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Distal tibial fractures and non-unions treated with shortened intramedullary nail

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Abstract We reviewed 18 patients, 14 with acute fractures and four with non-union of the distal tibia, treated between 1990 and 2001 with a shortened, reamed intramedullary nail. The mean follow-up was 38 (8–144) months. The fractures united at an average of 16 (12–18) weeks and the non-unions at 20 (12–30) weeks. Two patients required nail dynamization. No limb shortening nor material failures were seen. All patients returned to normal daily activities. Although technically demanding, intramedullary nailing for distal tibial fractures and non-unions with a shortened nail represents a safe and reliable method.

Résumé Nous avons revus 18 malades, 14 avec une fracture récente et quatre avec une pseudarthrose tibiale distale, traité entre 1990 et 2001 avec un clou intramédullaire court placé après alésage. Le suivi moyen était de 38 mois (8–144). Les fractures ont consolidé à une moyenne de 16 (12–18) semaines et les pseudarthroses à 20 (12–30) semaines. Deux malades ont nécessité une dynamisation du clou. Il n'y a pas eu de raccourcissement de membre ni d'ennuis de matériel. Tous les malades ont retrouvé des activités journalières normales. Bien que difficile techniquement, l'enclouage intramédullaire distal avec un clou court représente une méthode sûre et fiable.

Introduction

Reamed tibia intramedullary nailing is now commonly used in the management of tibia shaft fractures and is considered by some [2, 10] to be the treatment of choice in closed displaced fractures. The indications for intra-

medullary nailing of the tibia have been expanded to also include fractures in the distal metaphyseal region [1, 7, 9]. In contrast to diaphyseal tibial fracture intramedullary nailing, the nailing of dia-metaphyseal fractures with short distal fragment is associated with an increase in frontal and sagittal plane malalignment, as well as a risk for nail propagation or fracture augmentation in the ankle joint [4, 9, 11]. The incidence of malalignment is due to instability, which results from the great difference between the implant diameters and the medullary cavity in the metaphysis.

As the nail does not contact cortical bone, it may translate along the interlocking screws because of the free space between the screws and nail holes. Thus, the insertion of two interlocking screws in these unstable fractures becomes more important in maintaining reduction [6]. However, some tibial fractures are located too distal—4 cm or less of the ankle joint—to allow placement of two interlocking screws in the metaphyseal fragment. In these cases, it is possible to saw off the tip of the nail, thus allowing the nail to be inserted very distally, with the capacity to use two distal interlocking screws [3, 8, 9]. Increased risk for fracture healing in malalignment, due to the low stiffness in compression bending of the bone-modified implant construct [5], as well as screw breakage, has been reported [3].

We reviewed our results on managing these injuries consisting of very distal tibial fractures and non-unions with or without minimal ankle-joint involvement, over an 11-year period.

Materials and methods

Between 1990 and 2001, 18 patients having a fracture of the distal tibial metaphysis were treated with reamed intramedullary nailing using an implant in which the distal 1 cm, just below the lowest locking screw hole, had been removed. There were 13 men and five women, with a mean age of 36.4 (28–62) years. There were 14 acute fractures, which were treated in the first 48 h following the injury, and four non-unions—three after failed external hybrid osteosynthesis and one after failed conservative treatment. The mean time of secondary nailing was 15 (12–20) weeks. In all

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Fig. 1A, B Type C1 fracture of distal tibia. **C** Treatment with malleolar fixation, shortened nail and free intrafragmentary screw. **D, E** Solid union 6 months postoperative

Table 1 Post-operative mobilisation according to fracture type

Number of patients	Tibial fracture type	Fibula fracture location and number	Weightbearing until sixth week post-operatively
8	A1	Upper part—5 Middle part—2 Lateral malleolus—1	Partial Partial No
2	A2	Upper part—1 Middle part—1 Lateral malleolus—1	Partial Partial No
4	C1	Lateral malleolus—3	No

cases, a Grosse and Kempf (Howmedica, Rutherford NJ, USA) nail of an 11 (9–12) mm average diameter was used.

Fractures were classified according to the AO scale: ten fractures belonged to the 43-A category (8 A1 and 2 A2) and four to the 43-C (C1) category. In all cases, a fibula fracture co-existed as well (Table 1). In one case, there was a medial malleolar fracture, too. Two fractures were open (Gustilo type A). Pre-operative surgical planning was always performed and led to precise nail dimension.

Operative technique

Patients were submitted to total anaesthesia then placed on a fracture reduction table using radioscopic control. When the fibula fracture was located on its peripheral third (up to 10 cm from the edge of the lateral malleolus), the fibula was fixated with the use of a neutralisation plate. In this way, the reduction of the tibia fracture was facilitated, the length of the limb was maintained and its axis during nailing was ensured. The medial malleolar fracture was fixed using a malleolar screw. When the fracture line was intra-articular extending towards the ankle joint (category C1), one or more intrafragmentary screws were placed in the lower metaphysis of the tibia before the nailing; the nail's propagation in the joint was so avoided.

After introducing the guidewire, the exact length of the intramedullary canal was again calculated, and so was the length of the nail. Afterwards, the edge of the nail distal to the last screw hole (about 1 cm long) was cut on a sterilised table; the new edge was

then smoothed and rinsed with saline in order to remove all metal debris. A non-olive intramedullary guidewire was used, and the reaming proceeded peripherally till it reached the subchondral bone. The last reamer was 1 mm wider than the nail chosen. Special attention was paid to centring the edge of the wire guide in the distal tibial metaphysis in order to avoid displacement and angulation of the fracture. The nail was carefully introduced; the procedure was radioscopically controlled. The nail was locked either statically or dynamically with two peripheral screws (Fig. 1).

Active knee-joint and ankle-joint mobilisation was encouraged on the first post-operative day. Patients with A1 or A2 fracture without malleolar involvement were allowed partial weightbearing of about 20 kg until the sixth week and full weightbearing only after the third month. On the contrary, patients with malleolar or intra-articular tibial fractures (C1) were not allowed partial weightbearing until the sixth week (Table 1).

For the treatment of non-unions, the technique was slightly modified. No reduction table was used and no malleolar osteosynthesis was carried out. A fibular osteotomy was performed, and dynamic nailing without central locking was applied. The non-union area was not opened and no bone grafts were used, while the non-union site was always over-reamed. In one case (Fig. 2), the non-union was located 2 cm above the ankle joint. We then removed 2 cm of the nail, and only one distal locking screw was used. All patients were followed monthly until union occurred, then bimonthly up to the first year and yearly thereafter.

Fig. 2 **A** Nonunion after "hybrid" fixation of a distal tibial fracture. **B** Treatment using a dynamic, closed, reamed, modified nail with one distal locking screw. **C** Fracture union one year postoperative

Results

The mean follow-up was 38 (8–144) months. All fractures had united at the final review. Radiological union was achieved for all patients within an average of 16 (12–18) weeks. Two patients required nail dynamization by removal of the proximal locking screws. Four patients healed in malalignment. In two there was 5° and 6° of valgus deformity, while in the other two there was a 5° ante-curve. No further surgical intervention was needed. No shortening of the leg was noticed and no material breakage reported.

Two patients complained of mild anterior knee pain; no limitation of knee motion was observed. Four patients experienced a slight limitation in ankle motion (less than 10°); the Iowa ankle score ranged from 82/100 to 100/100 (mean 87/100). There was one infection, which was treated with wound debridement and intravenous antibiotics. All patients assumed their pre-operative activities. Non-unions healed at a mean of 20 (12–30) weeks; the Iowa ankle score ranged from 60/100 to 87/100 (mean 82/100).

Discussion

Intramedullary tibial fracture nailing has become the procedure of choice for the majority of unstable or displaced tibial diaphyseal fractures. Many studies document the advantages of the technique in term of a high rate of union and low incidence of malunion and infection [2, 10]. With this method, fractures located until 5 cm from the tibiotalar joint can be managed successfully.

The success of interlocking intramedullary nailing for the treatment of all types of fractures of the tibial diaphysis has led orthopaedic surgeons to extend the range of indications in order to address more distal fractures [6, 9]. However, the nailing of these unstable fractures is associated with many technical difficulties.

As the configuration in the distal tibial metaphysis becomes flare, the discrepancy between the nail diameter

and the diameter of the distal medullary canal increases, as well as the potential micro-motion of the nail. Screw breakage is also noticed more often in the wide metaphyseal region (locking screws of longer length) compared to the diaphyseal region. The insertion of two distal locking screws becomes therefore more necessary. It is also well documented that the placement of two distal screws increases the stiffness and strength of the bone-implant construct, thus leading to enhanced mechanical stability of the fixed fracture [2, 6].

The modification of the nail, by removing the distal 1 cm, allowed us to treat very distal tibial fractures and facilitated interlocking by two distal screws. The biomechanical consequences of cutting the tip of a tibia nail have been demonstrated by Gorczyca et al. [5]. Fixation strength is not enough to resist moderate compression-bending loads, and it is suggested that patients with distal tibia fractures treated with intramedullary nailing must follow weightbearing restrictions until fracture healing occurs in order to prevent fracture malalignment.

In our experience, all fibular fractures located up to 10 cm proximally from the edge of the lateral malleolus should be fixed with the use of a neutralisation plate. In this way, tibial fracture reduction is facilitated, the limb length can be maintained and its axis during nailing is ensured. This strategy leads to stable osteosynthesis, thus avoiding malunion, rotational deviations of the metaphyseal fragment, limb shortening and material failure (screw or modified nail breakage). Whittle et al. [12] also found necessary the fixation of same-level fibular fractures, while Robinson et al. [9] did not specifically pay attention to fibular osteosynthesis.

In our study, any fracture extension into the ankle joint was stabilised by one or more intrafragmentary cancellous screws before the nail's insertion in order to avoid intraarticular propagation of the nail or the fracture. Robinson et al. [9] described the stabilisation of displaced fracture extensions in the ankle joint after inserting the nail.

Secondary procedures were required in only two of our patients and consisted of nail dynamization by removal of the proximal locking screws. All patients had a

successful clinical result and returned to normal daily living activities. Distal tibial non-unions can be treated with the same technique.

This study suggests that inserting a modified, shortened tibial nail for very distal metaphyseal fractures, although technically demanding, represents a reliable method that offers a stable and biological fixation. Fracture healing is achieved without significant malalignment; limb shortening was not seen. Special attention must be given to fibular fixation and post-operative weightbearing protocol.

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