

Lower Infection Rate after Interlocking Nailing in Open Fractures of Femur and Tibia

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Between 1975 and 1987 91 patients with Types I and II open lower extremity fractures (66 tibia and 25 femur) have been treated surgically with interlocking nailing at the I University Clinic of Traumatology, and the Trauma Department of Wilhelminenspital, Vienna. Our infection rate of 1.2% was found to be lower than figures cited in the literature.

Conscientious indication of the interlocking nail in these circumstances cannot claim all the credit for these results, the appropriate preoperative management with preventive antibiotics together with excellent operative technique have to be taken into consideration as well. Reviewing these results, we have adopted the opinion that the interlocking nail, when selectively used in the hands of an expert, can be recommended not only in closed fractures but also in Types I and II open fractures of the femur and tibia, provided that the special principles of treatment in a particular case are not neglected.

The trauma which causes the fracture also sets the stage for infection by introducing risk factors such as soft-tissue injury as well as contamination of the integument. Available literature cites infection rate as between 2.3% (18) and 9.4% (9).

Antibiotic administration in these circumstances is a controversial therapeutic principle (12, 16, 18). Energy kinetics is an essential prognostic factor because it is decisive in assessing the extent of soft-tissue injury (11). The basic guidelines in the management of this injury have gone through changes in the course of the century. The initial philosophy was that operative treatment increased bacterial populations and induced infections, therefore operative treatment was contraindicated (6).

In vitro studies have shown that metals themselves do not in any way influence the bacterial growth or its propagation (10).

Advances in surgical technique together with supportive preventive antibiotics have contributed to the success of the operative stabilisation of open fractures. One still learns from modern literature about groups who hold a different view on the application of primary osteosynthesis in open fractures (1, 2, 7, 11, 19).

The particular claim to this choice of osteosynthesis is still controversial. The great fear of propagating intramedullary infection with its attendant phlegmon formation secondary to intramedullary reaming has rendered osteosynthesis in open fractures a much revered exceptional indication. There are still conflicting views on the

choice of treatment in open fractures, most especially of the long bones (5, 8, 13, 14, 17, 20, 21, 24). From these different views evolved the following results after a followup study on patients with Types I and II open fractures treated with interlocking nails.

Therapeutic Guidelines. Since most of these patients come in as multiple injured cases in profound shock, the initial step after admission is aimed at combating shock and this usually achieved by administering sufficient quantities of oxygen and fluids. In the interim, the open wound is covered with a sterile transparent film. The next step is a quick but thorough clinical and radiologic evaluation of the patient. Antibiotic therapy is started immediately, usually with a penicillin with specific activity against *Staphylococcus aureus*. No initial smear is taken for bacteriologic examination.

Operative Technique. After cleaning and draping the patient in the usual sterile fashion in the operating room, an extensive and meticulous debridement coupled copious irrigation of the wound with normal saline is carried out. When the surgeon is satisfied with his debridement and irrigation of the open wound, all the used instruments, gowns, and drapes are replaced by new sterile ones, then an attempt is made to reduce the fracture by closed means. This is carried out using the technique outlined by AO (Arbeitsgemeinschaft für Osteosynthesefragen) (15). Great attention is paid to the handling of soft tissues. Should the attempt to reduce fracture by closed means fail, an open reduction is performed, still paying attention to soft-tissue handling. After achieving reduction either by the closed or open reduction, the medullary canal is reamed using the AO guidelines. Again copious irrigation of the medullary

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canal is carried out. The decision to employ a static or dynamic interlocking nail depends on the fracture configuration.

Another important decision which also depends on the prevailing conditions is whether to effect primary wound closure or not. It is always important to make sure that the bone is covered by soft tissue, if the soft-tissue damage is not extensive and swelling is moderate then primary skin closure can be done, but if there is extensive soft-tissue damage as well as much swelling and the suspicion that the sutures will be under tension, then the skin is initially covered with a special synthetic material. Local conditions at the site of the open wound will dictate whether one can effect an early full-thickness skin graft or not.

Postoperative Management. Postoperatively the extremity is placed on a Braun's frame or a foam splint. The wound from the compound fracture is dressed at regular intervals with antiseptic dressings. Antibiotic therapy either orally or parenterally is continued on the

same chemotherapeutic basis as before. An antiphlogistic is also added to the drug regimen.

If other injuries do not contraindicate, the patients are mobilised on crutches on the second or third postoperative day, after removal of the drains. Low doses of heparin ($3 \times 5,000$ IU S.C.) as prophylaxis against thromboembolism are administered to the patients throughout the period of immobilisation.

MATERIALS AND METHODS

Between 1975 and 1987 91 patients with open fractures of the femur and tibia were treated with interlocking nails at the I University Clinic of Traumatology ($n = 64$), University of Vienna, and the I Department of Surgery ($n = 27$), Wilhelminenspital in Vienna.

A successful followup study was achieved in 79 (87%) of the 91 patients treated with interlocking nails for open fractures of the femur and tibia (23 patients with femur fractures and 56 patients with tibia fractures). The last followup of the 79 patients showed that they all had stable bones and a healthy soft tissue cover. Five patients were found to have died from



FIG. 1. A) Type I open fracture of the right femur in an 18-year-old female patient. B) Static interlocking nailing after closed reduction C) Dynamisation to effect axial compression 14 weeks postoperatively (removal of proximal bolts). D) Bone union, nail extraction 14.5 months after the accident.



FIG. 2. A) Type II open fracture of the left leg. There was a wound of 2-3 cm on the medial side. B) Closed reduction and dynamic interlocking nailing. C) 3 years after the accident, free movement.

natural causes during the period of study; one patient with suicide tendencies was admitted to a psychiatric unit; and six patients who changed their addresses could not be traced for followup. Available information from our outpatients' data bank revealed that these patients had developed no infections nor other complications, and that wound healing was complete.

Part I: Femur Fractures. Twenty-five patients in this study had open fractures of the femur, 15 of these (60%) were of Type I and ten (40%) Type II. There were 22 males and three females. The average age of the Type I patients was 37.4 years (17-66 years). The average age of the Type II fracture patients was 26.4 years (17-43 years) (Table I). Comminuted fractures and butterfly fragments were observed in more than 50% of the cases. Oblique fracture configuration was observed in 24% of the cases (Table II).

The fracture was situated in the middle third of the shaft in

TABLE I
Age and sex distribution, grading of open femur fractures ($n = 25$)

	Males ($n = 22$)		Females ($n = 3$)	
	Type I 13	Type II 9	Type I 2	Type II 1
Average age (years)	26 (18-58)	26.4 (17-43)	42 (17-66)	19 (19)

TABLE II
Distribution of fracture configuration in Types I and II open femur fractures

Butterfly fragments	$n = 10$	(40%)
Transverse fractures	$n = 5$	(20%)
Oblique fractures	$n = 6$	(24%)
Comminuted fractures	$n = 4$	(16%)
Total	$n = 25$	(100%)

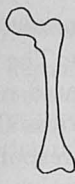
60%. In nine patients (36%) the fracture extended for more than a third of the length of the femur. One patient presented with a comminuted fracture which extended beyond half the length of the femur (Table III). Eleven patients had other organ injuries, of whom two were considered polytrauma cases.

Of the 25 open fractures of the femur closed reduction was achieved in 16 (64%), and nine (36%) required open reduction. In 19 patients (76%) the fracture was stabilised by static interlocking; in the remaining six patients (24%) stability was achieved with dynamic interlocking only. Two patients of the six had their dynamic interlocking nail supplemented with wire loops.

The patients spent an average of 5.3 days (1-21) days in bed before being mobilised on crutches. The average hospitalisation time was 18 days (7-54 days).

Two cases of early postoperative complication were encountered in this series. One was a haematoma formation on the

TABLE III
Distribution of fractures site in Types I and II open femur fractures in sixths

Shaft Length/6 (from proximal distalwards)	1/6	2/6	3/6	4/6
	0	2	1	0
1	0	2	1	0
2	8	6	1	0
3	7	1	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
<i>n</i> = 25	15	9	1	0
	(60%)	(36%)	(4%)	(0%)

second postoperative day. This was found to be from a bleeding vein which was ligated when the wound was opened and drained. No further complication was seen. The second case was an obese patient who developed deep vein thrombosis. He recovered and was discharged on the nineteenth postoperative day.

We had an early infection in one case, a 19-year-old male patient who had comminution between the second and the fourth sixth of the femoral shaft after a motor vehicle accident and had interlocking nail together with wire loops. In spite of the appropriate antibiotic coverage he did develop early postoperative infection. Resection of the avital bone and muscle tissue in the second operation did not alter the course of the infection to a purulent one. The nail was removed in this case and an osteotaxic Wagner apparatus applied 1 month after the accident. After two additional interventions which involved bone grafting, the fracture did progress eventually to a complete union without any further osteosynthetic means.

Results. Twenty-three out of the 25 patients treated with interlocking nails for open fractures of the femur progressed to bony union. There were no pseudarthroses. We encountered a case of subtrochanteric fracture with a fracture of the nail 12 weeks after the first operation from a second accident. Biomechanical deliberations favoured restabilisation with a DC-plate after extraction of the fractured nail. This fracture also attained bony union after the reosteosyntheses.

Fracture configuration and the extent of fracture healing determined when to effect dynamisation of the nail in cases of static interlocking. Fracture configuration also determined which bolts (proximal or distal) should be removed in the dynamisation which was normally after an average of 4.8 months (3–10 months). The nails were extracted after a period of 21.6 months (15–36 months) by which time bone consolidation was known to have taken place. At the time of the last followup eight patients still had their nails in place. These were mainly patients operated in 1987.

We did observe a case of 10° varus deformity. This patient had no symptoms and did not want any corrective osteotomy. One case of 10° internal rotational deformity of the femur was seen in the first followup session. Five patients had 5° internal rotational limitation of the hip and three patients had up to 10° flexion deficit of the knee, but had no related physical handicap. Nineteen patients were totally free of any complaints related to the femur fracture. A single patient with the nail still in place complains of the feeling of a foreign object in his body. Three patients complain of vague pains, usually experienced with changes in the weather, a feature which is very common in fracture patients.

Part II: Tibia Fractures. The number of cases with open fractures of the tibia in this study was 66, in other words, more than twice the number of femur fractures. The distribution was

45 (68%) Type I and 21 (32%) Type II open fractures. There were 45 males and 21 females. The average age of Type I open fracture cases was 39.1 years (15–92 years), that of Type II was 28.7 years (16–63 years) (Table IV). Comminuted fractures with butterfly fragment dominated in the tibia, too, with more than 50% presenting with this fracture pattern. The rotational fracture type was the second most common (Table V). The middle third of the shaft was the most common fracture site (Table VI).

Of 66 patients 23 (35%) sustained injuries to other organs. Eleven of these 23 patients were considered as polytraumatised cases. Closed reduction was possible in 57 cases (86%); nine patients (14%) required open reduction.

Static interlocking was used to obtain stability in 47 cases (71%), while 19 cases (29%) required only dynamic interlocking.

Patients spent an average of 7.3 postoperative days (1–87 days) in bed before they were mobilised on crutches. The average hospitalisation time was 17.8 days (4–90 days). It must be pointed out that this high figure for the average hospitalisation time as well as the time interval before mobilisation was due to a patient with an acetabular fracture who was treated conservatively and therefore had to stay in bed for a longer time before being mobilised on crutches. We had two cases of postoperative complications; the first, fat embolism in an obese patient who had a ruptured liver among other injuries. This patient did initially undergo surgical intervention to repair the


TABLE IV
Age and sex distribution, grading of open tibia fractures (*n* = 66)

	Males (<i>n</i> = 45)		Females (<i>n</i> = 21)	
	Type I 29	Type II 16	Type I 16	Type II 5
Average age (years)	43.3 (17–92)	31.7 (16–46)	34.9 (15–56)	25.7 (16–63)

TABLE V
Distribution of fracture configuration in Types I and II open tibia fractures

Butterfly fragments	<i>n</i> = 19	(28.8%)
Comminuted fractures	<i>n</i> = 15	(22.7%)
Rotated fractures	<i>n</i> = 11	(16.7%)
Transverse fractures	<i>n</i> = 9	(13.6%)
Oblique fractures	<i>n</i> = 8	(12.1%)
Deux-étage fractures	<i>n</i> = 4	(6.1%)
Total	<i>n</i> = 66	(100.0%)

TABLE VI
Distribution of fracture sites in Type I and II open tibia fractures in sixths

Shaft Length/6 (from proximal distalwards)	1/6	2/6	3/6	4/6
	0	5	2	0
1	10	5	2	0
2	17	4	2	0
3	16	7	2	0
4	5	0	0	0
5	0	0	0	0
6	0	0	0	0
<i>n</i> = 66	48	16	2	0
	(72.7%)	(24.3%)	(3%)	(0%)

abdominal injuries before having the fracture stabilised by interlocking nailing. The prompt intensive care measures which were effected after detection of the fat embolism on the first postoperative day did save the life of the patient. He spent 33 days in the intensive care unit before being transferred to the ward, and afterwards to a rehabilitation department for full recovery.

The other case of complication was a slow healing of the open fracture wound, but this eventually healed after 3 weeks.

There was no early infection in these series.

Results. Of the 66 patients treated with interlocking nail for open tibial fractures 56 could be followed up. We obtained sound bony union in all patients, and we had no pseudarthroses. From these 56 patients three were found to have loosening of the bolts. The loosening was attributed to the site of the fracture and the enforced mobilisation. In the second operation the bolts were replaced by bolts and nuts. We did encounter one case of fractured nail after 32 weeks. With this type of nail the fracture usually occurred at the site of the second proximal bolt. We no longer use this nail. After reosteosyntheses we achieved bone union without any problems. This type of implant failure has disappeared with the introduction of improved implants.

Dynamisation after static interlocking nailing in tibia fractures was done after an average period of 5 months (4–11 months).

The implants were removed after a period of 20.7 months (12–46 months). Twelve patients still have their implants in place.

A 10° valgus deformity of the tibia and pseudarthrosis of the lateral malleolus was seen in a patient who started weight bearing too early. It was assumed that excessive demands on the involved leg led to the deformities. Seven patients, four of whom still have their implants in place, have up to 10° flexion deficit of the knee.

At the level of the ankle joint four patients have up to 10° limitation of plantarflexion and six have more than 10° limitation of dorsiflexion. Of these ten patients still have their implants in place.

No patient was found to have limitation of extension-flexion movements of the toe during the followup. No contractures with the characteristic "clawed toes" were also seen.

Fifty patients have no complaints. They have gone back to the activities they had before the accidents and see no difference in performance. Three patients who complain of pains with changes in the weather still have their implants in place. A patient with pseudarthrosis of the lateral malleolus complains of pains in the ankle joint. Two patients who had other injuries as well complain of pains.

DISCUSSION

Literature reviews remark that the use of intramedullary nails in open fractures of long bones still remains a controversial issue. The constant fear that an infection can lead to a phlegmon of the medullary cavity and eventually an infected pseudarthrosis of the fracture is always considered when one mentions the use of interlocking nailing in stabilising open shaft fractures. It is imperative that our therapeutic concept is not misunderstood: we are not claiming that all open fractures stabilised with interlocking nailing will progress to bony union without any complications. Our early infection rate of 1.2% is lower than other published rates on surgically treated open fractures (5, 18, 20, 22). There was no incidence of late infection in our study.

The comminuted fractures and fractures with butterfly fragments which formed the bulk of the cases (more than 50% of all the cases) did progress to complete bony union just like the other fracture types, although one would have expected them to carry a higher infection rate and unfavourable results.

Most of the cases were reduced by closed means (80%) and stabilised with static interlocking (73%). The early postoperative complications in this study could not be attributed to the method of stabilisation since it is always difficult to implicate a particular factor as responsible for a particular complication in a multiply injured patient.

There was a single incidence of infection in which bacteriologic studies of the wound swab revealed resistance to the administered antibiotics.

There is a lot of talk these days about compartment syndrome, particularly after intramedullary nailing of the tibia. We did not encounter this problem in our study, nor did we observe "clawed toes" which one could have inferred as being a consequence of compartment syndrome.

Important points to remember are: adequate wound debridement, closed reduction whenever possible, sparing of soft tissue, adequate reaming and irrigation of the medullary cavity, and a well fitting implant. Under no condition whatsoever should the wound be closed under tension.

These very impressive results, with 96.2% infection-free cases in the followup as well as satisfactory evidence of bony union free from problems, are the products of the following factors: a good understanding of the associated risks even with very careful indications, a good biologic view of the benefits to be derived from stability without exceeding the limits of available surgical techniques, as well as the obvious favourable biomechanic properties of the implants.

CONCLUSIONS

The interlocking nail has now gained recognition as the standard method of treatment in shaft fractures of the femur and tibia. This achievement is not restricted to closed fractures only but also to certain open fractures, as shown by our study.

Our basic requirement for the use of interlocking nails in open fractures are: correct selection of patients, adequate preoperative management, including antibiotic therapy and a good surgical technique. All of these have contributed to the sound bony union with low infection rate in our study.

The use of the interlocking nail in open fractures whilst adhering to the requirements mentioned above shortens hospitalisation and rehabilitation time considerably. Early full weight-bearing in patients with open lower extremity fracture treated with interlocking nailing is second to no other osteosynthesis in similar injuries.

The interlocking nailing in selected Types I and II open fractures of the femur and tibia appears to have a lower infection rate when compared with other stabilising methods. This method can therefore be recommended in the circumstances outlined above.

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