

Compared Outcomes of Femoral Shaft Fracture Treatment in School-Age Children in Sub-Saharan Africa: Primary Open Reduction and Intramedullary K-Wire Fixation versus Traction followed by Spica Cast

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Abstract

Background: Elastic stable intramedullary nailing has become the treatment of choice for femur shaft fractures in school-age children in developed world. However, in the sub-Saharan Africa, this management is still challenging because of the lack of fluoroscopy in more hospitals. We performed either primary open reduction and intramedullary K-wire fixation (PORIKF) or conservative treatment. The aim of this study was to compare the clinical and functional outcomes of these two procedures employed. **Patients and Methods:** This retrospective study included 62 children with 64 fractures (10 years on an average; range: 6–15 years) treating for femoral shaft fractures either by PORIKF ($n = 21$; 23 fractures) or skin traction followed by spica cast ($n = 41$) between 2008 and 2017. Outcomes were assessed using Flynn criteria. Comparisons were made by Fisher and Student's t -test with a significant $P < 5\%$. **Results:** Outcomes were satisfactory in 21 cases (91%) in the PORIKF group compared with 32 (78%) in the conservative group ($P = 0.3012$). The average hospital stay was 18.6 days in the PORIKF group, whereas it was 20 in the conservative group ($P = 0.0601$). The mean time for bone union was 13.9 weeks in the PORIKF group and 13.2 weeks in the conservative group, ($P = 0.4346$). There was a statistically significant difference between the two groups in terms of major complications ($P = 0.0177$). One patient had osteomyelitis in the PORIKF group. Unacceptable shortening >2 cm was observed only in the conservative group. The average time to return to daily activities was 30 days shorter in the PORIKF group when compared to conservative group ($P < 0.05$). **Conclusion:** PORIKF provides better results than conservative treatment. Open reduction did not increase the rate of infectious complication.

Keywords: Children, femoral shaft fracture, K-wire fixation, open reduction, traction and spica cast

INTRODUCTION

Femoral shaft fractures (FSF) represents 1.6% of all paediatric fractures.^[1-5] Their treatment includes conservative method (early spica cast, and skin or skeletal traction followed by spica cast) and various surgical procedures such as external fixation, compression plating, rigid intramedullary nailing and elastic stable intramedullary nailing (ESIN).^[2,3,6-12] The indications of each method depend on certain factors such as age and weight of the child, associated injuries, fractures patterns, technical platform and habits of surgeons. Conservative treatment is traditionally used in young children

under 6 years of age. Above this age, ESIN is increasingly indicated by most authors in recent studies,^[2,6,7,9,12-14] but this technique has specific indications and requires specific implants and fluoroscopy which are lacking in most developing countries. In some hospitals in the sub-Saharan Africa (SSA), we systematically performed primary open reduction and

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intramedullary Kirschner wire (K-wire) fixation (PORIKF) in femur fracture fixation because of the lack of fluoroscopy.^[15-17] However, for structural conditions and economic constraints, skin traction followed by spica cast (ST/SC) was frequently the only option for us independently of patient's age and weight. The aim of this study was to compare the clinical and functional outcomes of PORIKF or ST/SC in the fixation of femur fracture for school-age children in order to suggest a strategy in low-income setting where fluoroscopy is lacking.

PATIENTS AND METHODS

This retrospective study was conducted in Yopougon Teaching Hospital over a period of January 2008–December 2017 on children with FSF within the age group of 6–15 years of either sex. We included all patients who underwent either PORIKF or ST/SC procedure for FSF with regular follow-up at least 6 months after bone union, and who had responded favourably for our convocation by phone for the latest follow-up.

Sixty-two ($n = 62$) out of 73 patients were included in the study. There were 42 boys (67.7%) and 20 girls (32.3%), with a mean age of 10 years, 3 months. Overall, 11 (15%) patients who live in remote cities, those who responded negatively to our convocation and those with missing or incomplete file data were excluded from the study. Associated injuries were polytrauma found in 11 patients (head trauma $n = 7$, blunt abdominal trauma $n = 4$), and other fractures (pelvis $n = 1$, leg $n = 2$, forearm $n = 2$) in five patients. All patients were admitted within the first 72 h after trauma and they were put in traction.

Operative treatment (primary open reduction and intramedullary K-wire fixation)

All the patients were treated under general anaesthesia in supine position, on the ordinary surgical table with antibioprophyllaxis; two K-wires were used in each patient. The K-wire was minimally inclined to form a 'C' or 'S' shape, according to the fracture site. One tip of the K-wire was bent and the other was marked by a felt pen in a concavity. A 2–3 cm long incision was made over the lateral and medial surface of the distal metaphysis or under the great trochanter of the femur concerned. After soft-tissue dissection, metaphysis was exposed and opened. K-wire was advanced proximally to the fracture site using a T-handle or a hammer; then open approach of the fracture site was performed. After that, a satisfactory reduction had been achieved and maintained by a clamp. The wire was then pushed into the opposite fragment and was oriented according to the initial mark. The distal ends of the nails were bent externally, cut as low as possible at the subcutaneous level, above the physis, and then buried under the skin. The wound was closed over suction drainage. Despite an unavailability of fluoroscopy, all steps of the nailing procedure were based on the principles described by the promoters,^[9] and nail diameter corresponded to 40% of the canal diameter at its narrowest portion. Partial weight bearing was authorised 4–6 weeks after surgery.

Conservative treatment (skin traction followed by spica cast)

The injured femur was kept on skin traction on the 20°–30° inclined bed. The traction force represents 1/7th of the patient body weight. When signs of callus formation were confirmed by the absence of tenderness at the site, a hip spica cast was applied without anaesthesia. All the patients were watched for 24 h in the hospital for any discomfort and then, they were discharged after care of spica. There were reviewed at 6 and 10 weeks with radiographs at each review to assess the progress of fracture healing. Once bone union was confirmed by the presence of bridging callus across at least three or four cortices on anteroposterior and lateral X-rays, the spica cast was removed and full weight bearing was allowed.

Comparison of the two methods

Patients were divided into two groups: ST/SC group included 41 patients (26 boys and 15 girls) with 41 fractures, while PORIKF group included 21 patients (16 boys and 5 girls) with 23 fractures. The demographic and clinical data are summarised in Table 1. Patients were followed up at interval of 1, 3, 6 and 12 months. After bone union, a clinical examination was performed at each visit to evaluate gait abnormalities, leg length discrepancy (LLD), non-union and malunion. Data collected included pre-operative time to surgery, hospital stay, bone union time, return to daily activities and time to nail removal. Complications and outcomes were recorded. LLD or shortening <2 cm and angulation <10° in the coronal and sagittal planes were tolerated, but any rotational malalignment was accepted in our practice.

The Titanium Elastic Nailing Score suggested by Flynn *et al.*^[18] as shown in Table 2 was applied to all cases, irrespective of the mode of treatment. Good to excellent results were taken as satisfactory outcome. Fisher's exact test was used to compare fractures characteristics and the outcome score of the patients. Comparisons of the means were made by Student's *t*-test. $P < 0.05$ (5%) was considered statistically significant.

RESULTS

There was no significant difference between the two groups in terms of age, gender, weight and fracture characteristics ($P > 0.05$). Table 3 shows the outcomes of this study. Satisfactory outcome was observed in 21 cases (91.3%) in the PORIKF group [Figure 1], and 32 (78%) in the ST/SC group; the difference was not statistically significant ($P = 0.3012$). The mean time between trauma and surgery was 9.6 ± 5.81 days (range: 1–20 days). Three patients were transfused, and six had a knee spica cast for instability or to correct axial deviation in the PORIKF group. The mean hospital stay after surgical procedure was 9.2 days. The cast change was noted in 15 cases (36.5%) in the ST/SC group. All the fractures healed. The mean time for nail removal was 9.5 ± 4.85 months (range: 3.3–24.3 months). The complications observed are summarised in Table 4 according to Moroz's system.^[19] Major complications occurred in three cases in the PORIKF group and in 17 in the

Table 1: Demographic and clinical data of the study population

	PORIKF	ST/SC	P
Gender (male/female)	16/5	26/15	0.3084
Age (years, mean±SD)	11.2±2.52 (7- 15)	10.1±3.01 (6- 15)	0.1249
Scholar status			
School children	16	29	
Unschoolled	5	12	
Mechanisms			
Road traffic accident	18	23	
Fall from height	2	7	
Sport injuries	-	8	
Home trauma	1	2	
Others	-	1	
Site of fracture			
Left	8	24	0.0673
Right	11	17	
Bilateral	2	-	
Level of fracture			
1/3 rd proximal	7	19	0.2954
1/3 rd middle	12	15	
1/3 rd distal	3	7	
Bifocal	1	0	
Pattern of fracture			
Transverse	15	25	0.3966
Oblique	7	14	
Spiral	1	2	
Weight (kg), mean±SD	34±12.9 (15- 66)	28.9±6.85 (13- 54)	0.3791
Hospital stays (days), mean±SD	18.68±9.06 (3- 34)	20±6.85 (13- 54)	0.0621
Bone healing (weeks), mean±SD	13.9±3.23 (8.5- 47.1)	13.2±2.54 (9- 25)	0.4346
Return to daily activities (weeks)	9.1±2.45	14.1±2.54	0.0000*

*Statistically significant. SD: Standard deviation, ESIN: Elastic stable intramedullary nailing, POR: Primary open reduction, ST/SC: Skin traction followed by spica cast

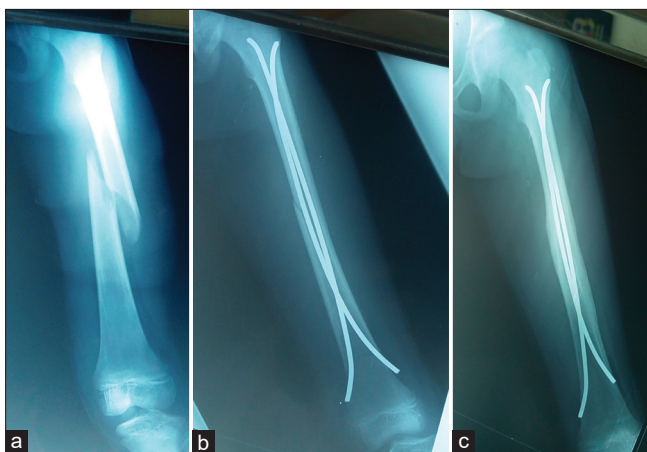


Figure 1: An 8-year-old girl sustained femoral shaft fracture. (a) Pre-operative anteroposterior view. (b) Post-operative appearance after open reduction and elastic stable intramedullary nailing; (c) Nine months' radiographs show complete union

ST/SC group ($P = 0.0177$). One patient in the PORIKF group had ipsilateral Salter–Harris type 2 fracture of distal tibial 5 weeks after surgery when he played football. The length of scar has no influence on the parent’s perception.

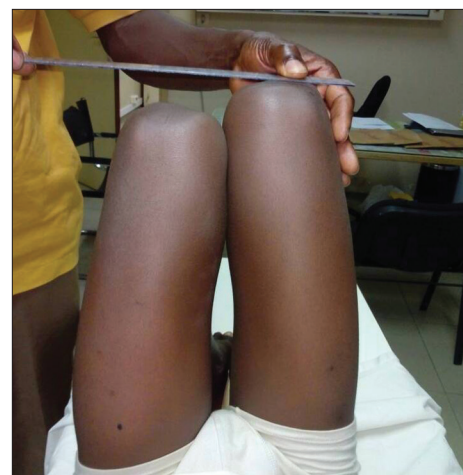


Figure 2: Clinical aspect of limb inequality (leg length discrepancy >2 cm) after conservative treatment

One patient had osteomyelitis in the PORIKF group. Osteomyelitis was due to *Staphylococcus aureus* and it was managed by reoperation, debridement and adapted antibiotics. The knee stiffness was resolved after physiotherapy.

Table 2: Flynn's scoring criteria^[18]

	Excellent	Good	Poor
Limb length discrepancy (cm)	<1	<2	>2
Malunion (°)	<5	5- 10	>10
Pain	Absent	Absent	Present
Complications	Absent	Mild	Major/extended morbidity

Table 3: Outcomes according to Flynn criteria

	PORIKF (n=23)	ST/SC (n=41)	P
Excellent (%)	13 (56.5)	26 (63.4)	0.4392
Good (%)	8 (34.8)	6 (14.6)	0.4392
Poor (%)	2 (8.7)	9 (22)	0.3012
Follow-up (years, range)	2.14 (0.5- 4)	4.45 (0.5- 6)	

PORIKF: Primary open reduction and intramedullary k-wire fixation, ST/SC: Skin traction followed by spica cast

Table 4: Distribution of complications

	PORIKF	ST/SC	P
Minor complications	20	28	
Skin irritation	3	0	0.6438
Knee stiffness	7	0	
Cheloid scar	2	0	
Spica cast change	0	15	
Superficial infection at nail entry point	3	0	
LLD <2 cm	3	8	
Malunion			
Valgus <10°	1	1	
Varus <10°	1	2	
Procurvatum <10°	0	1	
Recurvatum <10°	0	1	
Major complications	3	17	
Osteomyelitis	1	0	0.0177*
Delayed union	1	0	
Secondary displacement	0	5	
Malunion			
Varus >10°	0	4	0.3333
Procurvatum >10°	1	0	
LLD >2 cm	0	8	

Statistically significant, PORIKF: Primary open reduction and intramedullary K-wire fixation, ST/SC: Skin traction followed by spica cast, LLD: Leg length discrepancy

The average time to return to daily activities was 30 days shorter in the PORIKF group than that of the ST/SC group ($P < 0.05$). Eight patients in the ST/SC group with LLD >2 cm [Figure 2] complained for limping. Other complications such as compartment syndrome and refracture after nail removal were not observed.

DISCUSSION

The best method of treatment for paediatric FSF is still controversial, particularly for those who aged between

5 and 16 years.^[13,20] The standard of care in most developing countries is skeletal or skin traction and casting.^[21] In a large survey describing treatment patterns for paediatric femur fractures in low- and middle-income countries, the authors noted that non-operative management was frequently used than operative treatment in the adolescent age group (60% vs. 40%, respectively).^[14]

Currently, ESIN has become the treatment of choice in school-age children because it avoids the effect of prolonged immobilisation and reduces the loss of school days.^[4,12,13,22,23] To our knowledge, this is the first study comparing the outcomes between PORIKF and ST/SC in the fixation of FSF. This study showed that PORIKF provides better results than ST/SC (91% vs. 78%) although there was no significant difference. This is in agreement with previous reports that showed the benefits of ESIN for treating FSF than spica casting.^[7,10,13,24,25] A statistically significant difference favouring ESIN, also called TEN group, than spica group was reported.^[26,27]

Buechsenschuetz *et al.*^[27] documented titanium nail superior in terms of union, scar acceptance and overall patient satisfaction compared to traction and casting. Other studies showed that parents were more satisfied in the TEN group than that in the spica cast group.^[6,10] Although parent satisfaction was not studied in this series, we have shown that the length of scar has no influence on the parent's perception.

Time interval between trauma and surgery was too long in SSA: 7 days in Ghana^[21] and Sénégal,^[17] and 21 days in Togo.^[15] This delay was 2 to 4 fold longer than those of Bhuyan *et al.*,^[28] and Nascimento and Santuli^[13] who respectively reported 3.8 days in India and 5.3 days in Brazil. In our practice, this long delay was the time needed for nail acquisition and sterilisation and the availability of the operating room because one operating room was dedicated for all emergencies. However, in studies by Nisar *et al.*^[8] and Heffernan *et al.*^[23] in the UK and USA, 80% and 85% of the patients were, respectively, operated within 24 h. These differences of pre-operative time are likely reflective of the level of development of the healthcare system.

In the current study, there were no significant differences between both groups regarding hospital stay length. Most parents of our patients have informal sector activities. Lengthy hospitalisation causes financial hardship for families as well as high hospital bed occupancy rates. Increased hospital stay in the PORIKF group was only due to pre-operative delay, which is too long in this study. Logistic reasons and absence of health insurance were the common reasons. This was in contrary to those in previous studies which reported shorter hospital stay in TEN group than that in spica casting group.^[4,6,27] Other studies showed that hospital stay was longer in the operative group than the spica casting group.^[11,25,26] Say *et al.*^[11] applied the spica cast in the operating room within 24 h without skin or skeletal traction to avoid longer hospital stay. In Saseendar *et al.*'s^[26] study, patients were discharged from hospital after removal of suture to monitor the occurrence of early post-operative complications, and the

spica patients were generally discharged a day or two after spica casting, once the presence of plaster of Paris-related complication was assessed.

The present study showed that there was no significant difference in both groups in terms of bone union as experienced by Buechsenschuetz *et al.*^[27] Bone healing time was too long in both groups compared to 7–10 weeks reported by other authors.^[4,5,7,13] This was due to the fact that our patients did not respect follow-up appointments and medical instructions. We are aware that union time has to be interpreted with caution because most patients attended the follow-up visit at a later date than scheduled. Radiological union would have taken place long before X-rays were taken spuriously, inflating the union time. Verma *et al.*^[7] and Sekhar and Prasad^[29] showed shorter time of bone union in the TEN group compared with the spica casting group. In the study of Nascimento *et al.*,^[13] the mean time for bone union was 1.6 week shorter in the surgical group than in the conservatively treated cases.

Although there are no clear guidelines in the literature, the average time for nail removal in the current study is in accordance with previous reports.^[13,18] We agreed with Flynn *et al.*^[18,25] who recommended nail removal after fracture healing at 6 months to 1 year following surgery because we experimented the difficulty of nail removal 2 years after surgery.

Open reduction avoids exposure to radiation, but exposes to loss of blood and the high risk of infection, which is the leading complication. In this study, one deep infection or osteomyelitis was observed. Two out of nine patients treated using open reduction by Ndour *et al.*^[17] developed deep infection. In the largest review of 350 fractures treated percutaneously by the team of Nancy, one case of osteomyelitis was observed.^[30] In many studies reported, infection was superficial and was cured by oral antibiotic in the ESIN group.^[6,11,29] Other authors have observed superficial infection in their spica cast group.^[3,11] None of our patients treated conservatively developed infection as reported by certain authors.^[13,26]

There was no significant difference between the two groups in terms of LLD and malunion. However, there was higher rate of malunion in the ST/SC group, which was in accordance with the findings of previous reports of Shemshaki *et al.*^[6] and Mukherjee and Gupta.^[4] Unacceptable LLD (>2 cm) was observed only in the conservative group as reported by Khaffaf and Altaweel^[24] An 18% incidence of unacceptable shortening (>2.5 cm) was reported by Lee *et al.*^[31] after conservative treatment. To avoid malalignment in the conservative group, traction was exerted with Steinmann pin through a femoral metaphysis by Say *et al.*^[11] and Flynn *et al.*^[18] As reported by Mukherjee and Gupta^[4] in India, none of our patients experimented skeletal traction, which is no longer applied after iatrogenic fracture (Salter and Harris type 1) of the distal femur certainly due to defective technique of nail placement. However, we agreed that skeletal traction could prevent most cases of malunion and LLD.

This study showed favourable outcome in PORIKF group than ST/SC group in terms of major complications and return to daily activities. For these reasons, we agreed with Imam *et al.*^[2] who recommended operative treatment after a meta-analysis study including 1012 patients.

This study has some limitations: (1) the retrospective nature with the difficulties in data collection and the fact that it was monocentric and not randomised; (2) the absence of skeletal traction which would have certainly prevented certain cases of LLD and malunion in the ST/SC group was another major limitation and (3) the difficulties in the follow-up of patients due to the lack of calling system for follow-up visits, economic constraints, social reasons and no respect of appointment and medical instructions are the other limitations in this study. This was the case of the patient who sustained a Salter–Harris type 2 fracture.

CONCLUSION

Both conservative treatment and PORIKF provided satisfactory results in more than three quarters of case. In spite of certain limitations of the study, we suggested PORIKF for treating femoral shaft fracture in school-age children in developing countries in case of the unavailability of fluoroscopy because lengthy hospitalisation causes financial hardship for families who have no health insurance, as well as high hospital bed occupancy rates.

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Conflicts of interest

There are no conflicts of interest.

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