Orthopaedics & Traumatology: Surgery & Research 105 (2019) 173–177

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

Use of intramedullary nailing in poor sanitary conditions: French Military Medical Service experience

Alexandre Caubere*, Thomas Demoures, Camille Choufani, Victor Huynh, Olivier Barbier

Service de chirurgie orthopédique et traumatologie, HIA Bégin, 69, avenue de Paris, 94160 Saint-Mandé, France

ARTICLE INFO

Article history:
Received 16 April 2018
Accepted 10 October 2018

Keywords:
Intramedullary nailing
Neglected fracture
Low-income country

ABSTRACT

Introduction: Intramedullary (IM) nailing is the gold standard for treating long bone fractures in developed countries because of its minimally-invasive application and good biomechanical properties. In precarious conditions, external fixation or open plate fixation are often performed because surgeons do not have the means to carry out IM nailing. However, these procedures can lead to infection-related complications and mechanical failures. The aim of our study was to describe the outcomes and postoperative complications of IM nailing of closed, long bone fractures in patients operated in a French front-line combat surgical unit (role 2+). Our hypothesis was that IM nailing is a reliable technique with low morbidity for the initial treatment of long bone fractures, even in precarious situations.

Material and methods: This was a prospective, single-center, descriptive study of patients operated on between April 2016 and November 2017. All the patients with a closed femur or tibia fracture who were treated by IM nailing were eligible, no matter their time to surgery. The minimum follow-up was 6 months. The primary endpoint was the absence of infection-related complications and the secondary endpoint was fracture union.

Results: Fifty-eight patients were reviewed after an average follow-up of 4.7 months (range, 3–15 months). The mean patient age was 35.2 years (15–85 years) and the majority of patients were men (52 of 58). The fracture was in the femur in 74.1% ($n = 43$) of cases and in the tibia in 25.9% ($n = 15$) of cases. The time to surgery averaged 122.3 days (7–720 days) with a median of 60 days. In 74% of cases ($n = 43$), fracture realignment required an open surgical approach. The postoperative course was considered normal in 96.6% of cases ($n = 51$). No infections were reported as of the last follow-up visit. Union occurred in an average of 4 months in 70.7% of cases ($n = 41$). There were three cases of nonunion after 6 months.

Discussion: Even in precarious situations, IM nailing is an effective, reliable method with a low complication risk and high union rate for the treatment of neglected long bone fractures. This surgical treatment is well suited to the poor sanitary conditions on the African continent.

Level of evidence: II, low-powered prospective study.

1. Introduction

Trauma, especially due to road traffic accidents, is an endemic problem in Africa. The sanitary conditions in Chad are worse than those of other countries in sub-Saharan Africa [1,2] and the access to care is limited because of economic reasons (lack of pre-hospital medicine) and cultural reasons, as the citizens strongly believe in traditional medicine [3]. The large majority of long bone fractures are seen by surgeons a long time after the initial injury event. Given the large number of mechanical failures and infection-related complications following plate fixation (Fig. 1) of neglected fractures, the primary treatment of long bone fractures using IM nailing, no matter the time to surgery, appears to be relevant.

The aim of our study was to describe the outcomes and postoperative complications of IM nailing of closed, long bone fractures in patients operated in a French front-line combat surgical unit. Our hypothesis was that IM nailing is a reliable technique with low morbidity for the initial treatment of long bone fractures, even in precarious situations.

2. Material and methods

Since 1986, a French front-line surgical unit has been deployed at Camp Koseï in N'Djamena. The large majority of the practice is

* Corresponding author.
E-mail address: alexandre.caubere@hotmail.fr (A. Caubere).

https://doi.org/10.1016/j.otsr.2018.10.017
1877-0568/

Fig. 1. Failure of fracture fixation hardware; plate used for a fracture in the lower third of the right femoral shaft (AP and lateral views).

dedicated to assisting local civilian populations. While the orthopedic surgeon is isolated, he has, at his disposal, various internal and external fracture fixation materials, in particular, those for inserting an intramedullary nail (traction table, fluoroscopy, etc.). Access to antibiotics and laboratory work-ups is limited.

2.1. Study population

This was a prospective, descriptive study of patients operated between April 2016 and November 2017 in Chad. During this period, all patients with a closed femur or tibia fracture who were treated by IM nailing were eligible, no matter their time to surgery. Exclusion criteria were: any failure fixation requiring surgical revision by IM nailing, with open fractures mostly requiring staged surgery. The minimum follow-up was 6 months.

2.2. Surgical technique

The surgical procedure was performed by military orthopedic surgeons at the front-line surgical unit. The nail was inserted under fluoroscopy guidance with the patient on a standard or traction table. A standard nailing technique was used with AO nails (Fig. 2). Fractures that were more than 3 weeks old were approached directly and supplemented by autograft (iliac crest, bone removed during reaming) to stimulate bone healing. In the other cases, the fractures were preferentially treated without opening the fracture site unless required to reduce the fracture. In certain cases of chronic fracture, the bone ends had to be trimmed to reduce the fracture. The IM nail was locked depending on the type of fracture and the availability of fluoroscopy. Weight bearing was allowed immediately or delayed by a few weeks based on the surgeon's experience.

2.3. Data collection

The following data were collected: age, fracture location and mechanism, type of fracture (open/closed), time to surgery. During the postoperative course, the final follow-up visit was used to determine whether an infection was present (wound dehiscence or drainage, spontaneous pain or pain upon palpation, erythematous skin, swelling, edema). Union was determined based on the clinical examination (no pain upon palpation and weight bearing) and AP and lateral X-rays (continuous cortices and presence of fracture callus).

2.4. Statistical analysis

The demographic data was analyzed using Microsoft Excel (Microsoft, Redmond, WA, USA). The qualitative variables were compared using Fischer's exact test. A p value of 0.05 or less was considered significant.

Fig. 2. Dynamic IM nailing of a neglected fracture of the left tibia; appearance at 3 months postoperative. The size of the nail depends on product availability and distal locking depends on fluoroscopy availability.

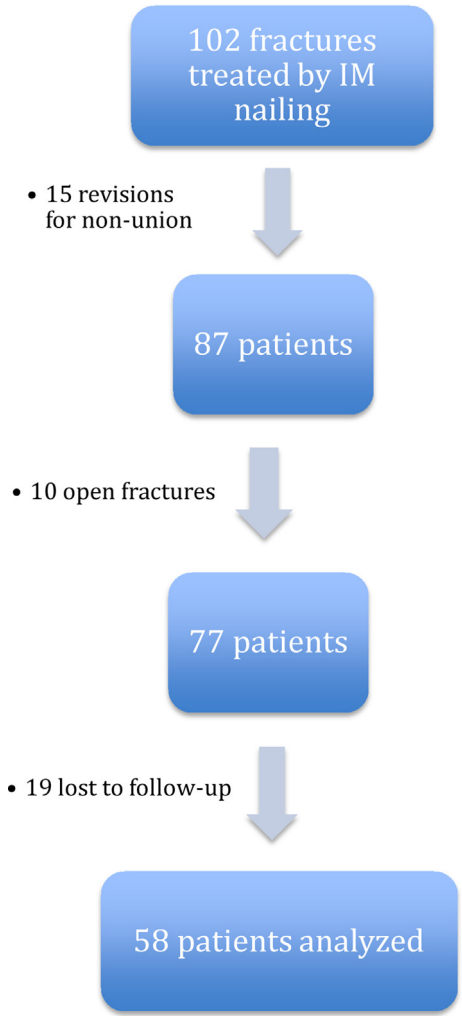

Fig. 3. Study flow chart (IM: Intramedullary).

3. Results

3.1. Study cohort

Between April 2016 and November 2017, 102 patients with a lower limb fracture were treated by IM nailing at the N'Djamena surgical unit. Twenty-five patients were excluded: 15 patients had a non-union revised by IM nailing and 10 had an open fracture. Nineteen patients were lost to follow-up. In all, 58 patients were analyzed (Fig. 3).

The injury mechanism was a traffic accident in every case. The average patient age was 35.2 years (range 15 to 85 years). The majority of patients were men ($n = 52$). The fracture was in the femur in 43 cases and the tibia in 15 cases. The median time to surgery was 60 days (SD: 134 days).

3.2. Surgical technique

After the procedure, the surgeon allowed full weight bearing in 33 patients and delayed weight bearing by 45 days in the other 25 patients. In 43 cases, fracture realignment required an open surgical approach. In these cases, the median time to surgery was 90 days (SD: 135.6 days). When the fracture was exposed, a bone graft was added in 22 cases (bone reaming debris or iliac crest graft). At the end of the procedure, bone shortening averaged 1.6 cm (range, 0 to 6 cm).

3.3. Complications and postoperative course

The patients were reviewed a mean of 4.7 months after surgery (3–15). The postoperative course was considered normal in the majority of cases ($n = 51$). No infections were reported as of the last follow-up visit. Union occurred in an average of 4 months in 41 cases. The fracture was still healing in 14 cases. There were three cases of non-union (Table 1) and one case of compartment syndrome in a 10-day-old closed mid-shaft tibial fracture.

4. Discussion

Our study found a low risk of infection and a high rate of bone union (4 months on average) in fractures treated by IM nailing, no matter the time elapsed between the accident and surgery. The complication rate was low, despite the need to directly access the fracture site to reduce the fracture and carry out the nailing in the large majority of cases ($n = 43$). Thus our primary hypothesis is verified: even in precarious situations, IM nailing is an effective, reliable method with a low complication risk and a high union rate for the treatment of neglected long bone fractures.

The primary limitation of our study is the large number of patients lost to follow-up; this is evidence of the challenges of following patients in Africa, who may be unable to travel long distances or who may not have the financial means to travel. The second limitation is the short follow-up, especially for the evaluation of fracture union. We had decided on a minimum follow-up of 6 months, a time frame in which we could diagnose non-unions. The strength of this study is that it was a prospective evaluation of fracture patients treated by IM nailing in precarious conditions.

The initial care of limb injuries in developing countries is often delayed because of the cost of treatment, lack of nearby hospitals and travel challenges related to the road conditions. The first practitioner consulted is often a "traditional one" [3]. In fact, patients prefer to receive treatment from a traditional practitioner for practical, financial and cultural reasons [1,4]. These neglected long bone fractures are a challenge for the orthopedic surgeon who often works in isolation with limited means [5,6].

Intramedullary nailing is the gold standard for treating long bone fractures in developed countries because of its minimally invasive application and good biomechanical properties [6–8]. In our practice, along with rigorous aseptic conditions, this technique requires specific instrumentation and the use of fluoroscopy. The sanitary conditions at the French remote surgical unit in N'Djamena are better than those in many hospitals in sub-Saharan Africa. In regional hospitals, IM nailing is difficult to perform because traction tables are frequently lacking, and fluoroscopy may not be available. In these conditions, even freshly closed fractures are treated by open surgery. The Surgical Implant Generation Network (SIGN) intramedullary nail was developed for use in low-income countries [9,10] and allows IM nailing to be performed without fluoroscopy. In fact, use of plate fixation to treat this type of fracture is not without consequences, such as hardware failure and infection-related complications. Eliezer [11] found a 25% reoperation rate for plate fixation versus 5.2% for IM nailing in a study of 331 femoral shaft fractures. IM nailing has a low risk of reoperation with good functional scores and return to activity at 1 year of follow-up.

Few published articles have evaluated the effectiveness or morbidity of IM nailing in countries with poor sanitary conditions. Our findings are consistent with those of other published studies. Most of these studies found the infection rate was similar to the one reported in developed countries [12,13]. Eliezer [11] reported a 3.3% infection rate (9 of 272 cases). Young et al. [14] used the Fracture Care International database to review 46,113 IM nails implanted in various developing countries to determine the infection rate after

Table 1
Detailed information about our nonunion cases.

Age (years)	Injury mechanism	Location	Time to surgery (days)	Fracture type	Fracture site opened	Follow-up (months)
30	Road accident	Femur	180	Closed	Yes	15
25	Road accident	Femur	90	Closed	Yes	12
40	Road accident	Femur	150	Closed	Yes	9

IM nailing and relevant risk factors. The mean follow-up was 215 days with a median of 100 days. The infection rate was 1% (0.8% in the femur and 1.5% in the tibia). Antimicrobial prophylaxis reduced the risk by 29%. The risk of infection was increased when the procedure was performed due to non-union. The authors concluded that the infection rate after IM nailing was low but doubled in non-union cases. It is important to point out that our infection rate was zero, despite the reduction technique used. In 74% of cases, the fracture site had to be opened, although it did not increase the risk of infection. However, this may have consequences on bone healing. Although not statistically proven, our non-union cases all had an open approach to the fracture site. It is also accepted that draining the fracture hematoma is associated with a higher risk of non-union [15].

Gahukamble [16] reported on a case series of 11 patients from India who had neglected femur fractures. Fracture union was achieved in an average of 12 weeks. The main complication was knee contracture related to restoring the bone length in patients with malunion or non-union who initially had considerable limb shortening. We did not evaluate this aspect in our study, as our primary treatment objective was to allow patients to return to full weight bearing. Knee stiffness secondary to fracture realignment is likely, given the lack of physical therapy options in these developing countries.

We found no benefit of using a bone graft when the fracture was operated later on (> 3 weeks). We wondered if adding a bone graft during the treatment of neglected long bone fractures would increase the union rate. In a prospective study, Tall [17] showed that Judet's osteoperiosteal de-cortication procedure [18], in combination with IM nailing, is sufficient to achieve union when treating neglected fractures. Union was achieved in 4 months along with good functional results [17]. They recommend not adding a bone graft in fractures undergoing delayed treatment. In a second article [19] on the treatment of femoral non-union using this same technique, there were no infections and the union rate at 3 months was excellent. When the fracture site must be opened to reduce the fracture, osteoperiosteal decortication in combination with IM nailing is a simple, effective method to achieve union, no matter the chronicity of the fracture.

We have no evidence that delayed weight bearing can delay bone union. According to Keon Oh [20], reaming and immediate weight bearing can be sufficient for bone union to occur. A bone graft only seems necessary when more than 2 cm of shortening is present or the bone defect spans more than half the diameter of the diaphyseal shaft.

Lastly, realignment of certain femur fractures can be associated with nerve and vascular complications [21,22]; however, this complication was not found in our cohort. Although we did not specifically analyze the dangers of realignment, the average shortening was less than 2 cm, which does not appear to cause specific complications during realignment [23].

5. Conclusion

The sanitary conditions in some of the hospitals in developing country require having recourse to simple surgical treatments to limit the risk of complications. IM nailing of closed femur or tibia fractures is a reliable, effective treatment with low morbidity that is well suited to these conditions.

Ethical considerations

The views expressed are solely those of the authors and do not necessarily reflect the official policy or position of the French military medical service.

Disclosure of interest

The authors declare that they have no competing interest.

Funding sources

None.

Contributions of authors

All the authors contributed to the writing of the article.

Acknowledgements

The authors wish to thank all the orthopedic surgeons in the French military medical service that operated on the patients included in this study.

References

[1] Mathieu L, Mottier F, Bertani A, Danis J, Rongiéras F, Chauvin F. Management of neglected open extremity fractures in low-resource settings: experience of the French Army Medical Service in Chad. Orthop Traumatol Surg Res 2014;100:815–20.
[2] Département du développement humain. In: Le secteur de la santé au Tchad: analyse et perspective dans le cadre de la stratégie de réduction de la pauvreté. Ministère de la Santé et des Affaires sociales; 2004. p. 1–7.
[3] Omololu AB, Ogunlade SO, Gopaldasani VK. The practice of traditional bone-setting: training algorithm. Clin Orthop 2008;466:2392–8.
[4] Di Schino M, De Belenet H, Drouin C, Candoni P, Gonzalez JF, Limouzin J, Grimaldi FM. Réflexions sur la chirurgie orthopédique en milieu tropical. Rev Rhum 2003;70(2):185–94.
[5] Canadian Orthopaedic Trauma Society. Non-union following intramedullary nailing of the femur with and without reaming. Results of a multicenter randomized clinical trial. J Bone Joint Surg Am 2003;85–A:2093–6.
[6] Wolinsky PR, McCarty E, Shyr Y, Johnson K. Reamed intramedullary nailing of the femur 551 cases. J Trauma 1999;46:392–9.
[7] Ruedi TP. AO principles of fracture management. 2nd ed. Stuttgart, New York: Thieme; 2000.
[8] Helfet DL, Haas NP, Schatzker J, Matter P, Moser R, Hanson B. AO philosophy and principles of fracture management – Its evolution and evaluation. J Bone Joint Surg Am 2003;85:1156–60.
[9] Sekimpi P, Okike K, Zirkle L, Jawa A. Femoral fracture fixation in developing countries: an evaluation of the Surgical Implant Generation Network (SIGN) intramedullary nail. J Bone Joint Surg Am 2011;93:1811–8.
[10] Phillips J, Zirkle LG, Gosselin RA. Achieving locked intramedullary fixation of long bone fractures technology for the developing world. Int Orthop 2012;36:2007–13.
[11] Eliezer EN, Haonga BT, Morshed S, Shearer DW. Predictors of reoperation for adult femoral shaft fractures managed operatively in a Sub-Saharan country. J Bone Joint Surg Am 2017;99:388–95.
[12] Jenny JY, Jenny G, Kempf I. Infection after reamed intramedullary nailing of lower limb fractures. A review of 1464 cases over 15 years. Acta Orthop Scand 1994;65:94–6.
[13] Court-Brown CM, Keating JF, McQueen MM. Infection after intramedullary nailing of the tibia Incidence and protocol for management. J Bone Joint Surg Br 1992;74:770–4.

[14] Young S, Lie SA, Hallan G, Zirkle LG, Engesæter LB, Havelin LI. Risk factors for infection after 46,113 intramedullary nail operations in low- and middle-income countries. World J Surg 2013;37:349–55.
[15] Frölke JP, Bakker FC, Patka P, Haarman HJ. Reaming debris in osteotomized sheep tibiae. J Trauma 2001;50:65–70.
[16] Gahukamble A, Nithyananth M, Venkatesh K, Amritanand R, Cherian VM. Open intramedullary nailing in neglected femoral diaphyseal fractures. Injury 2009;40:209–12.
[17] Tall M, Bonkoungou D, Sawadogo M, Da SC, Toe MF, Bone Joint Trauma Study Group (GETRAUM). Treatment of nonunion in neglected long bone shaft fractures by osteoperiosteal decortication. Orthop Traumatol Surg Res 2014;100:299–303.
[18] Judet R, Judet J, Patel A. Osteo-muscular decortication. Presse Med 1966;74:1139–41.
[19] Tall M, Ouedraogo I, Nd Kasse A, Tekpa BJD, Bonkoungou G, Belem S, et al. Femur malunion treated with open osteotomy and intramedullary nailing in developing countries. Orthop Traumatol Surg Res 2012;98:784–7.
[20] Oh JK, Bae JH, Oh CW, Biswal S, Hur CR. Treatment of femoral and tibial diaphyseal nonunions using reamed intramedullary nailing without bone graft. Injury 2008;39:952–9.
[21] Boopalan PRJVC, Sait A, Jepegnanam TS, Matthai T, Varghese VD. The efficacy of single-stage open intramedullary nailing of neglected femur fractures. Clin Orthop 2014;472:759–64.
[22] Mahaisavariya B, Laupattarakasem W. Late open nailing for neglected femoral shaft fractures. Injury 1995;26:527–9.
[23] Cauchoix J, Morel G. One stage femoral lengthening. Clin Orthop Relat Res 1978;136:66.