Scientific Research Publishing

Open Journal of Orthopedics, 2023, 13, 108-121
https://www.scirp.org/journal/ojo
ISSN Online: 2164-3016
ISSN Print: 2164-3008

Exclusive Fibula Osteosynthesis for Treating Open Fractures Gustillo I-III B of the Distal Half of the Leg Bones in a Resources-Limited Setting

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How to cite this paper: Toha, G.K., Budema, P.M., Ahuka, O.L., Uwonda, A.B. and Tshimbila, J.M.V.K. (2023) Exclusive Fibula Osteosynthesis for Treating Open Fractures Gustillo I-III B of the Distal Half of the Leg Bones in a Resources-Limited Setting. *Open Journal of Orthopedics*, **13**, 108-121.
https://doi.org/10.4236/ojo.2023.133012

Received: February 19, 2023
Accepted: March 28, 2023
Published: March 31, 2023

Abstract

Introduction: Management of open leg bones fractures is a challenging health issue for the surgeon, particularly true in resource-limited settings. In this study, we evaluate exclusive fibular osteosynthesis in the treatment of open fractures of the distal half of the leg bones as a therapeutic option in our context. **Methods:** This is a prospective, experimental, multicenter study of 30 open fractures of the distal half of the leg bones treated with exclusive fibula osteosynthesis, conducted in 3 hospitals in the DRC from January 1, 2013 to September 30, 2016. **Results:** The age range of 20 to 40 years grouped 22 (73.4%) patients, the sex ratio was 1:1 and the unemployed were the most involved with 16 (53.3%) cases. The Gustilo II, I, III B and III A types represented 40%, 33.3%, 20% and 6.7%, respectively. The fractures were located in the distal third in 12 (40%) cases, in the middle third in 11 (36.7%) cases, and in both malleoli in 7 cases (23.3%). Osteosynthesis of the fibula by screw plate was applied in 22 (73.3%) patients and pinning in 8 (26.7%). Satisfactory reduction of the tibial fracture site was achieved in 29 (96.7%) cases and 100% bone healing was achieved within an average of 10 weeks. Four (13.3%) loss of alignment, 1 (3.3%) infection, 1 (3.3%) skin necrosis and 2 (6.7%) ankle stiffness complicated our fractures. **Conclusion:** Exclusive osteosynthesis of the fibula as a common technique for fractures of the distal half of the leg bones allowed us to reduce, immobilize and consolidate the tibial fracture in the required time and to preserve the mobility of the ankle.

Keywords

Fibular Exclusive Osteosynthesis, Open Tibial Fractures, Resources Limited Settings, Tibial Fracture Consolidation

1. Introduction

Of all long bones fractures, tibial shaft fractures are the most common [1] [2]. Their incidence rate is estimated at 16.9/100,000/year [3]. In recent times, there has been growing epidemic of open tibial fractures in populations in Low and middle-income countries (LMICs) [4]. Open leg bone fractures have always been a challenge for the surgeon with respect to the high frequency of integumentary injury, infection, and delayed healing, thereby compromising any osteosynthesis of the tibia [5] [6] [7] [8]. Locked centromedullary nailing, minimally invasive screw plate fixation and external fixation are the most recommended techniques [9]. In underdeveloped countries, the management of open leg bones fractures poses enormous difficulties, given the limited local possibilities [10] [11] [12]. In the DRC, this situation of lack of working tools has already been decried by several authors [10] [11] [12] [13]. Under these conditions, the surgeon frequently resorts to orthopaedic treatment with all its constraints [13] and innovations are not rare. This is particularly true for the Province of South Kivu, which has been plagued by wars that have led to the destruction of the medical infrastructure and difficulties in supplying working tools, including surgical implants. Kuyigwa *et al.* had already recommended a large study on the treatment of open fractures of the distal third of the leg bones by exclusive osteosynthesis of the fibula [12]. In the present work, we present the results of exclusive fibula osteosynthesis as a common technique for all open Gustilo I-IIIB fractures of the distal half of the leg bones.

2. Methodology

This work was conducted in the Department of Surgery from January 1, 2013 to September 30, 2016 at HPGRB, the surgical services of HGRC and HGRK from May 09 to September 30, 2016, in the Province of South Kivu, DRC. This is a prospective and experimental study. The population is represented by patients who experienced an open fracture of the distal half of the leg bones during the study period and met the inclusion criteria. By distal half of the leg bones, we mean the mid-leg up to and including the two malleoli, including fractures located in the middle and distal thirds of the leg bones, Dupuytren's fractures, tibial pilon fractures, bi-malleolar and bi-malleolar equivalent fractures. We used emergency and hospitalization records, operative reports, X-rays and photographs as documentation.

The inclusion criteria of the patients included in this work are the following: having experienced an open fracture of the distal half of the leg bones during the

study periods, having a complete file, getting the postoperative follow-up during the six months after the operation, accepting to be part of the study.

Were excluded from this study: closed leg bone fractures, open fractures of the proximal half of the leg bones, not agreeing to be part of the study. Also not included in this study were open fractures of the distal half of the leg bones without displacement, fractures by firearm and explosives, leg bones fractures Gustilo III C, concomitant opening of the fibular focus.

The medical treatment started at the arrival of the patients consisted of antibiotic prophylaxis with ampicillin (3 times 2 grams per day) and gentamycin (2 times 80 mg per day), anti-tetanus serotherapy (3.000 IU), and anti-tetanus vaccination (0.5 ml) for patients whose vaccination schedule against clostridium tetani was not up-to-date. Surgical treatment was performed in 3 stages: surgical trimming of the tibial focus wound on admission, deferred fibular osteosynthesis as soon as the tibial skin opening wound did not or no longer showed signs of infection, directed healing for tibial focus wounds, or a rotation flap.

We analyzed the following parameters: age, sex, occupation, skin opening (Gustilo), fracture site, time between fracture and osteosynthesis, definitive surgical treatment, reduction, occurrence of infection of the surgical wound and traumatic skin opening, postoperative onset of walking and time of actual walking, and association with a fracture of another long bone of the limbs. During the first 6 months postoperatively and at highly variable intervals, we evaluated all patients clinically and radiologically at least twice. This variability in postoperative controls was dictated by the ability to afford all required exams as the majority of our patients were poor and by the fact that our research did not benefit from any material or financial support. The constituent elements of the evaluation were the limb axis, bone consolidation, ankle mobility.

Postoperative reduction of the tibial fracture was considered radiologically satisfactory when the tibial bone fragments were in contact with at least 50% of the fracture margins, with an angulation not exceeding 10 degrees overall and without rotation [14] [15]. We used the following elements to judge consolidation: clinically, the absence of abnormal mobility of the fracture site, indolence on walking and on the anvil test, and radiologically, the demonstration of a jointed callus with disappearance of the fracture line [14] [16]. Joint mobility was considered good, compared to the healthy limb, when the patient was able to walk on the tips of the toes and on the heel.

Surgical Technique for Fibular Osteosynthesis

Under spinal anesthesia, patients were placed on the operating table in the supine position. A cushion was slid under the homolateral buttock to avoid the usual external rotation in this type of fracture [8] [17]. A pneumatic tourniquet was placed at the root of the thigh. After cleaning and brushing the entire limb with betadine, a pack of sterile compresses was placed on the inside of the leg, covering the traumatic opening of the tibial fracture site and thus isolating it from the rest of the outside of the leg. A narrow stockinette was placed on the

limb, holding the pack of compresses in place. The stockinette was then opened with scissors on the outside of the leg, followed by a skin incision of 8 to 15 cm, centered on the fibular fracture. The leg fascia was opened longitudinally and the muscle fibers of the lateral fibular were spread in their directions until the fibula was reached. Using two Hohmann retractors, the fracture site was approached and roughened minimally on its lateral side. The fracture was reduced with two Verbrugue forceps and fibular osteosynthesis was performed. The implants used varied according to the availability of implants. Two types of implants of varying sizes and firms were used: the screw plate and the rush pin (Figure 1). Since no image intensifier was available, indirect reduction of the tibial fracture was not performed intraoperatively. The surgical site was cleaned generously with saline and 50% saline mixed with betadine. A two-plane suture covered with betadine-soaked compresses was performed on a makeshift suction drain (60 cc syringe put under negative pressure). No other immobilization measures were instituted. The drain was removed and the wound was left open between the 2nd and 3rd POD. From this point on, patients were allowed to walk without support using a pair of crutches. The decision to support partially or totally depended on the perception and the conviction of recovery of each patient. The removal of the skin sutures was performed on the 12th day of surgery.

The collected data were compiled and analyzed using Epi info 3.5.4 and Microsoft Word and Excel software. Because the number of patients in the subgroups was small and many of the variables were of the ordinal data type, we

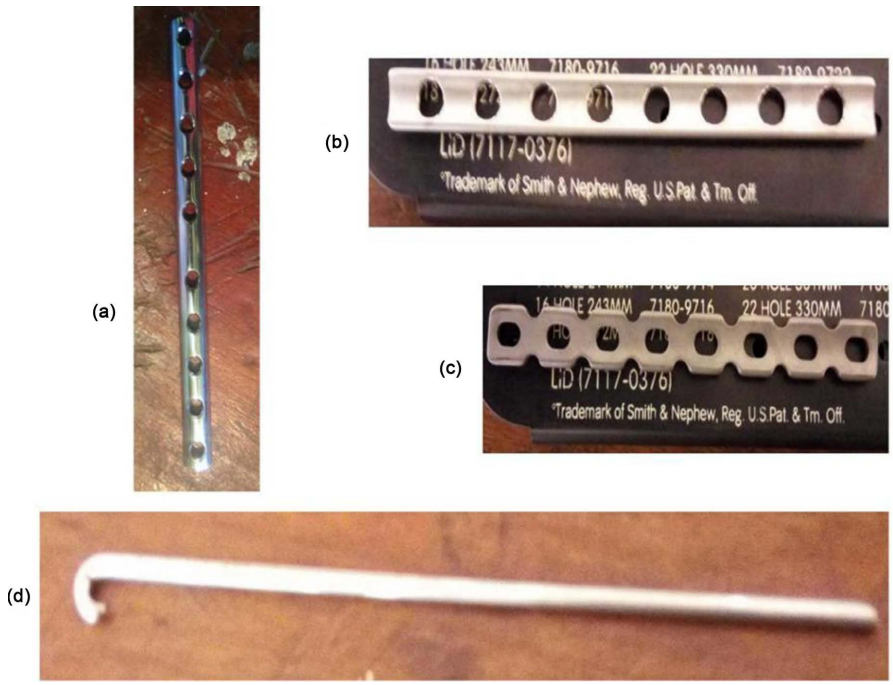


Figure 1. Implants used. (a) AO screwed one-third tube plate (It was cut into two plates to serve two patients); (b) One-third tube screw plate (Trademark of Smith Nephew, Reg. U.S.Pat Tm.Off.); (c) Quarter tube screw plate (Trademark of Smith Nephew, Reg. U.S.Pat Tm.Off.); (d) Rush pin.

decided to use nonparametric tests for the statistical analysis. Results are presented as percentages and standard deviations. The statistical decision was made at the 0.05 level.

Ethical approval was obtained from the institutional ethical committees of hospitals involved the present research.

3. Results

We registered 30 patients coming from the city and neighboring territories, among them 15 (50%) were women (sex ratio 1:1). Twenty-two patients (73.4%) were aged between 20 and 40 years with a mean age of 34.7 years (SD: 16.20), males and females were equally represented with 15 (50%), the unemployed accounted for 16 (53.3%) fractures. Considering the degree of integumentary lesions, Gustilo types II, I and III B were the most recorded and grouped respectively 12 (40%), 10 (33.3%) and six (20%) cases while III A is recorded in only two (6.7%) cases. The distribution of open fractures in the distal half of the leg bones was as following: 12 (40%) in the distal third, 11 (36.7%) in the middle and 7 cases (23.3%) in both malleoli. The time from admission to fibular osteosynthesis ranged from two to 45 days, with a median of five days. Fractures associated with the open fracture of the distal half of the leg bones involved the homolateral femur (floating knee) in three (10%) cases, and a heterolateral femur fracture in one (3.3%) case. With regard to management, we used screw plate osteosynthesis of the fibula in 22 (73.3%) patients and pinning in eight (26.7%) fractured patients (**Figures 2-4**). No immobilization was performed after surgery and skin sutures removal occurred at 12th post-operative day in all patients (POD). Reduction of the tibial fracture site was satisfactory in 29 (96.7) cases. All our patients have formed a callus within a mean time of 10 weeks. Complications were as follows: one (3.3%) infection, one (3.3%) skin necrosis in front of the tibial focus, four (13.3%) loss of alignment that eventually developed into vicious callus, and two (6.7%) ankle stiffness as shown in **Table 1**. Two patients (6.6%) underwent reoperation.

4. Comments

The small sample size of this study basically explains its limitations. It may due to the fact that we did not take into consideration patients' refusals of care both in the emergency department and in hospital. Other patients who were unable to pay the deposit for osteosynthesis were treated orthopedically and were not included in this study. Furthermore, the multicenter nature was not achieved until May 2016, as both host medical facilities were resistant to changing their protocol at the start of the work. One hospital with an orthopedic and trauma department with good attendance refused outright to participate in the study.

However, our work retains the merit of being prospective and experimental. The management of leg bones fractures has always been the subject of controversy, even in affluent countries. The objectives of this management are rapid

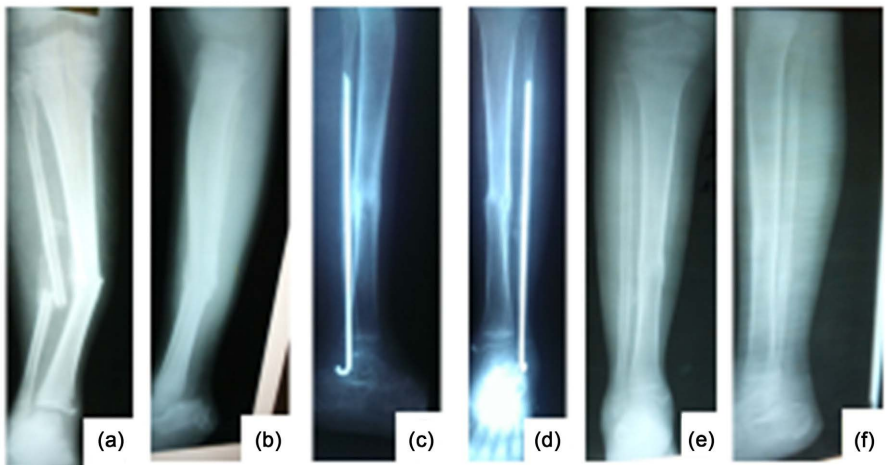


Figure 2. Open Gustilo II middle third fracture treated by pinning 3 weeks later (vicious callus in formation) due to lack of surety (13 years). Preoperative Rx of face (a) and profile (b). Postoperative Rx of profile (c) and face (d) at 12 weeks (jointed and uniform callus with disappearance of the fracture line). Postoperative X-ray of the face (e) and profile (f) at 6 months (no trace of fracture).

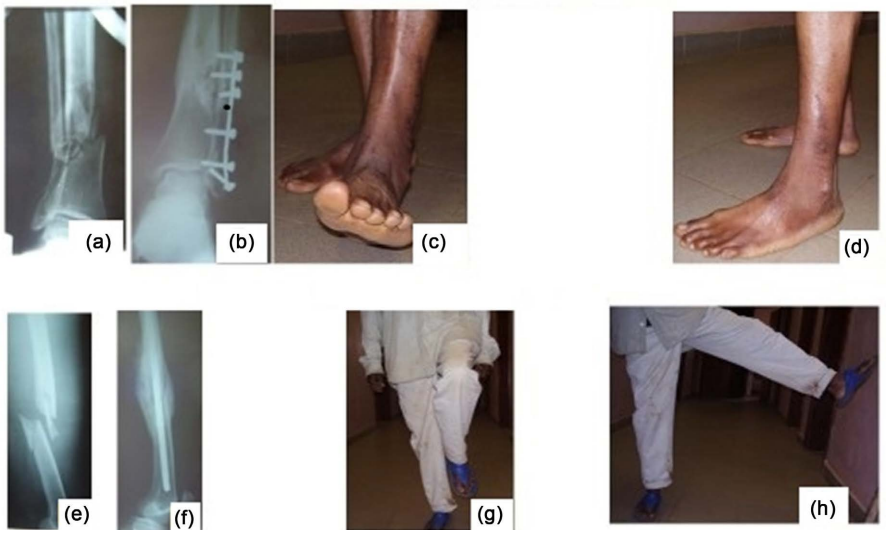
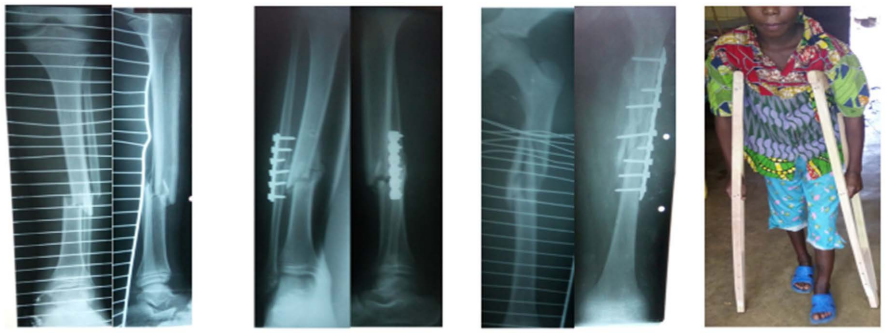


Figure 3. Floating knee treated with ECM and screwed one-third tube plate (51 years old). (a) Preoperative face-to-face Rx; (b) Postoperative face-to-face Rx at 14 weeks; (c) Complete dorsiflexion at 14 weeks; (d) Perfect plantar flexion at 14 weeks and good healing; (e) Preoperative femur profile Rx; (f) Postoperative femur Rx at 14 weeks G and (h) Perfect movements of all joints of the lower limb at 14 weeks 7.3. Genou flottant traitée par ECM et par plaque vissée tiers de tube (51 ans).

and optimal healing, reduction of soft tissue complications, prevention of pseudarthrosis and vicious callus, and preservation of function [8]. The techniques listed in the literature are numerous: locked or unlocked tibialcentromedullary nailing [2] [18] [19] [20], tibialcentromedullary nailing associated with fibular osteosynthesis [6], minimally invasive screw-plate osteosynthesis [21] [22], minimally invasive screw-plate osteosynthesis of the tibia associated with fibular osteosynthesis [8], the external fixator [2] [8] [16] [20] [23]. Each technique is



(a) (b) (c) (d)

Figure 4. Gustilo I fracture of the left leg bones associated with a closed fracture of the right femur (12 years old) treated with a quarter (fibula) and third (femur) tube screw plate (Trademark of Smith Nephew, Reg. U.S.Pat Tm.Off.). (a) Preoperative face/profile Rx; (b) Postoperative face/profile Rx at 4 weeks (early callus); (c) Contralateral femur fracture face preoperative and postoperative at 4 weeks (early callus); (d) Walking with crutches on the 5th DPO.

Table 1. Anatomical and clinical characteristics, treatment and evolution of fractures.

Parameters	n	Percentage
Skin opening		
Gustilo II	12	40
Gustilo I	10	33.3
Gustilo III B	6	20
Gustilo III A	2	6.7
Seat of fracture		
Distal third	12	40
Middle third	11	36.7
Bi-Malleolus	7	23.3
Osteosynthesis		
Screwed plate	22	73.3
Racking	8	26.7
Evolution		
Good mobility of the ankle	28	93.3
Osteoarthritis	2	6.7
Vicious callus	4	13.3
Infection	1	3.3
Associated Fractures		
Homolateral femur (floating knee)	3	10
Heterolateral femoral fracture	1	3.3

associated with complications during the treatment period: malalignment in the case of centromedullary nailing of distal third fractures [24], infection and

pseudarthrosis in the case of minimally invasive screw-plate osteosynthesis [8] [22], and delayed consolidation, infection of the anchoring pins, and malunion in the case of the external fixator [5] [23].

In our surgical practice, which is characterized by a shortage of working tools (external fixator, implants, image intensifier) and a less-than-ideal aseptic environment, osteosynthesis of the tibia in the case of an open fracture should be a matter of concern for any practitioner, since the risks of infection and skin necrosis [12]. We therefore decided to perform osteosynthesis of the fibula only. We assumed that leg fractures with an intact fibula are not very displaceable because the intact bone provides support for the fractured skeleton [14] [15]. Exclusive osteosynthesis of the fibula would transform the two-leg bones fracture into a fracture of leg bones with intact fibula (**Figure 5**) [12].

The advantages of fibular osteosynthesis as a complement to another procedure on the tibia in the treatment of leg bones fractures are variously appreciated in the literature [6] [8] [21] [22] [24] [25] [26] [27] [28]. It facilitates reduction of the tibial focus during surgery [22], avoids secondary displacement postoperatively [6] [21] [22] [26], and allows reconstruction of tibial length [8]. Sciadini MF *et al.* reported six cases of distal third fracture treated solely with a trans-syndesmotic screw plate of the fibula with good results [25]. Their design differs fundamentally from ours, in that the stability of the reduction was ensured by screws passing from lateral to medial through the fibula first and then through the tibia in both the proximal and distal fragments. We have used this technique partially in a case of open ankle fracture-luxation (Weber C, AO/OTA 44-C), with success. The most distal screw passed first through the fibula and then through the tibia with the aim of achieving a recall effect (**Figure 6**).

All our patients received antibiotic prophylaxis with ampicillin and gentamycin. Like us, De Giacomo AF *et al.* recommend a double antibiotic therapy combining a cephalosporin and an aminoglycoside [18]. The time from admission to fibula osteosynthesis varied from 0 to 45 days with a median of 5 days. This time allowed us to ensure the absence of suppuration opposite the tibial focus. During this period, the fractures were tracted on Braun splints or immobilized on posterior plaster cast splints. However, this waiting period also depended largely on the patient's payment of the deposit for the surgical procedure. Postponement of surgery has been recommended by many authors [20] [25]. This delay averages two days, ranging from 0 - 9 days for Ramos T *et al.* They advocate placement of an external fixator bridging the ankle while waiting for an anatomic environment to perform tibial osteosynthesis by centromedullary nailing [20]. Mathieu L *et al.*, treating neglected open fractures that are seen late, believe that good results can always be obtained except when the fractures are infected. They insist on obtaining a good soft tissue environment [29]. Dixit P *et al.* observe a mean delay of two days before any distal open leg bone fracture when there is edema and blisters [6].

Postoperatively, no additional immobilization was instituted in our patients. Furthermore, the socioeconomic level of the majority of our patients did not

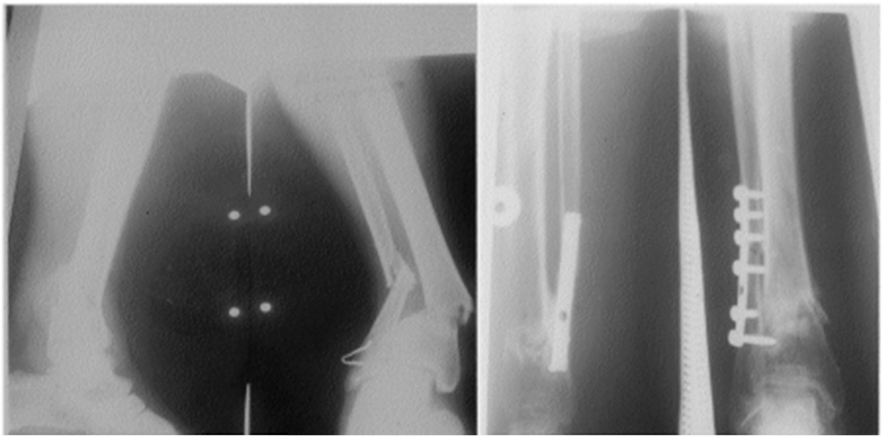


Figure 5. Osteosynthesis of the fibula transforms the fracture of two leg bones into a fracture of leg bones with intact fibula. (a) Preoperative X-ray profile and face; (b) Postoperative X-ray profile and face [12].

Figure 6. Gustilo III A fracture-luxation of the ankle (Weber C, AO/OTA 44-C). Preoperative Rx face and profile (a); Postoperative Rx, 1st DPO, face and profile (b); Postoperative Rx, at 6 months, 1st DPO removal of the synthesis material, face and profile (c).

allow them to obtain canes in real time. In the aim of obtaining autonomy, they initiated partial or even total support already during the first postoperative week by using makeshift canes (sticks). Our attitude is similar to that of Dixit P *et al.* because their patients started partial weight-bearing already on the 2nd OPD and full weight-bearing was allowed between four and six weeks [6]. Early weight-bearing in tibial fractures has been advocated by many authors [14] [15] [16] [20]. Others, however, recommend temporary immobilization. Asloum Y *et al.* treated a bi-malleolar fracture by osteosynthesis of the fibula and medial malleolus with immobilization for six weeks. Weight-bearing was not allowed until one month and rehabilitation was started after removal of the immobilization [17]. Gupta A *et al.* allowed partial weight-bearing only after 6 to 8 weeks and full weight-bearing between 12 and 14 weeks [21].

We achieved clinically bone consolidation in all cases and within an average of 10 weeks. The rate and time to consolidation varies from one author to another to another (**Table 2**) [30]. Treating open Gustilo II leg bone fractures by centromedullary nailing and external fixator, Gondalia V *et al.* reported respective

Table 2. Time to healing of leg bone fractures across the available literature from 2013 to 2016.

	Authors	Country	Year	Delay	Average
1	Esan O *et al.* [30]	Nigeria	2013		14.8 weeks
2	Yu B *et al.* [6]	Chine	2013	10 - 12 weeks	10.6 weeks
3	Abouchane *et al.* [14]	Maroc	2015		4 mois
4	Gupta A *et al.* [21]	Inde	2015	16 - 24 weeks	4 mois
5	Tekin AÇ *et al.* [16]	Turkie	2015		20.4 ± 4 weeks
6	Kitoko RA. [13]	RDC	2016		195.9 jours
7	Notre étude	DRC	2016	10 weeks	

consolidation rates of 90.9% and 56.25% [2]. The good consolidation score in our work may be due to the fact that we did not disturb the anatomical and physiological environment of the tibial focus, but also we excluded from our study the open Gustilo III C fractures known to have a poor prognosis. The quick healing of leg bone fractures in our patients may be due to three possible factors: 1) preservation of blood flow and periosteum, 2) micromovements at the tibial focus, and 3) early loading of the limb.

The postoperative course of our patients was simple in the majority of cases and the skin sutures were removed on the 12th day of surgery. We recorded one case of infection of the surgical wound (3.3%). This was a bi-malleolar open fracture that benefited from fibula osteosynthesis by pinning, which was complicated by infection, vicious callus and ankle stiffness. The occurrence of infection and skin necrosis in distal third leg bone fractures treated with tibial and fibular osteosynthesis may be due to several factors including: 1) the presence of integumentary lesions and their degree [18], 2) untimely and aggressive intervention while the skin has not yet healed well [6], and 3) the use during the same operative time of an internal and an external approach requiring extensive dissection that subsequently ischemicizes the soft tissue, periosteumand bone. In order to avoid these complications, some authors approach both leg bones with a single anterolateral approach to achieve concomitant osteosynthesis of the tibia and fibula [6]. Others, on the other hand, perform fracture stabilization in two stages: external fixator on admission and tibialosteosynthesis when the soft tissue condition becomes reassuring [5] [20]. Treating leg bones and tibial pilon fractures by external fixation and tibial synthesis in Kisangani (DR Congo) and Liege (Belgium), Kitoko A *et al.* recorded infection rates of 35.5% and 2.3% respectively [13]. De Giacomo AF *et al.*, in their study of open distal leg bone fractures Gustilo III reported infection rates of 4%, 52% and 42% for type IIIA, IIIB and IIIC respectively [18]. This infection rate is 6.67% for Gupta A *et al.* [21] while Gonalia V *et al.* put it around 24% [2]. The exclusive osteosynthesis of the fibula accounts for the low infection rate (3.3%) in our study, as the tibial focus was spared.

Other complications were noted in our study: four (13.3%) losses of alignment that developed into vicious callus, two of which were managed by rush pin and two by screw plate. Kitoko A *et al.* in Kisangani reported a loss of alignment in 22.4% of cases [13]. The loss of alignment recorded in our work may be due to the following factors: 1) the use of rush pins with a cross-sectional area far smaller than the medullary canal of the fibula, which led to external rotation in two cases, 2) the fall of the patients from their height when learning to walk in two other cases, and 3) the nature of the screwed plates (light and flexible screwed plates). Vallier HA *et al.* had already incriminated immediate loading against medical advice in the occurrence of loss of alignment [22].

In terms of function, 93.3% of our patients maintained good mobility of their ankles. We noted two (6.7%) cases of joint stiffness, one of which was severe in a patient who had developed both the infection and the vicious callus, and one of which was moderate in a patient with an open comminuted tibial pilon fracture. This rate of good functional outcome, justified by the absence of additional immobilization and early walking, is higher than that reported by Kitoko A *et al.* (73.3%) [13].

Two patients (6.7%) underwent reoperation, one of them because of an infection at the fibular surgical site, when the tibial focus was already clinically consolidated. The surgical procedure consisted of removal of the osteosynthesis material (rush pin) with simple postoperative follow-up. The second case involved a varus callus treated with an inappropriate screw plate that broke during a fall while walking. We removed the osteosynthesis material and straightened the varus by manually breaking the callus and making a cast boot at the patient's request. She did not accept a second osteosynthesis. Two patients who presented with a vicious callus, one in varus and the other in external rotation, were satisfied with the final results. Our results agree with those of other authors [2]. The indications for reoperation are mainly infection, implant failure and loss of alignment [31].

5. Conclusion

The treatment of open leg bone fractures is a real health issue through the literature. External fixation, centromedullary nailing and minimally invasive osteosynthesis are the most applied treatments for these bone injuries associated with musculo-fascial and integumentary damage. In conditions where there is a lack of external fixators and implants of the appropriate size and shape for each level of fracture, exclusive osteosynthesis of the fibula as a common technique for fractures of the distal half of the leg bones has been of great benefit. In the tibia, it reduced and immobilized the fracture site, restored its length, ensured consolidation within the required time, and preserved the mobility of the ankle. Infection, vicious callus and stiffness, which were rare in our study, were recorded. We recommend exclusive osteosynthesis of the fibula to surgeons practicing in resource-limited countries.

Authors' Contributions

Georges Toha Kuyigwa conceptualized the study, designed the methodology, collected data and wrote the first manuscript, Paul Munguakonkwa Budema, Akinja Bitum Uwonda and Ona Longombe Ahuka were involved in the review of the first manuscript and Jean Marie Vianney Kabangu Tshimbilaforthe revision of the final text before submission. All authors agreed with the actual version of the submitted manuscript.

Conflicts of Interest

The authors declared that they have no competing interests.

References

[1] Giovannini, F., de Palma, L., Panfighi, A. and Marinelli, M. (2016) Intramedullary Nailing versus External Fixation in Gustilo Type III Open Tibial Shaft Fractures: A Meta-Analysis of Randomised Controlled Trials. *Strategies in Trauma and Limb Reconstruction*, **11**, 1-4. https://doi.org/10.1007/s11751-016-0245-7

[2] Gondalia, V. and Siddiqui, S.S. (2015) "Management of Open Fracture of Tibia Diaphysis (Gustilo-Anderson Classification Type-II and Above)". *Journal of Evolution of Medical and Dental Sciences*, **4**, 7032-7041. https://doi.org/10.14260/jemds/2015/1021

[3] Larsen, P., Elsoe, R., Hansen, S.H., Graven-Nielsen, T., Laessoe, U. and Rasmussen, S. (2015) Incidence and Epidemiology of Tibial Shaft Fractures. *Injury*, **46**, 746-750. https://doi.org/10.1016/j.injury.2014.12.027

[4] Johal, H., Schemitsch, E.H. and Bhandari, M. (2014) Why a Decade of Road Traffic Safety? *Journal of Orthopaedic Trauma*, **28**, 8-10 https://doi.org/10.1097/BOT.0000000000000104

[5] Gill, S.P., Raj, M., Kumar, S., Singh, P., Kumar, D., Singh, J. and Deep, A. (2016) Early Conversion of External Fixation to Interlocked Nailing in Open Fractures of Both Bone Leg Assisted with Vacuum Closure (VAC)-Final Outcome. *Journal of Clinical and Diagnostic Research*: *JCDR*, **10**, RC10-RC14. https://doi.org/10.7860/JCDR/2016/17612.7265

[6] Dixit, P., Kripalani, S., Kulkarni, S.G., Saxsena, S. and Rathi, P.P. (2015) Treatment Results Of Spiral and Oblique Distal One-Third Tibia-Fibula Fractures With Interlocking Nails and Poller Screw. *Journal of Trauma and Orthopaedic Surgery*, **10**, 2-5.

[7] Kamath, J.B., Shetty, M.S., Joshua, T.V., Kumar, A. and Naik, D.M. (2012) Soft Tissue Coverage in Open Fractures of Tibia. *Indian journal of Orthopaedics*, **46**, 462-469. https://doi.org/10.4103/0019-5413.97265

[8] Yu, B., Huang, G., George, J.T., Li, W., Pan, S. and Zhou, H. (2013) Single-Incision Technique for the Internal Fixation of Distal Fractures of the Tibia and Fibula: A Combined Anatomic and Clinical Study. *Archives of orthopaedic and trauma surgery*, **133**, 1631-1637. https://doi.org/10.1007/s00402-013-1856-9

[9] Li, B., Yang, Y. and Jiang, L.S. (2015) Plate Fixation versus Intramedullary Nailing for Displaced Extra-Articular Distal Tibia Fractures: A System Review. European *Journal of Orthopaedic Surgery & Traumatology*, **25**, 53-63. https://doi.org/10.1007/s00590-013-1362-3

[10] Uwonda, A. and Panda, M.B. (2010) La minifixation externe des os des extrémités par le minifixateur "K-Digifix". *Annales Africaines de Médecine*,**3**, 419-425.

[11] Ibrahimu, T.K., Ibrahimu, B., Makekita, W.M. and Mudimisi, M. (2016) Les complications mécaniques de l'enclouage centromédullaire du fémur en milieu précaire. A propos de 6 observations à l'Hôpital de N'djili, Kinshasa. *Revue médicale des Grands Lacs*, **5**, 96-103.

[12] Kuyigwa, T.G., Uwonda, A.B. and Ahuka, O.L. (2014) Ostéosynthèse exclusive de la fibula dans le traitement des fractures ouvertes du tiers distal des os de la jambe en milieu à ressources limitées. *Revue médicale des Grands Lacs*, **3**, 53-62.

[13] Kitoko, R.A., Asolanyongo, M.K., Losimba, J.L., Georis, P., Gillet, P. and Bruyère, O. (2016) Pratique de l'ostéosynthèse des fractures de jambe en République démocratique du Congo. *Revue de Chirurgie Orthopédique et Traumatologique*, **102**, 306-309. https://doi.org/10.1016/j.rcot.2015.10.022

[14] Abouchane, M., Fadili, A., Belmoubarik, A., El Andaloussi, Y. and Nechad, M. (2015) Leg Fractures with Intact Fibula: Orthopedic Treatment or Intramedullary Nailing? (Comparative Study About 60 Cases). *The Pan African Medical Journal*, **20**, Article No. 222. https://doi.org/10.11604/pamj.2015.20.222.6164

[15] Dieme, C., Sarr, L., Gueye, P.A., Gueye, A.B., Sané, A. and Ndiaye, A. (2015) Les fractures de jambe à fibula inctate au service d'orthopédie-traumatologie CHU Aristide le Dantec. *Tunisie Orthopédique*, **7**, 21-24.

[16] Tekin, A.Ç., Saygılı, M.S., Adaş, M., Çabuk, H., Arslan, S.M. and Dedeoğlu, S.S. (2015) Outcome of Type 3 Open Tibial Diaphyseal Fractures Managed with a Limb Reconstruction System: Analysis of a 49-Patient Cohort. *Medical Principles and Practice*, **25**, 270-275. https://doi.org/10.1159/000443257

[17] Asloum, Y., Bedin, B., Roger, T., Charissoux, J.L., Arnaud, J.P. and Mabit, C. (2014) Internal Fixation of the Fibula in Ankle Fractures. A prospective, Randomized and Comparative Study: Plating versus Nailing. *Orthopaedics Traumatology: Surgery & Research*, **100**, 255-259. https://doi.org/10.1016/j.otsr.2014.03.005

[18] De Giacomo, A.F. and Tornetta, P. (2016) Alignment after Intramedullary Nailing of Distal Tibia Fractures without Fibula Fixation. *Journal of Orthopaedic Trauma*, **30**, 561-567. https://doi.org/10.1097/BOT.0000000000000637

[19] Ahmed, N., Khan, M.S., Afridi, S.A., Awan, A.S., Afridi, S.K. and Sultan, S. (2016) Efficacy and Safety of Interlocked Intramedullary Nailing for Open Fracture Shaft of Tibia. *Journal of Ayub Medical College Abbottabad*, **28**, 341-344.

[20] Ramos, T., Eriksson, B.I., Karlsson, J. and Nistor, L. (2014) Ilizarov External Fixation or Locked Intramedullary Nailing in Diaphysealtibial Fractures: A Randomized, Prospective Study of 58 Consecutive Patients. *Archives of Orthopaedic and Trauma Surgery*, **134**, 793-802. https://doi.org/10.1007/s00402-014-1970-3

[21] Gupta, R.K., Rohilla, R.K., Sangwan, K., Singh, V. and Walia, S. (2010) Locking Plate Fixation in Distal Metaphysealtibial Fractures: Series of 79 Patients. *International Orthopaedics*, **34**, 1285-1290. https://doi.org/10.1007/s00264-009-0880-4

[22] Vallier, H.A., Cureton, B.A. and Patterson, B.M. (2011) Randomized, Prospective Comparison of Plate versus Intramedullary Nail Fixation for Distal Tibia Shaft Fractures. *Journal of Orthopaedic Trauma*, **25**, 736-741. https://doi.org/10.1097/BOT.0b013e318213f709

[23] Piwani, M., Bhutto, I.A. and Ahmed, I. (2015) Evaluation of AO External Fixator in the Management of Open Diaphysial Fracture of Tibia Gustilo Type IIIa and IIIb. *Gomal Journal of Medical Sciences*, **13**, 66-69.

[24] Vallier, H.A., Cureton, B.A. and Patterson, B.M. (2012) Factors Influencing Func-

tional Outcomes after Distal Tibia Shaft Fractures. *Journal of Orthopaedic Trauma*, **26**, 178-183. https://doi.org/10.1097/BOT.0b013e31823924df

[25] Sciadini, M.F., Manson, T.T. and Shah, S.B. (2013) Trans-Syndesmotic Fibular Plating for Fractures of the Distal Tibia and Fibula with Medial Soft Tissue Injury: Report of 6 Cases and Description of Surgical Technique. *Journal of Orthopaedic Trauma*, **27**, 65-67. https://doi.org/10.1097/BOT.0b013e3182604582

[26] Bonnevialle, P., Lafosse, J.M., Pidhorz, L., Poichotte, A., Asencio, G. and Dujardin, F. (2010) Distal Leg Fractures: How Critical is the Fibular Fracture and Its Fixation? *Orthopaedics & Traumatology*: *Surgery & Research*, **96**, 667-673. https://doi.org/10.1016/j.otsr.2010.07.002

[27] Müller, T.S. and Sommer, C. (2012) Minimally Invasive Plate Osteosynthesis of the Distal Tibia. *Operative Orthopädie und Traumatologie*, **24**, 354-367. https://doi.org/10.1007/s00064-012-0169-4

[28] Rouhani, A., Elmi, A., Akbari Aghdam, H., Panahi, F. and Dokht Ghafari, Y. (2012) The Role of Fibular Fixation in the Treatment of Tibia Diaphysis Distal Third Fractures. *Orthopaedics & Traumatology*: *Surgery & Research*, **98**, 868-872. https://doi.org/10.1016/j.otsr.2012.09.009

[29] Mathieu, L., Mottier, F., Bertani, A., Danis, J., Rongiéras, F. and Chauvin, F. (2014) Management of Neglected Open Extremity Fractures in Low-Resource Settings: Experience of the French Army Medical Service in Chad. *Orthopaedics & Traumatology*: *Surgery & Research*, **100**, 815-820. https://doi.org/10.1016/j.otsr.2014.06.017

[30] Esan, O., Ikem, I.C., Oginni, L.M. and Esan, O.T. (2014) Comparison of Unreamed Interlocking Nail and External Fixation in Open Tibia Shaft Fracture Management. *West African Journal of Medicine*, **33**, 16-20.

[31] Foote, C.J., Guyatt, G.H., Vignesh, K.N., Mundi, R., Chaudhry, H. and Heels-Ansdell, D. (2015) Which Surgical Treatment for Open Tibial Shaft Fractures Results in the Fewest Reoperations? A Network Meta-Analysis. *Clinical Orthopaedics and Related Research®*, **473**, 2179-2192. https://doi.org/10.1007/s11999-015-4224-y