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CLOSED AND OPEN GRADE I AND II TIBIAL SHAFT FRACTURES
TREATED BY REAMED INTRAMEDULLARY NAILING

THESE

Préparée sous la direction du
Dr François Chevalley, PD MER

et présentée à la Faculté de biologie et de médecine
de l'Université de Lausanne pour l'obtention du grade de

DOCTEUR EN MEDECINE

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Originaire de Pully (VD)

Lausanne
2006

Résumé

TRAITEMENT PAR ENCLOUAGE CENTRO-MEDULLAIRE ALESE DES FRACTURES DIAPHYSAIRES DU TIBIA FERMEES ET OUVERTES STADE I ET II SELON GUSTILLO

Ali Djahangiri, MPP 2006 ; 15 :293-8

Objectif :
Le but de cette étude est d'évaluer les résultats du traitement par enclouage centre-médullaire alésé des fractures diaphysaires du tibia aussi bien fermées que pour les fractures ouvertes de stade I et II selon Gustillo.

Méthodes:
Entre 1997 et 2000, 119 patients présentant une fracture diaphysaire du tibia ont été traités dans notre service par un enclouage centre-médullaire alésé. En postopératoire, 96 patients, soit 70 fractures fermées et 26 fractures ouvertes I et II selon Gustillo, ont été suivis cliniquement et radiologiquement pour une période de plus d'une année et demi.
L'introduction du clou centro-médullaire a été faite selon la technique habituelle, soit transtendineuse ou paratendineuse rotulienne. Tous les clous ont été alésés jusqu'à 1,5 mm au-dessus du diamètre du clou.
Les patients ayant une fracture isolée du tibia ont été immédiatement mobilisés en charge partielle pour une période de 6 semaines. Ceux qui avaient des lésions associées, notamment au niveau de la cheville épsilatérale, ont nécessité la mise en place d'un plâtre de type Sarmiento.

Résultats :
Six patients (6,3%) ont développé un syndrome des loges après chirurgie. Quarante-huit cas (50%) ont nécessité une dynamisation du clou après une période moyenne de 12 semaines en raison d'un retard de consolidation.
En général, 90,6% des fractures ont consolidé après 24 semaines postopératoires en moyenne, sans aucune différence significative entre les fractures fermées et les fractures ouvertes. Deux patients (2,1%) présentant une fracture ouverte degré II ont développé une infection profonde ayant nécessité un traitement. Nous avons également observé 9,4% de cals vicieux minimes et sans conséquence clinique. Huit patients (8,3%) ont eu une brisure des vis de verrouillage mais également sans conséquence clinique.
Au dernier contrôle, 52% des patients, dont l'introduction du clou s'est faite en transtendineux ont des douleurs antérieures du genou contre 14% parmi ceux où l'introduction était paratendineuse.

Conclusion : L'enclouage centre-médullaire reste le traitement de choix pour les fractures diaphysaires du tibia, qu'elles soient fermées ou ouvertes degré I ou II selon Gustillo.

Original Paper

Closed and Open Grade I and II Tibial Shaft Fractures Treated by Reamed Intramedullary Nailing

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Abstract
Objective: To evaluate the results of closed and open grade I and II tibial shaft fractures treated by reamed nail and unreamed nailing. *Subjects and Methods:* Between 1997 and 2000, 119 patients with tibial shaft fractures were treated with reamed tibial nails. Postoperatively 96 patients (70 closed and 26 grade I and II open fractures) were followed clinically and radiologically for up to 18 months. The nail was inserted either by patellar tendon splitting or by nonsplitting technique. The nail was inserted after overreaming by 1.5 mm. Postoperatively, patients with isolated tibial fracture were mobilized by permitting partial weight bearing on the injured leg for 6 weeks. Patients with associated ankle fractures were allowed to walk with a Sarmiento cast. *Results:* Postoperatively, 6 (6.3%) patients developed a compartment syndrome after surgery. In 48 (50%) cases, dynamization of the nail was carried out after a mean period of 12 weeks for delayed union. Overall, a 90.6% union was obtained at a mean of 24 weeks without difference between closed or open fractures. Two (2.1%) patients with an open grade II fracture developed a deep infection requiring treatment. A 9.4% rate of malunion was observed.

Eight (8.3%) patients developed screw failure without clinical consequences. At the last follow-up, 52% of patients with patellar tendon splitting had anterior knee pain, compared to those (14%) who did not have tendon splitting. *Conclusion:* Reamed intramedullary nail is a suitable implant in treating closed as well as grade I and II open tibial shaft fractures.

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Introduction

The treatment goal of tibial shaft fractures is to achieve union with correct alignment and restoration of normal knee and ankle mechanics as well as regaining early autonomous ambulation. This is achieved by either nonoperative treatment or by surgery, using reamed or unreamed intramedullary nailing, open reduction and internal fixation (ORIF), and external fixation [1–6]. Locking Grosse and Kempf (GK) intramedullary nail was introduced in 1974. It permits wider indications for tibia nailing to proximal and distal fractures and enables simultaneous treatment of unstable fractures in length and rotation to stabilize middle shaft fractures [7, 8].

Intramedullary nailing has gained wide acceptance in the management of both closed and open fractures of Gustilo types I and II, as well as IIIAs and IIIBs [9–12].

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Table 1. Fractures graded according to the AO and Gustilo classification

	AO type A	AO type B	AO type C	Total
Closed	46	14	10	70
Gustilo I	13	2	0	15
Gustilo II	5	2	4	11
Total	64	18	14	96

The advantage is that closed reduction and good union rate are achieved [5]. Reaming of the tibia allows the insertion of a large diameter nail, which confers more stability, allows much earlier weight bearing, limits the risks of material fractures and reduces the risks of a second operation [13, 14]. This study evaluated the results of closed and open grade I and II tibial shaft fractures treated by GK type reamed intramedullary nailing and unreamed nailing.

Materials and Methods

Of all adult patients treated for closed or open fractures of the tibial shaft between 1997 and 2000, 96 met these study criteria. Those treated nonoperatively, with external fixator or by ORIF were excluded from analysis, as were those treated with a GK nail (Stryker Howmedica), had polytrauma or primary treatment with an external fixator. Some were lost to follow-up.

Clinical charts and X-ray films of the 96 patients (65 males and 31 females; average age 43.6 years, range 18–72, 64 AO type A fracture, 18 type B and 14 type C) were retrospectively evaluated. Forty patients were injured as a result of a fall or a twist. Thirty-two patients were involved in a motor vehicle accident as either a driver, a passenger or a pedestrian and 24 were sports injuries. These included 70 closed, 15 open grade I, and 11 open grade II tibial fractures (table 1).

Seventeen patients presented an associated ipsilateral ankle fracture (11 lateral malleolus, 3 medial malleolus and 3 bimalleolar). Five patients had a fracture line that reached down the pilon, requiring an osteosynthesis with an anteroposterior lag screw.

Open wounds were debrided and closed. Antibiotic prophylaxis was performed with cefuroxime (1.5 g intravenously preoperatively, and 0.75 g 8 h postoperatively). The prophylaxis (0.75 g of cefuroxime 8-hourly) was extended to 48 h for open fractures.

The nail entry site was done by splitting the patellar tendon in 67 cases and without splitting in 29 cases. The diameter of the inserted nail was 9, 10, 11, and 12 mm in 16, 29, 45 and 6 cases, respectively. Eighty-nine nails were statically interlocked, and for the rest (7 cases, with a middle-third transverse fracture), the nail was locked with double distal interlocking screws. Of the 89 cases with a high tibial shaft fracture, 8 required a proximal anteroposterior screw.

Compartment pressure was measured when lower limb compartment syndrome was suspected (based on clinical symptoms: pain on passive stretching of the compartment or pain out of proportion to the injury). Fasciotomy was performed when there was a difference in compartment pressure and diastolic pressure, ΔP = <30 mm Hg.

After 48 h, patients with an isolated tibial fracture started 20 kg partial weight bearing on the injured leg for 6 weeks. In cases with an associated ankle fracture, weight bearing under protection with a Sarmiento plaster was allowed. Postoperatively, patients were followed up clinically and radiologically for up to 18 months. Clinical examination entailed evaluation of the presence of anterior knee pain, fracture-related pain, neurological status, the step angle, and shortening of the leg. The length of time for resumption of normal activities was also noted.

Clinical charts and anteroposterior and lateral X-ray views of the injured leg were assessed blindly by an independent examiner. Union, delayed union or malunion and metalwork failure were noted. Fractures were considered clinically united when pain-free walking was possible. On the X-ray films, union was defined as bridging callus on two radiographic views with disappearance of the fracture line. The absence of union after 3 months was considered as delayed union. After 6 months, it was considered as pseudarthrosis. Malunion was defined as varus/valgus greater than 5°, and/or anteflexum/recurvatum angulation greater than 10°, and/or internal/external rotation greater than 10° after union.

Union, nonunion, infection rates as well as the incidence of compartment syndrome were evaluated separately in closed and open fractures for any significant differences. The association between the presence of compartment syndrome, the elapsed time between trauma and surgery, and operation time itself were also noted. Lastly, the presence of anterior knee pain was evaluated with respect to entry point of the nail and if the nail was proud or seated.

Statistical analysis of all data was performed using Wilcoxon signed-rank test for independent samples, p = 0.05.

Results

Nine (9.4%) patients with neurological symptoms after the operation recovered within 3 months: 6 of the 9 had limb compartment syndrome treated by fasciotomy and, the remaining 3 who did not have clinical symptoms of compartment syndrome presented with extensor hallucis longus weakness and hypoesthesias of the first web space.

Three cases out of the 6 with compartment syndrome had closed fracture and 3 had Gustilo grade I open fracture. None of these patients presented an associated ankle fracture. They were operated on average 24 h after admission (range 4–48 h) and the mean intervention time was 105 min (range 60–145 min).

Postoperative X-ray films showed 1 varus, 2 valgus, and 4 recurvatum deformities exceeding 10°. In 6 patients, a distraction greater than 2 mm at the fracture site
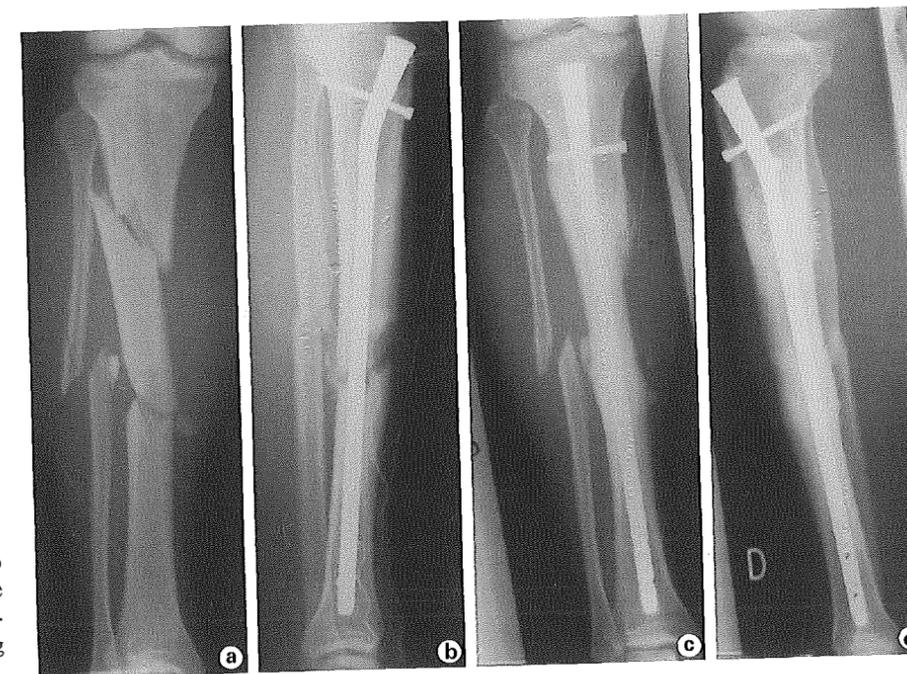

Fig. 1. Images in a 44-year-old man who was involved in a car accident. Preoperative anteroposterior X-ray view (**a**), postoperative lateral X-ray view (**b**) and after healing (**c, d**).

was observed. Five of these patients developed a compartment syndrome requiring fasciotomy.

Clinically, fracture union was observed on an average at 18 weeks (range 13–46) for both closed and open fractures, regardless of whether they were weight bearing or partial weight bearing (table 2). No statistically significant difference was found in union times between closed and open injuries (p > 0.05). For compartment syndrome, no correlation was found between the time elapsed from accident to surgery or with operative time itself (p = >0.05). A strong correlation was noted between compartment syndrome and fracture distraction after reduction (p = <0.05).

In 48 (50%) cases, delayed union requiring dynamization at 12 weeks on average was found. Union after dynamization was observed on average after 6 weeks (range 4–10 weeks, fig. 1).

Nonunion occurred in 5 (5%) patients. Three of these 5 patients had a closed fracture and the other 2 an open grade II fracture (fig. 2). Treatment for nonunion consisted in 2 cases of bone grafting, in 2 cases of exchange nailing and in 1 of nail removal with application of a walking cast. Two (2.1%) patients, both grade II open fractures, developed a deep infection. Treatment consisted of administration of antibiotics, nail removal and plaster until healing.

Table 2. Union time in weeks

	Partial weight bearing (n = 79)	Sarmiento plaster (n = 17)
Closed (n = 70)	(n = 52) 24 (13–36 ± 5.8)	(n = 14) 23 (13–35 ± 6.7)
Open I and II (n = 26)	(n = 27) 24 (13–46 ± 9.8)	(n = 3) 26 (18–39 ± 10.6)

No significant differences were found between closed and open fracture or whether treatment was partial or full weight bearing.

Statistically, no significant difference was observed between closed and open fractures with both compartment syndrome and delayed union (p = >0.05). However, a statistically significant correlation was observed between open fractures and infection (p < 0.05).

Eight (8.3%) patients had implant failure: 4 proximal and 4 distal screw breakages. In 6 of these 8 patients, the fracture was overdistracted, but all progressed to bony union. At the last follow-up, 27 patients had difficulties due to fracture repair: 2 (2.1%) neurological symptoms and 5 (5.2%) occasional fracture-related pain. Fifteen (15.6%) had ankle pain but only 5 of them had an operated ankle fracture.
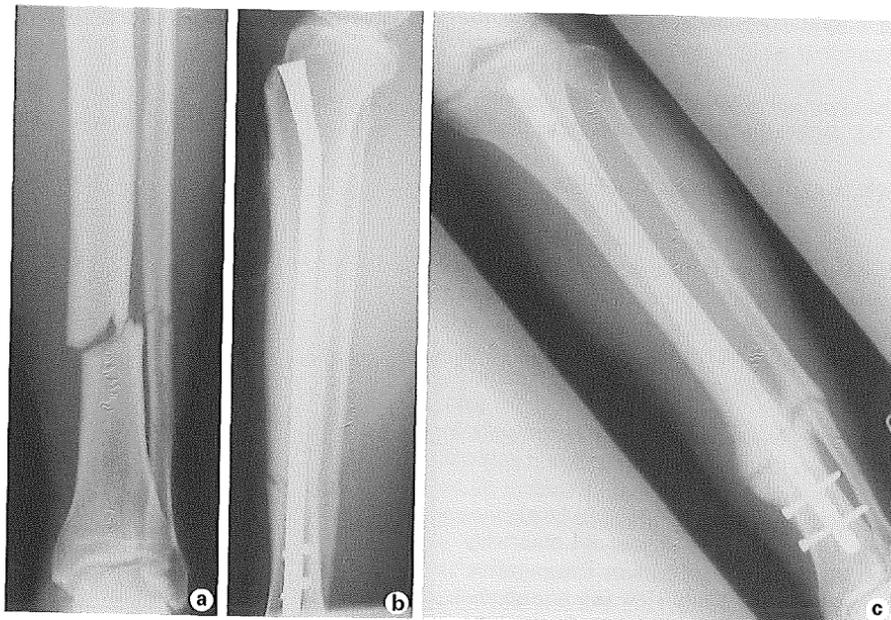
Fig. 2. Images in a 50-year-old man who fell from a 6-meter height. Preoperative antero-posterior X-ray view (**a**), postoperative lateral X-ray view (**b**) and pseudarthrosis (**c**).

Thirty-nine (41%) patients complained of anterior knee pain. Analysis of the results showed that 52% of patients who were nailed by splitting the patellar tendon presented anterior knee pain and only 14% complained of knee pain when the tendon had not been split, irrespective of weather the nail was proud or well seated. This difference was statistically significant (p < 0.05). For 9 (9.4%) patients, the fractures healed with malunion: 2 in varus of 8 and 10°, respectively, 5 in valgus of 8° on average (range 7–10°) and 2 external rotation malalignment with a step angle discrepancy of 10°. All malunions were asymptomatic. No anterecurvatum deformity and leg shortening occurred.

All patients, excluding office workers, resumed work 5 months (range: 3–15) after injury. Sporting activities were possible at 6.5 months (range: 3–18).

Discussion

In this study, a combined union rate of 90.6% was noted for closed and open grade I and II tibial fractures treated by intramedullary reamed nailing. These findings are comparable with others, for both reamed and unreamed nailing [9, 15].

Time to complete union as confirmed by radiological union was 4 weeks longer compared to the published union times [1, 16, 17]. Possibly, this difference could be due to interobserver variability in X-ray film evaluation [18] and the definition of union. However, clinically judged union time (as observed on average 6 weeks prior to radiological union) compared favorably with previously reported data [1, 16, 17].

The 8.3% screw breakage rate compares favorably with other studies on unreamed nailing [11, 13, 15]. The strength of intramedullary nails is primarily determined by their diameter. This is also true for interlocking screws. Therefore, larger nails are stronger and more resistant to failure than smaller unreamed nails and these confer increased stability of the fracture site [14]. The nonunion rate in this study was similar to that reported in the literature [2, 17, 19] and no difference was noted in nonunion rates between closed and open fractures. However, Bhandari et al. [15] showed that reamed nailing reduced the risk of nonunion by 57%, irrespective of whether the fracture was closed or open. Although several biological studies have shown a negative effect of reaming on intramedullary blood flow [20], others have demonstrated that this does not influence callus formation [9, 15, 21, 22].

The malunion rate of 9.4% in this study is similar to that reported earlier [23]. That our rotational malalignment patients (2 cases) were asymptomatic, is in agreement with the observation that deformities less than 15° tend to produce little symptoms [24, 25].

The cases with compartment syndrome (6 patients) in the current study were linked to intraoperative overdistraction with no association with delay in surgery time. These findings are in accordance with published data [26]. Although it has been suggested that reaming tends to increase the risk of compartment syndrome, the converse has also been shown in a study involving compartment pressure measures before, during and after surgery [27].

McQueen et al. [26] reported good functional outcome for patients who had decompression within 24 h. In this study, it is interesting to note that postoperatively 3 patients with a closed fracture presented a dropped hallux with hypoesthesias of the first interdigital space without any confirmation of compartment syndrome. All experienced spontaneous resolution within 6 months, as was reported previously [28]. We hypothesized that a branch of the deep peroneal nerve was damaged during proximal interlocking even though it was performed from medial to lateral. However, a compartment syndrome with a mild clinical course or a distraction of the nerve due to the position on the orthopedic table cannot be excluded.

The two deep infections occurred in grade II open fractures. This low rate may be due to aggressive débridement and the associated use of intravenous antibiotics. Compared to other studies on reamed and unreamed nailing, this result suggests that reaming does not increase the infection rate even though ours was not a randomized trial [2, 9, 5, 23]. Recent reports showed no difference in infection rates in open fractures, regardless of whether they were treated with reamed or unreamed nailing [9, 13, 17]. However, infection rates can rise to 18% when grade IIIB open fractures are nailed after reaming [10].

The incidence of anterior knee pain (41%) in this current study compares favorably with that reported previously [29]. However, a statistical difference was found for knee pain in relation to the surgical technique (tendon splitting vs. no splitting) employed, p < 0.05. A large group of patients would be necessary to validate the findings here regarding anterior knee pain.

Conclusion

Reamed intramedullary nailing is an effective measure in treating closed and grade I and II open tibial fractures. Reaming permitted the insertion of stronger nail, which decreased material failure and increased fracture site stability. The incidence of anterior knee pain suggests avoiding patellar tendon splitting.

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