or minus antibiotics. They respond rapidly and external fixation can then continue.

A total of 530 fixator pins were used. Discharge from the pin site, which required treatment with antibiotics, was seen with 182 pins (34 percent). Bacterial culture was positive for Staphylococcus aureus in 32 cases and ß-hemolytic streptococci in 2 cases. Only 1 patient required repositioning of the pins for persistent infection.

Major infections. These are severe infections, usually concerning more than one pin, sometimes affecting both soft tissue and bone, that fail to settle with appropriate treatment. External fixation has to be abandoned.

Only 1 patient, an 89-year-old man, had persistent pin-site infections that required removal of the fixa-

tor. Following this, the infections settled: the fracture was managed in a cast brace and united without further complications.

8 patients had continued discharge from a single pin-site after removal of the fixator. Radiographs demonstrated ring sequestra in 6; the discharge stopped after a simple curettage under a general anesthetic.

Refracture

Refracture occurred in 1 patient who was playing football within 24 h of fixator removal. A fixator was re-applied and the fracture united without complications after a further 3.5 months.

Malunion

Angulation of more than 10 degrees was observed only in 8 patients (6 percent). A review of the radiographs demonstrated that the fractures had not been adequately reduced at the time the fixator was applied. These malunions are considered to be errors in surgical technique. No patient has reported any functional problems associated with the malunion. In no case has a corrective osteotomy been required.

Discussion

External fixation is now commonly used for the management of complex, open fractures of the tibia. The development of single-bar fixators (Burny 1979, De Bastiani et al. 1984) allows for easier application and better patient acceptance, thus extending its use to simple, closed fractures. We have found the Dynamic Axial Fixator a safe and effective device for managing tibial shaft fractures. Our results compare favorably with other forms of treatment, including internal fixation (Reudi et al. 1976) and non-operative management (Nicoll 1964). Oni et al. (1988) have recently reported delayed union in 18 percent of closed tibial shaft fractures treated in a plaster cast.

Patients with open tibial fractures have a worse prognosis, particularly if there is severe soft tissue injury (Gustilo et al. 1984). Our experience using the Dynamic Axial Fixator has been similar to that of Melendez and Colon (1989). Again, our results are similar to other forms of operative (Clifford et al. 1988) and nonoperative (Nicoll 1964) treatment and probably reflect the nature of the injury rather than the method of management.

Wounds were closed as a delayed primary procedure using skin and muscle grafts where necessary, and, with this policy, no patient developed deep infection or osteomyelitis at the fracture site.

It is important that the initial reduction and alignment of the fracture is as nearly anatomical as possible. Inadequate reduction should not be accepted; it was the cause of malunion in all 8 of our cases. If the fracture is complicated, and reduction is likely to be difficult, we recommend that traction on an orthopedic fracture table is used when applying the fixator.

Meticulous care of pin-sites is essential. Minor infections are common but easy to treat and do not compromise external fixation. We have only had one major infection that required removal of the fixator and a change of treatment.

An advantage of the Dynamic Axial Fixator over other external fixators concerns the claim that dynamization (allowing increased axial movement at the fracture site) should promote union. We dynamized the fixators when callus appeared on the radiographs and thus fractures with a good prognosis (i.e., early callus formation) had early dynamization. In consequence, it is impossible to draw any firm conclusions about the role of dynamization from this or any other retrospective study. A prospective randomized trial is needed to determine the effect of dynamization on fracture union.

References

Austin R T. Fractures of the tibial shaft: Is medical audit possible? Injury 1977; 9: 93–101.

Bach A W, Hansen S T. Plates versus external fixation in severe open tibial shaft fractures: a randomised trial. Clin Orthop 1989; 241: 57–65.

Burny F L. Elastic external fixation of tibial fractures; a study of 1421 cases. In: External fixation: the current state of the art. (Eds. Brooker A F Jr, Edwards C C). Williams and Wilkins, Baltimore 1979; 55–73.

Clifford R P, Beauchamp C G, Kellam J F, Webb J K, Tile M. Plate fixation of open fractures of the tibia. J Bone Joint Surg (Br) 1988; 70: 644–8.

De Bastiani G, Aldegheri B, Renzi-Brivio L. Treatment of fracture with a dynamic axial fixator. Bone Joint Surg (Br) 1984; 66: 538–45.

Edwards C C, Simmons S C, Browner B D, Weigel M C. Severe open tibial fractures: results of treating 202 injuries with external fixation. Clin Orthop 1988; 230: 98–115.

Gustilo R B, Anderson J T. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones. Retrospective and prospective analysis. J Bone Joint Surg (Am) 1976; 58: 453–8.

Gustilo R B, Mendoza R M, Williams D N. Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma 1984; 24: 742–6.

McKibbin B. The biology of fracture healing in long bones. J Bone Joint Surg (Br) 1978; 60: 150–62.

Melendez E, Colon C. Treatment of open tibial shaft fractures with the Orthofix fixator. Clin Orthop 1989; 241: 224–30

Nicoll E A. Fractures of the tibial shaft: a survey of 705 cases. J Bone Joint Surg (Br) 1964; 46: 373–8.

Oni O O A, Hui A, Gregg P J. The healing of closed tibial shaft fractures: the natural history of union with closed treatment. J Bone Joint Surg (Br) 1988; 78: 787–90.

Reudi T, Webb J K, Allgower M. Experience with the dynamic compression plate (DCP) in 418 recent fractures of the tibial shaft. Injury 1976; 7: 252–7.

Winquist R A, Hansen S T, Clawson D K. Closed intramedullary nailing of femoral fractures: a report of five hundred and twenty cases. J Bone Joint Surg (Am) 1984; 66: 529–39.