Attempted unreamed nailing in tibial fractures

A prospective consecutive series of 55 patients

Bo Uhlin and Richard Hammer

We evaluated the possibility of unreamed insertion of an intramedullary nail (IMN) in a consecutive series of 55 tibial shaft fractures in 55 patients (30 men). 43 fractures were closed and 12 fractures were open. All surgeons involved were instructed to try unreamed insertion primarily. Selection of nail diameter was based on measurements of the narrowest part of the medullary canal on preoperative AP- and lateral radiographs, with a millimeter-ruler. Of the 25 cases where a 9 mm nail was chosen, 10 were impossible to insert without reaming. An 8 mm nail was selected in the remaining 30 cases, and here 10 required reaming. Mean time-to-union was 4.2 months. Delayed union was noted in 9 patients of whom 6 had been stabilized with an unreamed nail.

The concept of unreamed insertion must be questioned since this could be done in only 35 patients and, in addition, we were not able to demonstrate any significant differences in time-to-union in fractures stabilized with an unreamed or a reamed nail. Implant failures were seen in 5 patients, all stabilized with an 8 mm nail. Failure of interlocking screws did not affect the final outcome. However, a possible combination of screw breakage and healing disturbances may lead to the need for more complex surgical procedures. Due to these reasons and the fact that the 8 mm nail could not be inserted unreamed in 10 of 30 patients, we stopped using the 8 mm nail.

Department of Orthopedic Surgery, University Hospital, SE-581 85 Linköping, Sweden. Tel +46 13-22 20 00. Fax -16 45 00. E-mail: Richard.Hammer.@ort.us.lio.se. Correspondence: Dr. R. Hammer
Submitted 97-01-13. Accepted 98-02-13

Intramedullary nailing is currently widely used to stabilize unstable diaphyseal fractures of the tibia (Collins et al. 1990, Court-Brown et al. 1990, Gregory and Sanders 1995, Wiss and Stetson 1995). The possible negative effects of reaming have been discussed (O'Dwyer et al. 1994) and the use of an unreamed nail has been advocated in cases where the soft tissue envelope is compromized (Whittle et al. 1992), because of serious concern that the vascular injury initiated by the original trauma would be exacerbated by the additional interference with cortical circulation, following reaming (Klein et al. 1990).

Devascularization of the tibial cortex during reaming is probably unavoidable. Its extent, duration and eventual effects on fracture healing in humans is unclear (Bone et al. 1994, Anglen and Blue 1995). The increased rate of implant failures with unreamed nails is related to the type of fracture and the use of smaller diameters of the nail and the interlocking screws (Whittle et al. 1992, Fairbanks et al. 1995). Furthermore, the rationale for using an unreamed nail in closed, grade I and grade II open tibial fractures is open to doubt (Court-Brown et al. 1990). We evaluated the possibilities of unreamed insertion of an intramedullary nail in a consecutive series of patients with a fresh tibial shaft fracture.

Patients and methods

During 1991–1993, a consecutive series of 55 tibial shaft fractures in 55 patients (mean age 40 (13–77) years, 30 men) were stabilized with an intramedullary nail at our hospital.

Indications were: an unstable closed, grade I, grade II or grade IIIA (Gustilo et al. 1984) fracture, located between 8 cm distal to the proximal tibial plateau and 4 cm proximal to the ankle joint.

43 fractures were closed and 12 fractures were open. 2 patients had a segmental fracture, 8 had an associated ipsilateral ankle fracture and 6 had multiple injuries (Table 1). All surgeons involved were instructed to try unreamed insertion primarily. Available nail diameters were 8 and 9 mm (Russel-Taylor, Smith & Nephew, Memphis, USA). Proximal and distal interlocking screws were routinely used in all patients.

Table 1.

A	B	C	D	E	F	G	H	I	J	K	L
1	F	46	L	0	0	U	9	0	2	0	0
2	F	51	L	0	0	U	9	0	1.5	0	0
3	F	36	L	0	0	U	9	0	2.5	0	0
4	M	17	L	0	0	R	9	0	2.5	2	0
5	M	54	L	0	0	U	9	0	3	0	0
6	F	71	L	0	1	U	8	0	3	0	0
7	M	21	L	0	0	U	8	0	1.5	0	0
8	M	24	H	0	0	U	8	1.5	3	0	0
9	M	27	L	0	0	R	9	0	3.5	2	0
10	M	21	L	0	0	R	9	0	3	0	0
11	M	32	L	0	0	R	9	0	2.5	0	0
12	F	44	L	1	1	R	9	0	3.5	0	0
13	M	41	L	0	1	U	9	0	4.4	0	0
14	F	51	H	0	0	U	8	0	3	0	1
15	F	39	L	0	0	U	8	6	10.5	0	1
16	F	38	L	1	0	R	8	0	3.5	3	0
17	F	42	L	0	0	R	8	0	4	0	0
18	M	45	L	0	0	U	9	0	4	0	0
19	F	77	L	0	0	U	9	0	8.5	0	0
20	F	50	L	1	0	U	8	0	3.5	0	0
21	M	25	H	0	2	U	9	0	2	0	0
22	M	53	H	1	0	R	8	0	12.5	2	2
23	F	34	L	0	1	U	9	0	2.5	0	0
24	F	43	L	0	1	R	8	0	6.5	0	0
25	M	48	L	0	1	U	8	0	3	0	0
26	F	20	H	0	2	U	8	0	3.5	2	0
27	M	42	L	0	0	R	9	0	3	0	0
28	M	60	H	1	0	R	8	13	19	2	0
29	M	16	H	0	0	U	8	0	4.5	0	1
30	F	25	H	1	2	U	9	0	3.5	2	
31	F	67	L	0	0	U	8	0	1.5	0	0
32	M	31	H	0	0	U	8	0	2	0	0
33	F	63	L	0	1	U	8				
34	M	15	H	0	0	U	8	0	2.5	0	0
35	M	44	L	0	0	U	9	0	3	0	0
36	M	49	H	0	0	R	8	0	3	0	9
37	M	49	H	3	2	U	8	0	6	2	0
38	M	15	L	0	0	R	9	0	3	0	0
39	M	63	H	0	2	U	8	3	11	2, 3	1
40	M	15	L	0	0	U	8	0	3	0	0
41	F	60	L	0	0	U	8	0	2.5	0	0
42	F	66	L	0	0	U	9	3.5	6.5	0	0
43	F	54	L	0	0	U	8	0	4	0	0
44	F	46	L	0	0	U	8	0	4	0	0
45	M	13	H	0	2	U	8	0	4.5	1	0
46	F	67	H	0	1	R	8			0	0
47	M	28	H	1	0	R	9	2	4.5	2	0
48	F	22	H	1	0	R	8	2	3.5	0	0
49	F	49	H	3	0	U	9	9.5	12	0	0
50	M	56	L	0	0	U	9	2.5	7	0	0
51	M	37	H	0	0	U	9	0	4	2	0
52	M	22	H	1	0	R	9	0	2.5	0	
53	M	21	L	0	0	R	8	0	3	0	0
54	M	24	H	1	0	R	8	0	3	2	0
55	F	49	L	0	0	R	8	0	2.5	0	0

A Patient no.
B Sex
C Age
D High/low energy trauma
E Fracture classification
  0 closed
  1 open grade I
  2 grade II
  3 grade III
F Associated injury
  1 Ipsilateral ankle fracture
  2 Multiple injuries
G Unreamed
  Reamed
H Nail diameter (mm)
I Dynamization (month)
J Time-to-union (month)
K Complications
  1 Infection
  2 Compart. syndrome
  3 DVT
L Implant failure
  0 None
  1 Interlocking screws
  2 Nail

Time from admission to nailing was less than 24 hours in 52 patients and within 48 hours in 54 patients. One multiply-injured patient had a unilateral external fixator for provisional stabilization, followed by intramedullary nailing, 10 days after injury.

Selection of an 8 or a 9 mm nail was based on measurements of the narrowest section of the medullary canal on preoperative AP and lateral radiographs, using a millimeter-ruler and corrected for radiographic magnification. An over-reaming of the canal with 1 mm was done, if unreamed insertion was unsuccessful.

The preoperatively selected nail diameter was always used, i.e., an unsuccessful attempt at unreamed insertion of a 9 mm nail was not repeated with an 8 mm nail. All patients were given parenteral antibiotics for 24 hours and a low molecular heparin was given subcutaneously, until the patient was mobilized.

Postoperative weightbearing was restricted to 10–15 kg for the first 6 weeks. If radiographic callus formation was seen at this time, a gradual increase to full weightbearing was encouraged.

Union was defined as bridging callus in at least two radiographic projections or bridging callus in one projection and painfree full weightbearing, without support. Incomplete radiographic union more than 6 months after injury was regarded as a delayed union.

53 patients were available for follow-up pending union.

Results

Mean time-to-union was 4.2 months (median 3.2 months). 9 patients required more than 6–19 months to radiographic consolidation. 4 delayed unions were seen in patients stabilized with an unreamed 9 mm nail. The other 5 had an 8 mm nail, 2 were unreamed and 3 were reamed. All 9 were locked statically and dynamization was done late, at an average of 4.8 (1.5–13) months after nailing.

1 segmental fracture went on to non-union. This fracture was stabilized with a reamed 8 mm nail that failed 9 months after injury. The patient had an exchange nailing and a bone graft and the subsequent course was uneventful (Figure). Interlocking screw failure occurred in an additional 4 patients, all with an unreamed 8 mm nail. 52 fractures united within 10 degrees of normal alignment and 1.5 cm of length.

Complications

There were no intraoperative technical complications and no postoperative neurological abnormalities. One 13-year-old boy developed a superficial infection at

Grade I open high-energy segmental tibial shaft fracture stabilized with a reamed 8 mm interlocked nail. The distal fracture was located at the level of the proximal locking hole and is not shown on this radiograph.

Union was inadequate on the radiographs at 6 months after injury.

Fatigue fracture of the nail at the proximal fracture site, 9 months after injury.

Solid union was achieved 3 months after an exchange nail (9 mm) and a bone graft.

Table 2. Distribution of reamed and unreamed cases vs nail diameter and success rate, defined as the quotient between numbers of unreamed and total cases in the respective nail diameter group

Nail diameter	Reamed	Unreamed	Total	Success rate
9	10	15	25	0.60
8	10	20	30	0.67
	20	35	55	0.64

the insertion site of a distal interlocking screw, 4 weeks after nailing. This healed successfully after screw removal and debridement. There were 2 cases of deep venous thrombosis. 20/55 fractures required reaming (Table 2). An intraoperative or early postoperative compartment syndrome developed in 11 patients: 5 in patients who sustained high energy injuries and were stabilized unreamed vs. 4 that occurred in high energy injuries and 2 in low energy injuries among the reamed patients.

Discussion

Our experience confirms that early stabilization of tibial shaft fractures with a locked intramedullary nail is associated with few serious complications. However, the possibility of unreamed insertion must be questioned since it was successful in only 35/55 patients.

This success rate might have increased, if an attempted and unsuccessful insertion of an unreamed 9 mm nail had been repeated with an 8 mm nail. We found the selection of appropriate nail diameter unreliable when it was based on measurements on preoperative radiographs, using a millimeter-ruler. These measurements might be more accurate if they were made with CT.

It has been claimed that the time required to perform an intramedullary nailing would be reduced if reaming were avoided (Anglen and Blue 1995). However, if an attempted unreamed insertion fails, it takes some time for the surgeon to accept this failure. Even if it is impossible to get the nail down, many surgeons continue their attempts for some time. This will not only increase the surgical time but may also be associated with an increased risk of complications, including propagation of fractures from the principal site of injury to the site of nail insertion, as well as distally into the talo-crural joint (Whittle et al. 1992).

An important physical feature of the unreamed nailing concept is reduction in the diameter of the nail. The reduction in the diameter is mechanically compensated for by increased wall-thickness of the nail, closed section design or by making the nail solid. This reduction in the diameter of the nail will require reduction in the diameter of the interlocking screw, with an increased risk of interlocking screw failure. The contact surface between the nail and the tibia will be reduced, with decreasing diameter of the nail. This has been reported to worsen the mechanical behavior of the tibia-nail construction (Schandelmaier et al. 1994) and may contribute to the increased rate of implant failures reported (Whittle et al. 1992, Court-Brown et al. 1996). In patients with midshaft stable fracture patterns—e.g., no substantial bone defect—the rate of implant failure seems to be low. However, in patients with comminuted unstable, segmental, proximal or distal third fractures, these features may increase the risk of healing disturbances, implant failure, malalignment and a need for a bone graft or a reamed exchange nailing procedure at a later stage (Bone et al. 1994, Anglen and Blue 1995, Lang et al. 1995, Riemer et al. 1995).

All implant failures in our series were noted among patients with an 8 mm nail. In addition, unreamed nails were commoner, but not significantly different, among patients with healing disturbances (6 of 9). We found no significant differences in time-to-union and rate of healing disturbances in fractures stabilized with an unreamed or a reamed nail. We believe that time-to-radiographic consolidation in our patients could have been reduced by a more aggressive dynamization protocol, combined with less restricted weightbearing instructions.

That this is of importance in the postoperative management of nailed tibial fractures was also evident from Riemer et al. (1995), who reported a 48% reoperation rate in statically locked nails, compared to 12% when dynamic locked nails were used ($p < 0.01$). However, in our study, the fear of implant failure when the 8 mm nail was used was one large contributing factor in allowing only partial weightbearing during the first 6 weeks postoperatively. Recently, Court-Brown et al. (1996) reported on 50 patients with tibial fractures and found a shorter time-to-union in patients stabilized with a reamed nail, compared to an unreamed nail (15 vs 23 weeks, $p < 0.01$). Malunion was seen only among patients in the unreamed group and the authors conclude that the most probable explanation was the high incidence of implant failures among these patients. That there are no disastrous effects of reaming on the union process is also demonstrated in an animal study by Schemitsch et al. (1995). They reported that perfusion of callus and early strength of union were similar, following intramedullary nailing, with or without reaming.

The only nonunion seen in our patients (Figure) demonstrates the need for active management of

nailed fractures. The failure of progression of radiographic signs of union at 6 months would have been a strong indication for dynamization or an exchange intramedullary nailing procedure, as advocated by Court-Brown et al. (1991).

Failure of interlocking screws did not affect the final outcome in our patients. However, a combination of screw breakage and healing disturbances may require more complex surgical procedures. Due to these reasons and the fact that the 8 mm nail could not be inserted unreamed in 10 of 30 patients, we stopped using the 8 mm nail in 1994.

In summary, the concept of unreamed nailing must be questioned and we recommend the use of a reamed nail, with a minimum diameter of 9 mm, and emphasize the importance of early weightbearing, dynamization, bone graft and exchange nailing in selected cases, should there be inadequate signs of radiographic and clinical union.

References

Anglen J O, Blue J M. A comparison of reamed and unreamed nailing of the tibia. J Trauma 1995; 39 (2): 351-5.

Bone L B, Kassman S, Stegeman P, France J. Prospective study of union rate of open tibial fractures treated with locked, unreamed intramedullary nails. J Orthop Trauma 1994; 8 (1): 45-9.

Collins D N, Pearce C E, McAndrew M P. Successful use of reaming and intramedullary nailing of the tibia. J Orthop Traum 1990; 4 (3): 315-22.

Court-Brown C M, Christie J, McQueen M M. Closed intramedullary tibial nailing. J Bone Joint Surg (Br) 1990; 72 (4): 605-11.

Court-Brown C M, McQueen M M, Quaba A A, Christie J. Locked intramedullary nailing in open tibial fractures. J Bone Joint Surg (Br) 1991; 73: 959-64.

Court-Brown C M, Will E, Christie J, McQueen M M. Reamed or unreamed nailing for closed tibial fractures. J Bone Joint Surg (Br) 1996; 78: 580-3.

Fairbanks A C, Thomas D, Cunningham B, Curtis M, Jinnah R H. Stability of reamed and unreamed intramedullary tibial nails: a biomechanical study. Injury 1995; 26 (7): 483-5.

Gregory P, Sanders R. The treatment of closed tibial shaft fractures with unreamed interlocking nails. Clin Orthop 1995; 315: 48-55.

Gustilo B R, Menoza M R, Williams N D. Problems in the management of Type III (severe) open fractures. A new classification of Type III open fractures. J Trauma 1984; 24: 742-8.

Klein M P, Rahn B A, Frigg R, Kessler S, Perren S M. Reaming versus non-reaming in medullary nailing:interference with cortical circulation of the canine tibia. Arch Orthop Traum Surg 1990; 6: 314-6.

Lang G J, Cohen B E, Bosse M J, Kellam J F.Proximal third tibial shaft fracture. Should they be nailed? Clin Orthop 1995; 315: 64-74.

O'Dwyer K J, Chakravarty R D, Esler C N. Intramedullary nailing technique and its effect on union rates of tibial shaft fractures. Injury 1994; 25 (7): 461-4.

Riemer B L, DiChristina G, Cooper A, Sagiv S, Butterfield S L, Burke III C J, Lucke J F, Schlosser J D. Nonreamed nailing of tibial diaphyseal fractures in blunt polytrauma patients. J Orthop Traum 1995; 9 (1): 66-75.

Schandelmaier P, Krettek C, Tscherne H. Biomechanische Untersuchungen von 9 Tibiaverriegelungsnageln im Knochen-Implant-Verbund. Unfallchirurg 1994; 97 (11): 600-8.

Schemitsch E H, Kowalski M J, Swiontkowski M F, Harrington R M. Comparison of the effect of reamed and unreamed locked intramedullary nailing on blood flow in the callus and strength of union following fracture of the sheep tibia. J Orthop 1995; 13 (3): 382-9.

Whittle A P, Russel T A, Taylor J C, Lavelle D G. Treatment of open fractures of the tibial shaft with the use of interlocking nailing without reaming. J Bone Joint Surg (Am) 1992; 74: 1162-71.

Wiss D A, Stetson W B.Closed intramedullary nailing of tibial shaft fractures. Clin Orthop 1995; 315; 56-63.