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Treatment of femoral shaft fractures in six Kinshasa hospitals: closed-focus locked centromedullary nailing versus other means of osteosynthesis

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Abstract

Introduction*: The standard treatment for femoral shaft fractures (FSF) is locked centromedullary nailing (LCN). It is not always applicable in our setting. Instead, other osteosynthesis techniques are used. In this study, we compare the results of LCN with those of other osteosynthesis techniques in Kinshasa.*

Material and methods: *This is a retrospective, descriptive series of 110 cases, involving six public hospitals in the city of Kinshasa, from January 1, 2021 to December 31, 2023. The study involved patients aged 18 and over, managed by osteosynthesis of diaphyseal femur fractures using four techniques: closed-focus locked centromedullary nailing (LCN), open-focus non-locked nailing (NLN), screw plate (SP) osteosynthesis and external fixation (EF).*

Results: *The mean age was 41.9±16 years, 67.3% male (M/F sex ratio 2), FSF were closed in 87.2% and open in 12.8%, including 5.4% type 1, 5.4% type 2 and 1.8% type 3 in the Guistillo and Anderson class. Accidents on public roads (APR) accounted for 84.6% of the circumstances of occurrence. The techniques used were: screw-plate (45.4%), LCN (20%), NLN (27.2%) and EF (7.2%). Postoperative complications were: 25 infections on osteosynthesis material (IOM) (22.7%), 11 pseudarthroses (10%), 11 cases of pulmonary embolism (10%) and 8 mechanical implant failures (7.2%). Nineteen (76%)*

IOM involved in screw-plate, 3 (12%) involved in LCN, 2 (8%) in EF and 1(4%) in NLN. 45.5% of patients with implant failure had presented with pseudarthrosis (p<0.001). Seven mechanical hardware failures involved in screw-plate (disassemblies) and only 1 involved NLN (nail migration), none for LNC. A mean loading time of 6.72 ± 4.83 days with a significant correlation (p<0.001, min 0.2, max 3) for closed-focus locked centromedullary nailing.

***Conclusion**: FSFs are common in young, active, male adults, the main cause of which is road accidents. LCN is the best technique, with several advantages and fewer complications.*

Introduction

Femoral shaft fractures (FSF) are frequent traumatic injuries in young, active adults, caused in 3/4 of cases by accidents on public roads [1]. It is a fracture of the diaphysis of the femur between the lesser trochanter and the supra-condylar region [2]. Worldwide, the incidence is around 10-15/100,000 people per year. [3, 4] with an increased prevalence in young adult males [5].

The usual treatment for femoral shaft fractures is surgical, although the modalities are still controversial. However, locked centromedullary nailing remains the reference and basic technique [1, 6], as it offers the advantage of a minimally invasive approach, rapid consolidation and functional recovery [4].

Surgical treatment involves osteosynthesis using a wide variety of techniques [7].

Around the world, several osteosynthesis modalities are still used, including nailing (locked or unlocked), long trochanteric nails, dynamic compression plate(DCP) and locking compression plate (LCP) diaphyseal plates, and external fixators (EF) [1]. Their indications vary according to the patient's condition, the type of injury, the level of technical facilities and the operators involved [6]. All these techniques involve the placement of external or internal hardware to stabilize the focus until complete consolidation is achieved. Centromedullary nailing and plate fixation are the two main internal fixation techniques [5,8].

Although locked centromedullary nailing has established itself as the treatment of choice for femoral shaft fractures, the fact remains that it is a fairly demanding technique in terms of technical facilities, which limits its application, especially in resource-limited countries where other means of osteosynthesis continue to be used.

In this study, we compare the results of LCN with those of other means of osteosynthesis in Kinshasa, where centromedullary nailing is clearly progressing despite the context of a country with limited resources.

MATERIALS and METHODS

Type, period and scope of study

This is a retrospective, descriptive case series carried out in six public hospitals in the city of Kinshasa, Democratic Republic of Congo. These were: University Hospital of Kinshasa (UHK), General Reference Hospital of Kinshasa (GRHK), Ngaliema Clinic, Chinese-Congolese Friendship Hospital (CCFH), General Reference Hospital of Makala (GRHM) and Military Hospital of the Republican Guard Colonel Tshatshi (MHRGCT), over a three-year period, from January 1, 2021 to December 31, 2023.

Study population, sampling and patient selection.

The study involved patients aged 18 and over, undergoing osteosynthesis of diaphyseal femoral fractures at the above-mentioned hospitals. Recruitment was exhaustive and consecutive.

All patients aged 18 and over with diaphyseal femoral fractures treated by osteosynthesis in the selected hospitals were included in our study.

Patients under 18 years of age were not included.

Patients whose records could not be retrieved were excluded.

Data collection

Data were collected retrospectively by the principal investigator from patient files and operating theatre registers, and recorded on a pre-designed data collection form.

The variables investigated were: sociodemographic (age, sex and profession), clinical (trauma circumstances, skin condition), therapeutics (surgical technique: locked centromedullary nail, unlocked nailing centromedullary by open surgery, screw-plate and external fixtors) and evolutionary: infection on osteosynthesis material (IOM), pseudarthrosis, pulmonary embolism, mechanical complication of the material and the time required for management and time to treatment. Patients were followed up for up to six months postoperatively.

Four main techniques were used in this series:

a. Open-focus DCP screw-plate osteosynthesis via a lateral approach.
b. Open-focus, non-locking centromedullary nailing via a lateral approach, with Küntscher nail insertion performed under visual control;
c. closed, anterograde LCN via a minimally invasive approach, with nail insertion performed under scopic control. Locking was systematically bipolar.
d. External fixation was performed using the Hoffman model, with frame mounting.

We compared LCN with three other techniques.

In this study, high-energy trauma was defined as any road accident resulting in a fractured femur, polytrauma or death to at least one victim. Any fall from a height equivalent to the 3rd floor of a multistorey building [9].

Statistical analysis

The data collected were entered using Excel 2013, checked, encoded and transferred to SPSS version 22.0 for analysis. Continuous variables were summarized as means and standard deviation, while categorical variables were summarized as numbers and proportions. Student's t test, Mann Withney U test, Pearson's Chi-square test or Fischer's exact test were used for variable comparisons. The p-value was set at less than 5%.

Ethical and regulatory considerations

Authorizations have been obtained from the hospitals concerned and from the local ethics committee. The authors declare that they have no conflicts of interest.

RESULTS

Patient flow diagram

Figure 1 shows the patient flow diagram.

We collected 202 patient records, of which 28 patients were not included and 64 were excluded from the study. Sample study was 110 patients.

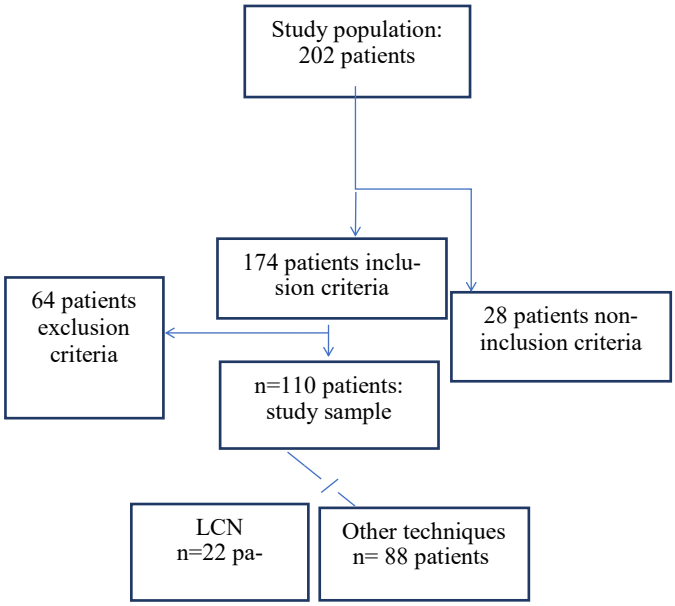

Figure 1: Patient flow diagram.

Patient distribution by care site

Table 1 shows the distribution of patients by site of care.

We registered 110 patients with femoral shaft fractures in six hospitals in the Kinshasa city, distributed as follows: UHK 39 patients (35.5%), GRHK 20 patients (18.2%), NGALIEMA Clinic 19 patients (17.3%), CCFH 15 patients (13.6%), GRHM 12 patients (10.9%), MHRGCT 5 patients (4.5%)

Table 1: Breakdown of patients by hospital of care

Hospital	Frequency (n=110)	(%)
NGALIEMA **Clinic**	19	17.3
U**HK**	39	35.5
CCFH	15	13.6
GRHK	20	18.2
GRHM	12	10.9
MHRGCT	5	4.5
Total	110	100

Legend: UHK = University hospital of Kinshasa, CCFH = Chinese-Congolese Friendship Hospital GRHK= General Reference Hospital of Kinshasa, GRHM= General Reference Hospital of Makala, MHRGCT: Military Hospital of the Republican Guard Colonel Tshatshi.

Patient socio-demographic characteristics

Table 2 shows the patients' socio-demographic characteristics.

Characteristics	Frequency (n=110)	%
Age of patients (X±SD)	41,9±16	
Age range (year)		
≤20	8	7.3 %
21 – 40	52	47.3%
41 – 60	35	31.8%
≥61	15	13.6%
Profession		
Employees	60	54.5%
Students	16	14.5%
Unemployed	34	30.9%
Gender		
Male	74	67.3%
Female	36	32.7%

The mean age was 41.9 ± 16 years (extremes 18 and 81), with almost half (47.3%) in the 21 to 40 age bracket. Males predominated at 67.3%, with an M/F sex ratio of 2. Employees accounted for 54.5%.

Table 2: Patient socio-demographic characteristics
Legend: X = mean, SD = standard deviation

Trauma circumstances

Figure 2 shows the circumstances of the trauma
The circumstances in which FSFs occurred were dominated by public road accidents in 93 cases, a proportion of 84.5%.

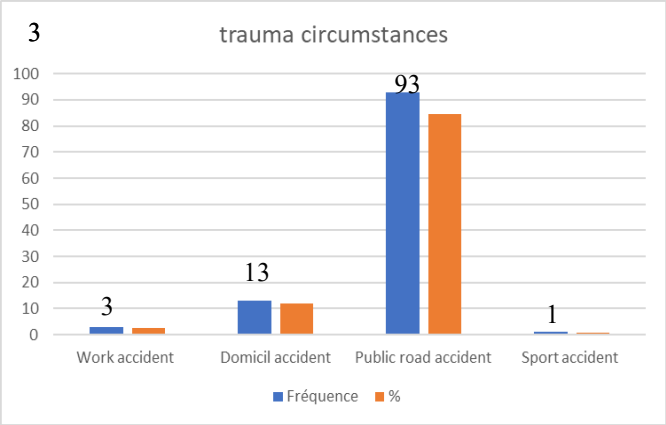

Figure 2: Trauma circumstances

Trauma energy		Frequency n = 110	%
Low energy	Household accident	5	4.5
	Fall from his height	8	7.3
High energy	Motorcycle collision	23	20.9
	Automobile collision	8	7.3
	Motorcycle-automobile	20	18.2
	Motorcycle-pedestrian	25	22.7
	Automobile-pedestrian	15	13.6
	Automobile rollover	2	1.8
	Fall from great height	3	2.7
	Wall collapse	1	0.9
Total		**110**	**100**

Table 3: Trauma mechanism and energy

Trauma mechanism and energy

Table 3 shows the mechanism and energy of trauma.

High-energy trauma was found 97 times (86.2%) (93 public road accidents + 3 falls from height and one wall collapse). Collisions between motorcycles and pedestrians were more frequent (22.7%).

Surgical indications and materials used

Table 4 shows the surgical indications and materials used.

Open fractures 12.8% (n=14) and eight classified as Guistillo 2 and 3 were treated with external fixators (EF). Two Guistillo 1 class fractures were treated with LCN and 4 with SP. The screw plate was the most commonly used material (45.5%). The locked nail was used in 22 cases (20%) and the unlocked nail in 30 cases (27.2%).

Materils **used**	**Type of fracture (Skin condition)**				
	Closed fracture	**Open fracture**			
		Type 1	Type 2	Type 3	Total
Locked nail	20 (18.1%)	2 (1.8%)	0	0	22 (20%)
Nail not locked	30 (27.2%)	0	0	0	30 (27.2%)
Screwed plate	46 (41.8%)	4 (3.6%)	0	0	50 (45.4%)
External fixator	0	0	6 (5.4%)	2 (1.8%)	8 (7.2%)
Total	96 (87.2%)	6 (5.4%)	6 (5.4%)	2 (5.8%)	110 (100%)

Table 4: Materials used according to skin condition and indications

Materials used and post-operative complications

Table 5 shows the distribution of post-operative complications according to the materials used.

Out of 110 femurs operated on, there were 25 infections on osteosynthesis materials, of which 19 (76%) were found in patients operated on by SP, with a significant correlation p=0.007.

Complications	Type of materials					
	Frequency n=110 (%)	Locked nail n = 25(%)	External fixator n = 8 (%)	Unlocked nail n = 30(%)	Screw plate n = 50(%)	p
Infection on material						
No	85(77.3)	21(96)	6(75)	27(90)	31(62)	0.007
Yes	25(22.7)	1(4)	2(25)	3(10)	19(38)	
Pulmonary embolism						
No	99 (90)	21(96)	7(87.5)	26(86.7)	45(90)	0.853
Yes	11(10)	1(4)	1(12.5)	4(13.3)	5(10)	
Pseudarthrosis						
No	99 (90)	22(22.2)	6(75)	29(96.7)	42(84)	0.005
Yes	11(10)	0	2(25)	1(3.3)	8(16)	
Mechanical failure of material						
No	102 (92.7)	22(21.6)	8(7.8)	29(96.7)	43(86)	0.089
Yes	8 (7.2)	0	0	1(3.3)	7(14)	

Table 5 shows the distribution of post-operative complications according to the materials used.

Type of mechanical complication according to material used

Table 6 shows the type of complications according to the material used.

Disassembly of the implant concerned the SP in 7 cases (87.5%) and unlocked nail in one case (12.5%).

	Type of matérial				Total
Mechanical complication	Locked nail	Unlocked nail	Screw plate	External fixator	
Disassembly of the implant	0	0	7 (87.5%)	0	7
Fracture **of** mate**r**ia**l**	0	0	0	0	0
Migratio**n**	0	1 (1.5%)	0	0	1
Total	**0**	**1 (12.5%)**	**7 (87.5%)**	**0**	**8 (100%)**

Table 6: Type of mechanical complication according to material

Materials used and pseudarthrosis

Table 7 shows the occurrence of pseudarthrosis according to the material used.

Of 50 patients operated on with screw plates, 8 (16%) developed pseudarthrosis. 2 of 6 patients operated on with EF developed pseudarthrosis.

	Type of material				Total
Pseudarthrosis	Locked nail	Unlocked nail	Screw plate	External fixator	
Yes	0	1 (3.3%)	8 (16%)	2 (25%)	11 (10%)
No	22 (100%)	29 (96.7%)	42 (84%)	6 (75%)	99(90%)
Total	**22**	**30**	**50**	**8**	**110(100%)**

Table 7: The occurrence of pseudarthrosis according to the material used.

Limb loading time according to material used

Table 8 shows the time taken to load the limb according to the material used.

An average time of 6.72 ± 4.83 days, with a significant correlation (p<0.001, min 0.2, max 3) for LCN.

Almost all limb loading was performed between 1 and 14 days. It was 108.08 ± 44.24 days for the SP (min 35 max 364, p<0.001), 99 ± 9.38 days for the EF (min 84 max 112) and 57.19 ± 33.04 days for the unlocked nail (min 3 max 24).

		Materials				p
Number of days	n =110 (%)	Screw plate	External fixator	Unlocked nail	Locked nail	
1-14	21(19.1%)	0(0%)	0(0%)	0(0%)	21(95.5%)	
15-28	8(7.3%)	0(0%)	0(0%)	7(23.3%)	1(4.5%)	<0.001
29-42	10(9.1%)	2(4%)	0(0%)	8(26.7%)	0(0%)	
45-56	3(2.7%)	0(0%)	0(0%)	3(10%)	0(0%)	
> 56	68(61.8%)	48(96%)	8(100%)	12(40%)	0(0%)	

Table 8: Time to limb loading according to material used

DISCUSSION

This study was carried out to compare the results of diaphyseal fracture treatment using 4 surgical techniques. It showed that results were better with LCN than with the other techniques (unlocked, SP and EF) in terms of time to limb weight-bearing and occurrence of postoperative complications.

In our study, the mean age was 41.9 ± 16 years (extreme between 18 and 81 years), with a greater proportion (47.3%) of patients found in the 21 to 40 age range, showing that this fracture is more prevalent in young adults. These results concur with those of Ngo et al; Fonkoué et al and Nzanzu et al (in the Democratic Republic of Congo) respectively 42.8 ± 17.9; 34.6 ± 13.6 and 30 years [10-12]. This is in fact the age of intense physical activity with risk of trauma. Males accounted for the majority in 67.3% of cases, with a M/F sex ratio of 2.05, similar to almost all the data found in the above-mentioned literature [2,10-13]. In France, Bonneviale et al [14] also found a higher proportion of men (68%) than women (32%) in their series. Employees accounted for more than half (54.5%) of patients, demonstrating that young working people are more exposed to the risk of accidents. [13].

Developments in orthopaedics over the last few decades have made LCN the gold standard in the treatment of FSF. This calls for a standardized technical platform already in place in developed countries, and currently being installed in developing countries. SP osteosynthesis was the most commonly used technique in our series (45.4%). These results have found similarities in the literature from countries with limited resources [7, 13], where ex-

ternal fixation and open-focus osteosynthesis are more often performed due to lack of social security coverage and technical facilities [15]. In our study, the following reasons may explain this frequent use of SP: surgeons' habits, and the unavailability or lack of maintenance of fluoroscopy equipment and an orthopaedic table in some hospitals.

SP has the advantage of enabling anatomical reduction and rapid mobilization of the knee, as well as being low-cost, and the technical set-up is simple and accessible. It does, however, have a number of disadvantages at the femoral level: longer consolidation time than LCN, risk of disassembly, delayed weight-bearing, increased risk of infection due to the direct approach to the focus [16].

Open non-locked was used in 30 patients, i.e. 27.2%. This technique has been abandoned in the West, and is virtually non-existent in Western literature at present. Nevertheless, it is still used in countries with limited resources. Bakriga et al [17]. and Kouassi et al [18] found acceptable results for this technique, with the advantage of being less expensive in a context of under-equipment. Its disadvantages are similar to those of open-focus techniques.

Closed-focus LCN was used in 20% of cases in our series. These figures are still low in comparison with the numerous reports in developed countries describing LCN as the reference treatment for FSF [1,25, 5, 16]. Our proportion, like that of certain studies on the African continent, is still low [7, 10, 11]. The LCN has the advantage of being biomechanically very stable, due to its intramedullary position and bipolar locking. This allows early loading. It is less invasive, performed in a closed setting with preservation of the peri-fractural hematoma associated with limited micro movements at the site, which favours rapid bone callus formation. It offers better biomechanical properties than SP and non-locked [5]. Even for open fractures, locked nail, used as an osteosynthesis technique, gave good results in a French series of Mazen[19].

External fixation was the technique least used in our series (7.2%). EF has only a limited place in the treatment of femoral fractures: wide-open fractures, particularly ballistic fractures [14], and orthopedically-controlled damage in unstable polytrauma patients with femoral shaft fractures whose general condition allows only minimally invasive osteosynthesis [14, 20-22]. The low proportion of open fractures in our series justifies the limited use of EF.

Four complications were noted in our series: 25 cases of IOM, of which 19 for SP, i.e. 76% with a significant correlation ($p = 0.007$), 3 (12%) for open-focus ECMNV, 2 (8%) for FE and 1 (4%) for closed-focus locked nail. Conventional SP requires an open focus, which increases the risk of infection [23, 16].

In the series by Loïc F et al [11]in Cameroon, of the 59 femurs operated on with SP, 8 presented an infection on osteosynthesis material, a rate of 13.5% ($p=0.013$) compared with 1 femur out of 214 operated on with LCN (0.5%). Like us, this series thus found a high rate of infection for SPs compared with LCN, which is in line with what is described in the literature [11, 26]. In our study, the fractures were mostly closed. The approach to the fracture site had an influence on the occurrence of infection.

Pulmonary embolism was found in 11 patients

postoperatively, of whom 5 (45.5%) were operated on by SP, 4 by open focus non-locking nail (36.4), 1 by external FE (9.1%) and 1 by LCN (9.1%).

The femur fracture is itself emboligenic [24]. In addition, centromedullary nailing is thought to be responsible for some fat embolism due to the reaming process [16, 24].

In our series, however, LCN had the lowest proportion of thromboembolic complications. This could be explained by the early management of patients who benefited from this technique, and the antithromboembolic prophylaxis instituted systematically postoperatively.

Of the 11 pseudarthroses recorded in our series, 8 (72.7%) resulted from SP osteosynthesis, 2 (18.2%) from EF and 1 (9.1%) from open non-locked nail.

Open-focus plate osteosynthesis results in loss of the fracture hematoma and de-periostealization of the focus, which slows the consolidation process [24]. In our series, pseudarthrosis after SP osteosynthesis had a significant relationship (p=0.005).

EF was the second most common technique for pseudarthrosis (18.2%) in our study. In Marocco, Razzouki [26] recorded 37.5% of pseudarthroses in patients operated on with EF, 4.5% with SP and 1.6% with LCN.

In Toulouse, Bonneviale's study of external fixation in 27 diaphyseal femoral fractures included 5 cases of diaphyseal femoral pseudarthrosis, i.e. 18.5% [14]. This proportion is similar to our own.

The EF, as much as the SP, does not allow early loading, which is a factor stimulating consolidation.

No femur operated on by LCN had complicated pseudarthrosis in our series. These are the advantages of the closed focus, preservation of musculoperiosteal bone vascularization, perifracture hematoma and the natural bone supply provided by reaming at the fracture site [24]. In addition, the possibility of early loading and the dynamization of the fracture site offered by LCN help to reduce the occurrence of pseudarthrosis [27]. Nevertheless, cases of pseudarthrosis have been reported in the literature after LCN at low proportions. [15, 21, 28].

In our study, there were 8 mechanical complications (7.2%), of which 7 out of 8 (87.5%) were plate dismantling and 1 (12.5%) migration of an unlocked nail. There was no statistically significant correlation (p = 0.089).

Essadki et al [29] in Belgium, in their series of 31 aseptic mechanical complications of osteosynthesis for diaphyseal femoral fractures, found that disassembly occurred mainly in simple fractures: 8 disassemblies out of 13 simple fractures, i.e. 6%, and 13 ruptures (72%) out of 18 complex fractures. The causes of this type of complication in this series were: early loading, pseudarthrosis and delayed consolidation.

In our study, the most plausible cause of osteosynthesis material disassembly would be pseudarthrosis, out of 8 patients with mechanical implant complications, there were 5 (62.5%) pseudarthrosis (p<0.001). 45% of patients with implant failure had presented a pseudarthrosis, p<0.001. This implant failure involved 7 SPs (disassembly) and one unlocked nail (migration).

A mean time to weight-bearing of 6.72 ± 4.83 days,

with a significant relation (p<0.001, min 0.2, max 3) for closed-focus LCN. Theoretically, patients who had a static set-up are allowed to fully press on their lower limb if interfragmentary contact is sufficient. For patients who have had dynamic mounting, walking with full weight-bearing is immediately permitted, especially if the line is transverse or short oblique with good interfragmentary contact [27].

In our series, treatment was not immediate, but early (less than a week). In fact, treatment was coordinated with the physiotherapy team, whose availability imposed a certain length of hospital stay. Nevertheless, LCN had the shortest turnaround time compared with other techniques, which is in line with what is described in the literature. The average hospital stay for patients operated on with LCN was 0.56-0.45 months, or around two weeks. This is still high by standard. Indeed, due to the limited number of specialized rehabilitation structures and teams providing aftercare at home, patients were kept in hospital to begin rehabilitation and continue postoperative care until complete healing.

For SP, the mean time to loading was 108.08 ± 44.24 days, or approximately 3.5 months. Theoretically, progressive loading is initiated when a callus appears, usually in the 3-4th month [6, 24]. This corresponds roughly to the results of our study.

A Malian study by Diallo et al [13] found similar results to ours, with a time to weight-bearing of 4 months, lower than those found in a Cameroonian study by Fonkoué et al [11] in which the mean time to walking with full support without canes was 6.36 ±4.4 months.

The length of hospital stay for SP surgeries in our series (2.49 ± 3.59 months) was considerably longer than that described in the literature (average 10 days) [25]. The scarcity of specialized rehabilitation facilities and the naturally long lead time (at least 3 months) favoured prolonged hospitalization. In addition, the infectious complications of SP osteosynthesis require in-hospital care, which prolongs the length of hospital stay.

Open-focus nail unlocked had a mean loading time of 57.19 ± 33.04 weeks.

Despite the absence of recent Western publications on this technique, in Africa, Bakriga [17] noted that in his series, this technique had enabled early authorization of weight-bearing in patients with a predominantly single line. In our series, we noted a shorter loading time for open nail not lucked than for SP.

The centromedullary nail, although not locked, remains an intramedullary stent, providing good stress distribution on the diaphysis, unlike the SP, which is extramedullary and laterocortical. If, in addition, the nail used has a good endomedullary anchorage and the line is simple (transverse or short oblique), this can confer a good degree of stability to the assembly and enable much earlier loading than with a screwed plate. This limits the risk of material failure.

For the EF, the mean time to loading was 14.14 ±1.34 weeks. In the literature, loading is possible as soon as a unitive callus bridging the focus on two incidences has formed, generally not before the third month [8]. The delay found in our series

was therefore in line with that found in the literature.

CONCLUSION

Diaphyseal fractures of the femur are a frequent occurrence, most often in young, active, male adults, and are primarily caused by road accidents.

Locked centromedullary nailing is the best technique, with good results and fewer complications than other techniques. It has the advantage of a minimally invasive approach, limiting the risk of infection. It gives good stability to the construct, and enables early mobilization and weight-bearing. Nevertheless, it requires a standardized technical platform that is not always available in a context of limited resources. This technique is progressing in Kinshasa, but the rate of its use is still below world standards.

Authors' contributions

Jephté Tshimbalanga: study design, data collection and drafting of the manuscript

Hugues Albini: conception of the study and drafting of the manuscript

All other authors: correction of the manuscript

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