THE UNREAMED LOCKED INTRAMEDULLARY TIBIAL NAIL : A FOLLOW-UP STUDY IN 51 PATIENTS

P. MERTENS, P. BROOS, P. REYNDERS, R. DESWART *

The authors reviewed 51 patients with a fracture of the tibia primarily treated with an unreamed intramedullary nail. There were 29 open and 22 closed fractures. All fractures healed within one year of the trauma. There were no deep infections. The most frequently observed complication was failure of interlocking screws (20%), but this complication had a negligible influence on bone healing. Re-nailing with a reamed nail was necessary in 18%.

According to the criteria of Klemm and Börner an excellent result was obtained in 55% and a good result in 44%.

The authors recommend unreamed nailing in fractures with soft tissue injuries ; they recommend to dynamize the implant after six weeks in transverse and short oblique fractures and to replace the unreamed nail by a reamed one after three months in case of delayed union.

Keywords : tibia ; fracture ; intramedullary nail.
Mots-clés : tibia ; fracture ; enclouage.

INTRODUCTION

After the introduction of intramedullary nailing in the treatment of fractures of long bones by Küntscher in 1940, significant advances have been made regarding the operation technique as well as the quality of the implant (10, 18).

Most fractures of the tibial shaft can be firmly stabilized using reamed interlocking nails. Nevertheless, due to the reaming procedure, the endomedullary vascularization of the bone can be damaged resulting in a higher risk of infection and a longer healing time. It has also been proved that, especially in patients with multiple injuries, hypovolemia and pulmonary contusion, the reaming procedure increases the risk of fat embolism syndrome and ARDS (25, 26, 36). So it seems to make sense that the incidence of these complications could be decreased by using an unreamed nail (2, 16). Unreamed tibial nails also tend to be useful in open fractures. Complex open fractures (Gustilo IIIb and IIIc), for which external fixation was formerly regarded as the "golden standard" can be stabilised with an unreamed nail with excellent results (27). The intramedullary implant makes secondary intervention on soft tissues easier and is associated with better patient comfort.

We reviewed 51 patients with an open or closed fracture of the tibial shaft, treated with an unreamed nail. Special attention was given to the mechanical complications, the healing time and the final functional outcome.

MATERIALS AND METHODS

From January 1992 till May 1996, 51 fractures of the tibial shaft were primarily treated using a stainless steel unreamed tibial nail (UTN) in the University Hospital Gasthuisberg Leuven. The UTN was only used in fractures with important soft tissue damage or in polytrauma patients with at least two fractures of long bones, hypovolemia and/or a thoracic trauma needing early ventilation and intubation. Patients with an isolated fracture, without soft tissue damage, were treated with a conventional reamed nail.

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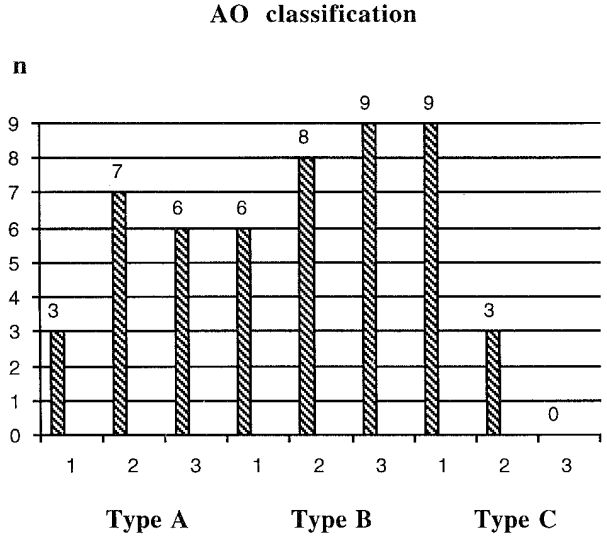
Thirty-four patients were men and seventeen were women. The average age was 37 years (range 14 to 90 years). Forty-two fractures were the result of high energy trauma (traffic accident, fall from a height). The fractures were classified using the AO classification system (Table I).

Table I. — Fractures classified following the AO method

TYPE A	1	3
	2	7
	3	6
TYPE B	1	6
	2	8
	3	9
TYPE C	1	9
	2	3
	3	0

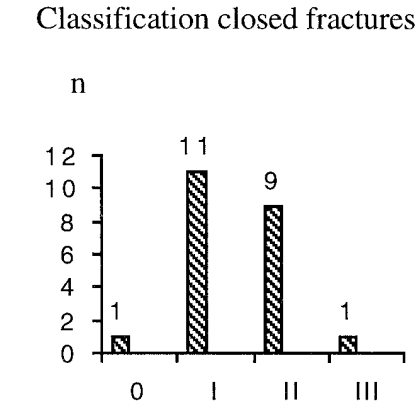


The severity of the soft tissue lesions was graded following the classification systems proposed by Oestern and Tscherne for closed fractures (24) and by Gustilo *et al.* (11) for open fractures (Fig. 1). Forty patients suffered from associated injuries (Table II).

All operations were performed within 24 hours of admission at our hospital. Nailing was performed without a traction table but using the Reynders frame (28).

All nails were locked using at least two screws proximally and distally. An adjuvant fasciotomy was performed on six occasions : six times during the same

Closed : n = 22 (43%)				Open : n = 29 (57%)			
Tscherne	0	1	5%	Gustilo	I	6	21%
	I	11	50%		II	20	69%
	II	9	40%		IIIa	1	5%
	III	1	5%		IIIb	1	5%
					IIIc	0	0%



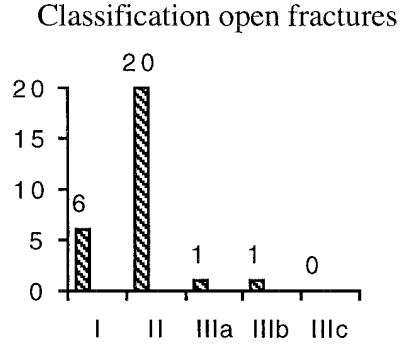


Fig. 1. — Fracture classification.

Table II. — Associated pathology (n = 40)

1.	Craniocerebral trauma	4
2.	Thoracic trauma	7
3.	Abdominal trauma	3
4.	Spinal injury	1
5.	Vascular injury	2
6.	Fracture upper limb	
	ipsilateral	1
	contralateral	3
7.	Fracture lower limb	
	ipsilateral	10
	contralateral	9

surgical procedure on clinical grounds, twice within 48 hours after the operation due to elevated intracompartmental pressure. In one case the fibula was fixed with plate and screw osteosynthesis. In 22 patients at least one secondary operation was necessary because of soft tissue lesions : 12 times a simple secondary closure, 7 times skin grafting, 3 times a free vascularised muscular flap. All patients received antibiotics (cephalosporins) for at least 48 hours and low molecular weight heparine subcutaneously. Active mobilisation of knee and ankle joints was started immediately after the operation. Partial weight bearing was allowed as soon as possible. After six weeks, full weight bearing was permitted. Dynamisation by removing the proximal screws was not routinely performed in our department. Nevertheless it was performed eleven times in transverse and short oblique fractures. If after three months, delayed fracture healing was suspected, secondary nailing with a thick reamed nail was considered.

The surviving patients were followed for at least one year after injury. The final functional evaluation was made using the criteria of Klemm and Börner (15) (Table III).

Table III. — Functional results after tibial fracture healing (Klemm and Börner classification (14))

Excellent
Full hip and knee motion
No muscle atrophy
Normal radiological consolidation
Good
Minimal loss of hip and knee motion
Less than 2 cm muscle atrophy
Less than 5° axial deviation
Poor
Moderate (25%) loss of hip and knee motion
More than 2 cm muscle atrophy
Axial deviation 5°-40°

RESULTS

Two patients died within one month after trauma due to multiple organ failure.

In one patient a pulmonary embolism was diagnosed based on the ventilation-perfusion scintigraphy.

Deep infection was never observed. Nevertheless one patient needed a wound debridement for superficial infection. The most common complication was breakage of the interlocking screws : ten patients had a total of 12 broken screws.

The distal screw was broken or bent in 8 cases, the proximal in 4. All screw failures were noticed after partial weight bearing. There was no clear relationship between screw breakage and fracture type. Secondary nailing with a reamed interlocking nail was necessary in nine cases (18%) : 7 times after three months (following our initial strategy), and twice later on (after 5 and 6 months) because of a clear evolution to delayed union despite good initial periosteal callus formation. In three patients the secondary nailing was accompanied by cancellous bone grafting. Nevertheless all fractures were clinically and radiographically healed within one year of the injury, without limp, shortening or rotational deformity.

In all patients fracture healing was achieved radiologically and clinically after an average time of 6.4 months (range 3 m - 10 m). The mean healing time was slightly longer in open than in closed fractures (7.7 months versus 5.8 months) ; it was also longer in fractures complicated by breakage of the screws (6.6 months versus 5.6 months for those without screw fracture).

According to the Klemm and Börner classification, we noted an excellent result in 27 patients after 12 months, a good result in 20 patients after 12 months and a poor result in two patients (Fig. 2) (Table IV). In one case, a patient with an adjacent knee dislocation, the poor result was due to important periarticular ossifications.

DISCUSSION AND CONCLUSIONS

In 1951 Küntscher was the first to use the principle of reaming before insertion of the nail (17). The reamed interlocking nail was developed in the seventies in order to enlarge the indications for intramedullary fixation (36).

Nevertheless, the reaming procedure is not without danger. Reaming creates heat-necrosis, raises intramedullary pressure and causes cortical vessel thrombosis and damage to the tibial medullary artery (19). Some authors reported a

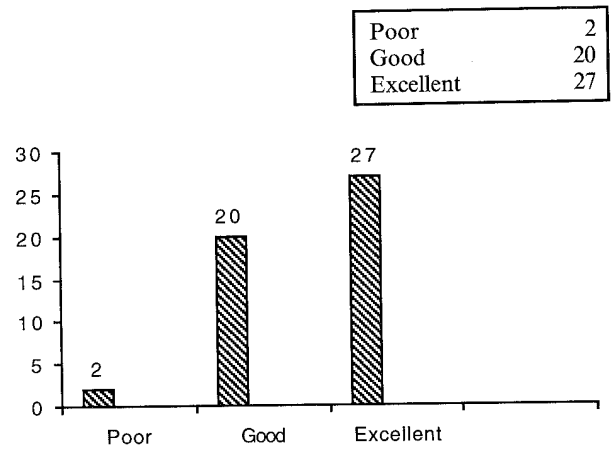


Fig. 2. — Functional evaluation (Klemm K. W., Börner M. Interlocking nailing of complex fractures of femur and tibia ; Clin. Orthop. 212, 89, 1986) n = 49.

Table IV. — Time to fracture healing

Average time to healing of all fractures :	6.4 months
Open fractures :	6.4 months
Closed fractures :	5.8 months
Fractures without screw failure :	5.6 months
Fractures with screw failure :	6.6 months

decrease of up to 70% of the endomedullary blood flow (14, 19, 34). As devascularisation is associated with a higher risk of infection, it has been suggested not to use a reamed nail in open fractures (10). In addition, especially in patients with associated thoracic trauma, reaming procedures may increase the risk of "fat embolism syndrome" and ARDS (23, 25, 26, 36). Nailing of proximal and distal fractures of the tibia often resulted in axial and/or rotational instability (3, 31).

The common approach for open fractures was primary fixation using an external fixator followed by intramedullary nailing after reaming (5, 21, 27, 33, 35). The most important advantages of external fixation are its relative simplicity, the stability of fixation and the preservation of the endosteal vascularity. Nevertheless, several complications have been seen with the use of the external fixator : pin tract infection, loosening and deep infection are frequent (32). Besides, there is a significant risk of deep infection if nailing after reaming is performed following external fixation. Deep infection is especially associated with the usage of a reamed nail in a secondary intervention (5). For all these reasons, the unreamed interlocking tibial nail has become the treatment of choice for Gustilo I, II, IIIa open tibial fractures (5, 7, 21, 27, 32, 35).

In a study concerning 70 unselected open fractures of the tibia a better outcome is seen after unreamed nailing than after external fixation (21). Sargeant *et al.* used the unreamed nail in 14 compound fractures without infection or non-union (33). In comparison with a reamed nail, the UTN proved to offer a number of theoretical and practical advantages. The operation is quicker and it is associated with smaller blood loss. The risk of fat embolism, ARDS and adjacent pulmonary damage is reduced. There is less iatrogenic damage to the vascularization of the bone, so quicker bone healing may be expected. The latter advantage however, could be neutralized by the fact that the fixation is less stable in comparison with reamed implants and a higher incidence of mechanical complications could therefore be expected. Reamed nails are thicker and more solid and have more endosteal contact, mainly in the midshaft, compared to the unreamed ones (1). So, it is not clearly demonstrated that UTN's should be used for closed fractures as well. The data from different authors are controversial. In another study by Mayr *et al.* concerning 70 closed tibial fractures, 35 were treated with an unreamed nail and 35 were treated with a reamed nail. They concluded that using the unreamed nail was advantageous (20). On the other hand, Gregory and Sanders observed no difference between patients treated with UTN and patients treated with a reamed nail (9). In a recent prospective study, Court-Brown *et al.* even reported a superiority of the reamed nail for stable closed fractures (6).

In a clinical comparison, concerning simple fractures of the tibial shaft, Rucholz *et al.* observed earlier painless full weight bearing after an average of 9.7 weeks in patients treated with a UTN versus 12 weeks in patients treated with a reamed nail (30). Haddad *et al.* however concluded that reamed nailing allows early (partial) weight bearing

and that the unreamed nail necessitates slower mobilisation and is associated with a higher re-intervention rate (12).

The main complication associated with the UTN is definitely screw failure and/or breakage (4, 7, 9, 12, 13, 16, 20, 21, 22, 27).

In our study, this complication was observed in 20% of the patients. Hadad *et al.* noted screw failures in 21% and Boenisch *et al.* in 30% (4, 12). As in our study, screw failure was not always associated with delayed union.

A biomechanical study with bone mineral density measurements shows the unreamed construct to be less stable. The screw failure is due to micromovements at the fracture site and to the increased force on the locking screw because of lack of bone-nail contact (8). According to Kneifel and Buckley one should consider the patient's weight and the diameter of the intramedullary canal in the pre-operative evaluation (16). Screw failure is more common in heavier individuals and in wide intramedullary canals (longer locking screws required) (16). Nail failure is a less frequent complication. Hahn *et al.* however reported 5 patients with a broken nail (13).

The technique of dynamisation is also a matter of discussion. The axial pressure in the fracture site will rise after removing distal or proximal interlocking bolts, which stimulates bone healing. The timing of dynamisation is difficult : too soon results in non-stable, incompletely healed fractures and shortening. Too late removal of screws can lead to a hypertrophic consolidation (4). For some surgeons an unreamed nail is only useful in combination with dynamisation after 6 to 8 weeks (29). Stegmann *et al.* even recommended dynamisation and/or bone grafting and locked unreamed tibial nails to enhance union and to reduce the time needed for fracture healing (35). With this protocol, the time to union decreased significantly from 37 to 24 weeks. In delayed union (insufficient radiological consolidation after 3 months), dynamisation and bone grafting are an alternative to be considered, for replacing the unreamed nail by a reamed one (5, 7). The screw failure may be seen as a mechanism of auto-dynamisation and can, in some cases, be an advantage (4). This is probably the reason why screw failure is not necessarily associated with healing problems.

In our series, re-nailing with a reamed nail was necessary in 18% of the cases. This is not surprising as Duwelius *et al.* mention a re-intervention rate of 57% and Gregory and Sanders even inform the patients of the possibility of a second operation (7, 9).

In conclusion, we believe that the UTN should be the treatment of choice for most tibial shaft fractures with important soft tissue damage. We also advise informing the patient that a second operation (dynamisation or re-nailing) may be necessary. In transverse or short-oblique fractures, dynamisation should be routine after six weeks. If healing is delayed over three months, re-nailing with a strong reamed nail is advocated. For isolated closed fractures and for delayed nailing after primary external fixation we suggest the use of reamed nails.

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SAMENVATTING

P. MERTENS, P. BROOS, P. REYNDERS, R. DESWART. Resultaten van de ongeriemde vergrendelde tibianagel.

De auteurs hebben 51 patiënten met een tibiafractuur behandeld met een ongeriemde vergrendelde nagel nagekeken. Het betrof 29 open en 22 gesloten fracturen. Alle fracturen waren geheeld binnen het jaar ; er trad geen enkele diepe infectie op. De belangrijkste complicatie was vervorming of breuk van de vergrendelpen, doch dit had slechts een geringe invloed op de consolidatie. In 18% was een heringreep met uitriemen en een nieuwe nagel noodzakelijk. Volgens de criteria van

Klemm en Börner was het resultaat uitstekend in 55% en goed in 44% der gevallen.
De auteurs stellen een ongeiemde nagel voor bij fracturen met wekedelen schade, dynamisatie na 6 weken en bij vertraagde consolidatie een geriemde nagel na 3 maand.

RÉSUMÉ

MERTENS P., BROOS P., REYNDERS P., DESWART R. Résultats de l'enclouage verrouillé sans alésage du tibia chez 51 patients.

Les auteurs ont revu 51 patients qui avaient présenté une fracture du tibia traitée au départ par enclouage verrouillé sans alésage. Vingt-neuf fractures étaient ouvertes et vingt-deux étaient fermées. Toutes les fractures étaient consolidées endéans l'année ; il n'y a pas eu d'infection profonde. La complication la plus fréquente a été la rupture ou la déformation des vis de verrouillage, mais cette complication n'a eu qu'une influence négligeable sur la consolidation. Un réenclouage après alésage a été nécessaire dans 18% des cas. D'après les critères de Klemm et Börner, le résultat a été excellent dans 55% des cas, et bon dans 44%. Les auteurs recommandent l'enclouage sans alésage pour les fractures accompagnées de lésions des tissus mous ; ils suggèrent de dynamiser l'implant après six semaines dans le cas de fractures transversales et obliques courtes ; dans le cas d'un retard de consolidation, ils suggèrent un réenclouage avec alésage au troisième mois.