

Complications after intramedullary nailing of femoral fractures in a low-income country

A prospective study of follow-up, HIV infection, and microbial infection rates after IM nailing of 141 femoral fractures at a central hospital in Malawi

Sven Young^{1,2,3,4}, Leonard N Banza^{3,4}, Geir Hallan^{1,5}, Fletcher Beniyasi³, Kumbukani G Manda³, Boston S Munthali³, Eva Dybvik⁵, Lars B Engesæter^{1,2,5}, and Leif I Havelin^{1,2,5}

¹Department of Orthopaedic Surgery, Haukeland University Hospital, Bergen; ²Department of Clinical Medicine, University of Bergen, Bergen, Norway; ³Department of Surgery, Kamuzu Central Hospital, Lilongwe; ⁴College of Medicine, University of Malawi, Lilongwe Campus, Lilongwe, Malawi; ⁵Norwegian Arthroplasty Register, Haukeland University Hospital, Bergen, Norway.
Correspondence: svenyoung@gmail.com
Submitted 13-07-08. Accepted 13-08-31

Background Some surgeons believe that internal fixation of fractures carries too high a risk of infection in low-income countries (LICs) to merit its use there. However, there have been too few studies from LICs with sufficient follow-up to support this belief. We first wanted to determine whether complete follow-up could be achieved in an LIC, and secondly, we wanted to find the true microbial infection rate at our hospital and to examine the influence of HIV infection and lack of follow-up on outcomes.

Patients and methods 137 patients with 141 femoral fractures that were treated with intramedullary (IM) nailing were included. We compared outcomes in patients who returned for scheduled follow-up and patients who did not return but who could be contacted by phone or visited in their home village.

Results 79 patients returned for follow-up as scheduled; 29 of the remaining patients were reached by phone or outreach visits, giving a total follow-up rate of 79%. 7 patients (5%) had a deep postoperative infection. All of them returned for scheduled follow-up. There were no infections in patients who did not return for follow-up, as compared to 8 of 83 nails in the group that did return as scheduled ($p = 0.1$). 2 deaths occurred in HIV-positive patients (2/23), while no HIV-negative patients (0/105) died less than 30 days after surgery ($p = 0.03$).

Interpretation We found an acceptable infection rate. The risk of infection should not be used as an argument against IM nailing of femoral fractures in LICs. Many patients in Malawi did not return for follow-up because they had no complaints concerning the fracture. There was an increased postoperative mortality rate in HIV-positive patients.

Even though Africa has 24% of the global burden of disease, it has only 3% of health workers and commands less than 1% of world health expenditure (WHO 2006). Of the estimated 234 million major surgical operations performed worldwide in 2004, only 3.5% were performed in the poorest 35% of the world's population (Weiser et al. 2008). Globally, 5.8 million people die annually as a result of injuries—more than die of HIV/AIDS, tuberculosis, and malaria combined (WHO 2006, Mathers et al. 2008). Of the 2.6 million young people between 10 and 24 years of age who died in the world in 2004, 97% died in low- and middle-income countries (LMICs). Over 40% of these deaths were due to injuries and, among these, road traffic injuries were the most common cause (Patton et al. 2009). Possibly more than 20 times as many as are killed by injuries survive and need treatment for their injuries (Peden 2004), and probably at least 3 times as many as are killed end up with a permanent disability (Kobusingye et al. 2001). The resulting long hospital stays and disabilities push poor people in LMICs further into poverty (Mock et al. 2003).

Kamuzu Central Hospital (KCH) is the referral hospital for 5.5 million people in the Central Region of Malawi. Despite being situated in the capital city, Lilongwe, KCH is drastically underfunded and lacks many basic facilities and human resources. Malawi is seriously affected by the HIV pandemic, and the national HIV prevalence in adults between 15 and 49 years of age was 10% in 2011 according to the UN (<http://www.unaids.org/en/regionscountries/countries/malawi/>). Internal audits at KCH have at times shown an HIV prevalence of more than 30% for patients admitted to the medical wards. Before 2007, only very basic orthopedic surgery was carried out and essentially all femoral fractures admitted to the hospital were treated with traction. From 2007, KCH has been

cooperating with Haukeland University Hospital in Norway and other international partners to improve surgical services and to start a surgical training program for general and orthopedic surgeons (Qureshi et al. 2013).

Orthopedic trauma surgery can prevent and treat disability, and is increasingly being shown to be as cost-effective as other essential health interventions in LMICs (Mock et al. 2003, Ozgediz and Riviello 2008, PLoS Medicine Editors 2008). However, there is still a prevailing belief among many surgeons and policy makers that infection rates are too high, and therefore results are not good enough, to recommend orthopedic implant surgery in low-resource settings. This perception is based mostly on papers about abdominal and gynecological surgery (Ibeziako et al. 1977, Ansaloni et al. 2001, Fehr et al. 2006), and probably on the individual experience of visiting surgeons who witness the stark contrast in infrastructure to their home setting in hospitals in LICs. Several studies have shown, however, that this is not necessarily the case in orthopedic surgery (Gross et al. 2010, Bates et al. 2012), but follow-up rates as low as 20% and below in some studies from LMICs make infection rates uncertain (Shearer et al. 2009, Young et al. 2011).

Low follow-up rates are a continuous problem in research in LMICs. In Malawi, patients often do not know their date of birth. People spell their names differently from one visit to the next and even use a different surname from one visit to another, sometimes using their “clan name” and at other times using their father’s surname—or first name. It is not unusual for patients even to start using a different name altogether. Though mobile phones are increasingly common among people in Malawi, not everyone has a phone, or even knows someone who owns a phone, and numbers are often discontinued because of loss of the phone or lack of payment. Addresses are imprecise and many villages have the same names. The roads in rural Malawi are bad, especially during and after the rainy season, making transport difficult and finding patients on outreach visits challenging. Surgeons working in low-income countries (LICs) often have the impression that patients do not return for follow-up if they have no complaints, but that they do return if they have a serious problem. A frequent reason given by patients for not returning for review in Malawi is the cost of transport (Yu et al. 2007, Bedford et al. 2011). In an earlier study of the SIGN Online Surgical Database (SOSD), we found that a statistical model supported the notion that patients who do not return for follow-up after trauma surgery in LMICs have few infections (Young et al. 2011), but prospective studies with better follow-up rates are needed to shed more light on this. In the present study, we wanted to find out whether it was possible to get close to 100% follow-up in a low-resource setting, and to determine whether the patients who did not return for follow-up after femoral nailing really did have less complications than those who returned as scheduled. Considering the regional impact of HIV, we also wanted to compare outcomes in HIV-positive and HIV-negative patients.

Patients and methods

All patients presenting at Kamuzu Central Hospital with a femoral fracture eligible for treatment with an IM nail between January 1, 2010 and April 3, 2012 were asked to participate in the study. Participation required giving informed consent to record data concerning their accident, health status, the IM nail operation, and follow-up. All patients were asked to have an HIV test. They were all thoroughly counseled about the reasons for testing, the consequences of the result, and possibilities for treatment. Treatment of their femoral fracture was the same irrespective of whether they complied with HIV testing, irrespective of the result, and irrespective of whether or not they were included in the study. No patients refused inclusion in the study. However, 6 patients who had incompletely filled out the study forms and who did not have a recorded address or telephone number were excluded from the study.

Data, including as accurate a birth date, name, and physical address as possible and a phone number for the patient, a relative, or friend, were recorded on a data collection form. Primary endpoints at follow-up were the same as for the SIGN online surgical database (SOSD) and included: presence of infection, partial weight bearing, painless full weight bearing, knee flexion over 90 degrees, and signs of healing on radiographs (Young et al. 2011, 2013). Surgeons classified infections, if present, as superficial (just involving the skin) or deep (involving bone and/or the implant).

All the patients were operated using a SIGN IM nail (Zirkle 2008). SIGN Fracture Care International (SIGN) is a non-profit organization based in Washington State, USA, that supplies intramedullary nails for the treatment of long bone fractures free of charge to hospitals in LICs. The SIGN IM nails are specifically designed to be used in a low-resource setting without a C-arm image intensifier or power tools. SIGN has supplied IM nails to KCH since 2008. Patients were mobilized with crutches as soon as possible after surgery, and discharged when they could walk without assistance.

All the patients were given a follow-up appointment 6 weeks after discharge, and were actively encouraged to come for this check-up, however happy they were with the result.

Patients who did return for this first follow-up visit were asked to return for a new visit and attempted followed-up until the fracture had healed clinically and radiographically. All the patients who had returned for at least 1 follow-up visit were classified as having returned for scheduled follow-up. Those who had not returned for follow-up and who had to be actively contacted by phone or outreach were classified as not having returned for follow-up. If possible, patients were contacted by phone and given a follow-up appointment. Patients who refused to come for follow-up when contacted by phone were interviewed by phone only. Those who could not be reached by phone but who had an accurate address were examined at their home on outreach visits if they could be found. When we

found the right village and family but the patient was not at home, we interviewed the family and if possible got a phone number to reach the patient on.

Infection was defined as any clinical infection relating to the operating incisions or the fractured bone. Possible risk factors for infection after orthopedic trauma surgery, including age, sex, surgical approach, time from injury to surgery, duration of surgery, open fractures, use of antibiotics, and operating techniques were included as variables in the analyses. Open fractures were classified according to Gustilo and Anderson (1976). Non-union is usually seen as a complication of surgery in literature from high-income countries. In LICs, however, it is a separate and common indication for surgery, as non-operative management is still widely used. Non-union has been shown to be a risk factor for infection in itself (Young et al. 2013) or might be an indirect measure of increased operating time, and was therefore analyzed as a separate risk factor. Delayed union or non-union was simply defined as a fracture that had no sign of healing in the expected time with conservative treatment. These patients were mostly referrals from other hospitals that had no other option than conservative management. They were grouped separately from the patients where IM nailing was the intention from the start of treatment.

Ethical approval for this study was given by the National Health Sciences Research Committee of Malawi (approval #753).

Statistics

The chi-square test was used to compare rates in 2 different groups. When any expected cell frequency was less than 5, we used Fisher's exact test. Independent-samples t-tests were used to compare means in 2 groups. Based on Levene's test for equality of variances, we used Student's t-test for equal variances and Welch t-test for unequal variances. All p-values were 2-tailed and the level of statistical significance was set to $p < 0.05$. Analyses were done using IBM SPSS versions 19.0 and 21.0.

Results

137 patients were included in this study. 32 fractures (23%) were classified as delayed or non-union at operation. 4 patients had bilateral femoral fractures, giving 141 IM nail operations—125 antegrade nails (89%) with a trochanteric approach and 16 retrograde nails. Of the patients included, 17% were female. The median age of the patients was 30 (12–78) years. For females, the mean age was 40 (SD 16) years and for males it was 32 (SD 12) years, the mean difference being 8 (95% CI: 3–14). 60% of fractures occurred in the right femur. 25% of patients were poly-trauma victims and 87% of fractures were due to high-energy trauma. 7% were open fractures (Gustilo grade 1: 2.8%; grade 2: 2.8%; and grade 3: 1.4%). 71% of the injuries were due to road traffic accidents (Table

Table 1. Registered mechanism of injury. 71 % of injuries were due to road traffic accidents

Mechanism of injury	n	%
Road traffic accidents	96	71
Minibus	22	16
Passenger in private vehicle	21	15
Pedestrian hit by motor vehicle	17	13
Cyclist hit by motor vehicle	17	13
Passenger on pick-up truck or lorry ^a	16	12
Ox-cart	3	2
Other injuries	40	29
Fall	16	12
Collapsing structure	9	7
Assault	8	6
Sports	4	3
Pathological fracture	2	1
Crocodile bite	1	1

^a "Passenger on pick-up truck or lorry" refers to patients who were passengers on the rear, open loading area of a pick-up truck or lorry, a common mode of public transport in Malawi.

1). 114 fractures were shaft fractures, 20 were subtrochanteric fractures, and 7 were distal metaphyseal fractures.

In acute fractures primarily planned for surgery, the mean waiting time from injury to surgery was 17 (SD 10) days. In patients with fractures defined as delayed or non-unions, surgery was performed median 11 weeks (5 weeks–11 years) after the injury. Mean time from injury to discharge for acute fractures was 30 (SD 15) days. Median time from surgery to discharge was 8 (1–90) days. The patients were ambulating with crutches median 6 (1–72) days postoperatively. Open reduction was used in 96% of cases and intravenous prophylactic antibiotics were given preoperatively in all but 2 cases. Mean operating time was 115 (SD 42) min and mean estimated blood loss was 306 (SD 234) mL. Fractures defined by the surgeon preoperatively as delayed or non-union had a mean operating time of 130 (SD 36) min and a mean estimated blood loss of 400 (SD 309) mL. Fractures that were defined as acute, and were planned for primary fracture treatment, had a mean operating time of 112 (SD 43) min, mean difference 18 min (95% CI: 0.6–35), and an estimated blood loss of 279 (SD 202) mL, mean difference 121 mL (95% CI: –10 to 252).

Follow-up

Of the 137 patients included, 108 had at least 1 registered follow-up contact, including those with study or outreach contacts, giving a total follow-up rate of 79%. The mean time from surgery to final follow-up was 381 (SD 310) days. 79 patients (58%) returned for follow-up as scheduled at postoperative discharge from hospital. Of the remaining 58 patients who did not return for follow-up, 11 returned for an outpatient visit after being contacted by phone. An additional 7 were only available for interview by phone. 7 more patients were found on outreach visits and were examined at home, while 4 were

Table 2. Overview of operations and patients with recorded follow-up information, with comparison between patients who returned for scheduled follow-up and those who did not

	Scheduled follow-up	No follow-up before study	p-value
<i>Patient characteristics</i>			
No. of patients	79	29	–
Mean age, years	33	37	0.2
Sex, n			
Female	15	4	0.8 ^a
Male	64	25	–
HIV, n			
HIV+	17	4	0.4
HIV– or unknown status	66	25	–
No. of nails	83	29	
Approach, n			
Antegrade femur	71	27	0.5 ^a
Retrograde femur	12	2	–
Fracture reduction, n			
Open	79	28	1.0 ^a
Closed	4	1	–
Proph. antibiotics, n			
Yes	82	28	0.5 ^a
No	1	1	–
Indication, n			
Acute fracture	63	22	1.0
Delayed / non-union	20	7	–
Open fracture, n			
Yes	6	1	0.7 ^a
No	77	28	–
<i>Outcomes</i>			
No. of nails	83	29	
Infections, n	8	0	0.1 ^a
Death < 30 days postop.	3	0	0.3 ^a
Mean operating time (min)	117	113	0.7
Mean estimated blood loss (mL)	291	367	0.2
^a Fisher's exact test			

contacted through relatives or friends found on these visits. We drove 2,006 km over 8 days to find these 11 patients: 182 km per patient found. As a result, we were able to contact 29 patients (or their relatives in the case of 2 late deaths) who did not return for follow-up before.

All the registered postoperative infections occurred in patients who returned for follow-up. No infections were registered in patients who did not return for follow-up as scheduled. No statistically significant differences were found in patient or operation characteristics, or in outcomes, between patients who returned for follow-up and those who did not (Table 2). Only 1 other major complication, an asymptomatic non-union of the femoral shaft discovered on the check radiograph in a 43-year-old HIV-negative man 2 years after surgery, was found in the patients who did not return for scheduled follow-up. The nail was dynamized by removal of the distal locking screws and the fracture healed without further treatment.

28 of the patients who did not return for follow-up gave different—and sometimes several—reasons for not returning. 19 patients stated that they could not afford the transport,

18 patients reported that they had had no problems and 4 did not think it necessary. 9 patients claimed to have come back, despite no follow-up being registered for them. Some of these patients reported that they had been turned back because the X-ray department was closed or the doctor was not available. Some of them, however, appear to have been seen and the follow-up not reported.

Microbial infection

No infections were found in the patients who did not return for scheduled follow-up. 8 infections, 7 deep and 1 superficial, were registered making the overall total infection rate in this study 6%, with 5% deep infections (Table 3). If only nails with registered follow-up (n = 112) were included in the analysis, the infection rate was 7%, or 6% deep infections. There was only one infection (1/32) among the fractures defined as delayed or non-union at the time of operation in this study. The other 7 infections were seen in fractures intended for primary treatment (6%, OR = 0.5, CI: 0.1–4). 10 fractures (7%) were open. Of these, only 1 developed an infection (OR = 2, CI: 0.2–17). This was an open knee injury with comminuted patella and femoral condyle fractures combined with a distal femur fracture. The patient waited 12 days for surgery (Table 3).

HIV infection

17% of patients were HIV-positive and 7% had an unknown HIV status (Table 4). No statistically significant difference was found in infection rates between HIV-positive patients (2/23, 9%) and HIV-negative patients (5%). For HIV-positive patients, mean time from injury to surgery in acute fractures primarily planned for surgery was 19 (SD 11) days and for HIV-negative patients it was 17 (SD 9) days, mean difference 2 days. Mean time from surgery to ambulation with crutches was 6 (SD 3) days in HIV-positive patients and 8 (SD 10) days in HIV-negative patients, mean difference being 2 days. None of these differences were statistically significant. The mean time to discharge from surgery was 8 (SD 3) days in HIV-positive patients and 11 (SD 10) days in HIV-negative patients, mean difference 3 days (95% CI: 0.7–5.6). Operating time and estimated blood loss were similar in HIV-positive and HIV-negative patients.

5 deaths (4%) were recorded. 3 deaths occurred in HIV-positive patients (3/23) and 2 in other patients (2/114, p = 0.03). 3 deaths occurred within 30 days postoperatively and they were as such defined as postoperative complications. 2 of these deaths were in HIV-positive patients (2/23) and 1 was in a patient of unknown serological status. No confirmed HIV-negative patients died in the first 30 days postoperatively (p = 0.03). When the patients with unknown serological status were grouped with the HIV-negative patients, this difference in postoperative mortality did not quite reach statistical significance (0.9%, p = 0.07). Both HIV patients who died postoperatively, a 50-year-old woman and a 47-year-old man, died

Table 3. Overview of the 8 patients with postoperative infections

Case no.	Age	Sex	HIV +/-	CD4	Time of diagnosis ^a	Risk factors?	Deep?	Treatment	Outcome
9	14	M	-	-	5 days postop.	-	Superficial	Oral antibiotics for 2 weeks	Completely recovered, and no infection at follow-up after 2 months.
11	20	M	-	-	1 month postop. (IV antibiotics 20 days)	Same side open grade 2 comminuted patellar and femoral condyle fx. Waited 12 days for surgery.	Deep	Oral antibiotics until healing, then removal of nail and other hardware.	Infection resolved. Painless weight bearing, but stiff knee, ROM 0–15 deg. only.
40	40	F	Unknown	-	5 days postop.	Psychiatric patient, non-compliant. Early postop. infection.	Deep	Oral antibiotics. Nail removed 14 months after surgery.	Wound dry on discharge after nail removal. Ambulating without support.
56	65	F	-	-	Not recorded	Cellulitis distally on same leg preop. Treated with IV antibiotics for 10 days.	Deep	Nail removal.	Neck of femur fracture on opposite side a few months after surgery.
93	25	M	-	-	2 months postop.	Old patellar ligament injury same side. Stiff knee. 3-hour operation.	Deep, discharging sinus	On list for removal of nail.	Fully weight bearing w/o pain. ROM 0–60 deg.
96	19	M	+	-	17 months postop.	-	Deep, discharging sinus	On list for removal of nail.	Fully weight bearing w/o pain. ROM 0–100 deg.
116	37	M	+	334	2 months postop.	-	Deep	Oral antibiotics until healing, then removal of nail.	Infection resolved. Fully weight bearing w/o pain. ROM 0–70 deg.
128	28	M	-	-	1 month postop.	Suboptimal surgery. Nail too short and locking screws missed nail distally. Unstable.	Deep. Wound break down	Debridement in theater and suppressive antibiotics. Nail removed when healed.	Infection resolved. Fully weight bearing w/o pain. ROM 0–90 deg.

^a Time from surgery to diagnosis of postoperative infection.

Table 4. Outcomes in HIV-positive and HIV-negative patients

	HIV+	HIV-	OR	95% CI	p-value
Patients	23	105			
Infection	2	5	1.9	0.3–10	0.6
Overall mortality	3	1	16	1.5–158	0.02
< 30-day mortality	2	0	^a	^a	0.03
Returned for scheduled follow-up	16	56	1.8	0.5–6	0.3

OR: odds ratio.
^a Undefined, zero in 1 cell.

of sudden-onset respiratory distress and hypotension a few days postoperatively, and before they were discharged—probably from pulmonary embolism (PE). The third HIV-positive

patient, a 32-year-old man, died of pneumonia 3 months after surgery. A 33-year-old man of unknown serological HIV status died before discharge from hospital, from respiratory problems of a less sudden nature than the 2 others. The only HIV-negative patient who died was a 75-year-old man who, according to his family, had died of malaria 10 months after surgery. He had apparently recovered fully after the surgery.

Discussion

In the present study from one of the poorest countries in the world, with 79% follow-up, the rate of deep infection was 5%. No microbial infections were found in the patients who did not return for scheduled follow-up, but were reached by phone or outreach visits. These main findings support the idea that

patients who do not return for follow-up in LICs have fewer complications than those who do return. HIV-positive patients did well after femoral nailing, but there may have been an increased 30-day mortality rate in these patients in our setting.

Follow-up

In our previous paper validating the data in the SOSD in late 2010, we reported a follow-up rate of 18% (Young et al. 2011). In that paper, we argued the case that the whole database could still be used to estimate risk of infection based on the assumption that patients who have not returned for follow-up are unlikely to have had infections. In the present study, we went to considerable lengths to try to find as many of the patients who did not return for follow-up as possible. We drove over 2,000 km on, at times, barely passable roads to try to find patients at home in their villages. As a result, we found 7 patients at home and managed to contact 4 more by phone. The extreme difficulty in getting to some of the villages, even in a good 4-wheel-drive vehicle, illustrates the patients' problems in returning for follow-up. Even before considering the cost of transport for people who have close to no cash income at all, it is understandable that many do not return if they feel well anyway. We believe that insisting on very high follow-up rates in clinical research from LICs is unrealistic, and that it can lead to exclusion of important information from the literature.

The most common reason given by patients for not returning for follow-up in the present study was the cost of transport. Other studies have also shown that transport expenses are a major barrier to follow-up in Malawi (Yu et al. 2007, Bedford et al. 2011). The present study lends some support to the assumption that patients who do not have problems do not return for review, at least in Malawi, as no infections were found in the 29 patients who did not return for follow-up of their own accord.

Infection rates

We found a rate of deep infection of 5% after femoral IM nailing at KCH. This must be seen in the context of the severe trauma being treated. 9 out of 10 femoral fractures were the result of high-energy trauma, 25% of patients were poly-trauma victims, and 7% of fractures were open. An analysis of risk factors for infection after 46,113 IM nail operations in the SOSD (Young et al. 2013) found an increasing risk of infection with decreasing resources in a country. Malawi is rated as number 170 of 186 countries in the United Nation's Human Development index (<http://hdrstats.undp.org/en/countries/profiles/MWL.html>), and as such is one of the poorest countries in the world. Limited resources increase the waiting time for surgery and introduce many other risk factors for infection, such as exhausted stocks of antiseptic solutions, old surgical drapes with holes, donated expired consumables, lack of bandages and linen in the wards, intermittent water supply, and so on. Although a postoperative deep infection rate of 5%

might seem high to surgeons working in high-income countries, rates of deep infection up to 4% after IM nailing of femoral fractures have been reported even in the UK (Malik et al. 2004) where the severity of trauma is likely to be much less and where there are few resource constraints. In Oslo, Norway, a recent study showed an infection rate of 9% after hemiarthroplasty for femoral neck fractures in elderly patients (Westberg et al. 2013). Infection after IM nailing of the femur is a serious complication and often leads to reduced range of knee motion, as was seen in several of our patients (Table 3). However, early debridement, suppressive antibiotic treatment until union, and subsequent removal of the nail and reaming of the IM canal is usually successful in eradicating the infection in our experience from Malawi. This is supported by a paper from 2010 describing the use of this treatment in the USA (Berkes et al. 2010). In our opinion, the infection risk after IM nailing in the present study is acceptable and the advantages of IM nailing over skeletal traction by far outweigh this risk (Gosselin et al. 2009, Young et al. 2012).

We do not think that the risk of infection should be used as an argument against IM nailing of femoral fractures in LICs, but efforts must be made to reduce the infection rate where possible through improvements in hospital infrastructure and supply chains, and systematic training of surgeons and theater staff. Where good alternatives for functional bracing exist, such as in closed tibial and humeral shaft fractures, this should still be the mainstay of treatment in this setting. This saves already limited operative resources and reduces the risk of infection in these patients.

HIV infection

Although there was an increased risk of microbial infection apparent in HIV-positive patients (9%) compared to HIV-negative patients (5%), the difference did not reach statistical significance. This is in line with an increasing number of publications from the region (Harrison et al. 2004, Harrison 2005, Bates et al. 2012), but most previous studies, including the present study, have been small and underpowered. A recent meta-analysis did suggest that there might be an increased risk of postoperative infections in HIV patients, but the analysis was based on many small and old studies, mostly of hemophilia patients, and the findings were not conclusive (Kigera et al. 2012). Larger prospective studies will be needed to shed more light on this, but the available literature, including this study, suggests that the risk of postoperative infection is not (at least greatly) increased in HIV-positive trauma patients.

Postoperative mortality, however, did appear to be increased in HIV-positive patients (2/23) compared to HIV-negative patients (0%, $p = 0.03$) in our study. The numbers were small, and care has to be taken in making conclusions from these, but there is some literature that may support this finding. HIV-positive patients have an up to 10 times increased risk of venous thromboembolism (VTE) (Ahonkhai et al. 2008), and immobilization in traction can lead to PE (Sekimpi et

al. 2011). Because of economic constraints, we did not have VTE prophylaxis with low-molecular-weight heparin or compressive stockings available at our hospital. Aspirin is a cheap alternative, but it was not used systematically during the study period. All 3 postoperative deaths were suspected to be PEs with sudden-onset hypotension and respiratory distress, though definitive diagnosis or post-mortem examination was not available at the time. Together with the seriousness of the trauma spectrum in our patients and the long period of immobilization while waiting for surgery, the lack of VTE prophylaxis could explain the overall postoperative mortality of 2.2% in this study. Patients waited an average of 2.5 weeks for surgery of acute fractures in this study. As HIV-positive patients have an increased risk of VTE, this might disproportionately affect this group.

HIV-positive patients did not have increased time to ambulation or increased length of stay postoperatively, and as such seem to have the same potential for rehabilitation postoperatively as other patients with femoral fractures. In our opinion, this, coupled with the possibility of increased risk of VTE with long preoperative traction times, supports the use of early IM fixation of femoral fractures in HIV-positive patients.

Median time from surgery to discharge was 8 days. At KCH, crutches are made for the patients by a carpenter and the patients have to pay a fee (approximately 2 USD) to receive them. This fee is waived for patients who do not have the funds. However, it often takes time for the patients to try to find money, and for the carpenter to make the crutches, and this contributes to the length of stay postoperatively. Once the patients have received their crutches, they are discharged within a median of 2 days. There is a large potential for decreasing the length of hospital stay both pre- and postoperatively for femoral fracture patients at KCH. Realistically, increased surgical capacity (more theaters and staff for orthopedic surgery) and better availability of affordable crutches could reduce the length of stay for operated patients from the current average of 30 days to around 10 days.

The average length of stay for patients with femoral fractures treated with traction can be expected to be between 6 and 8 weeks (Gosselin and Lavaly 2007, Doorgakant and Mkandawire 2012). However, many patients will need to stay longer. Complications are common, with up to 14% malunion and 22% non-union (Gosselin and Lavaly 2007, Gosselin et al. 2009). PE (Sekimpi et al. 2011) and serious infections (Young et al. 2012) have been reported. It has even been shown that IM nailing can be more cost-effective than traction (Gosselin et al. 2009). In our opinion, it is high time that IM nailing of femoral fractures is accepted as an essential part of healthcare delivery in LICs also.

The study had some obvious limitations, including the relatively small number of patients included, which limited the power. However, the fields of surgery and trauma care have largely been neglected in the global health discussion and as a result the idea that surgery is not safe or cost-effective in

resource-limited settings has gone unchallenged. In light of the setting in which this study has been conducted, and of the fact that we have managed to get close to 80% follow-up amidst huge resource challenges, we do believe that our study brings some new information to the field of orthopedic trauma care in LICs in general, and more specifically in HIV-positive patients.

Conclusions

100% follow-up is not realistic in research in low-income countries. In the present study, patients often did not return for follow-up if they had no problem. The most frequent reason given for this was the cost of transport. Low follow-up rates must, to some degree, be accepted in research carried out in such countries; otherwise, we could be excluding essential knowledge about patients in these countries from the literature.

The 5% infection rate is acceptable, considering the spectrum of serious trauma in this study. Risk of infection should not be used as an argument against IM nailing of femoral fractures in low-income countries.

HIV-positive trauma patients had a higher postoperative mortality rate than other patients. If confirmed in larger studies, this might possibly be explained by the increased risk of venous thromboembolism in people living with HIV. Otherwise, HIV-positive trauma patients did just as well, or better, postoperatively and did not have a significantly increased risk of microbial infection. We recommend early IM fixation of femoral fractures in HIV-positive patients.

SY: study design, data collection, and statistics. LB, FB, KM, and BM: data collection. ED: independent review of statistics. GH, LBE, and LIH: study design. All the authors contributed to critical analysis and interpretation of data and statistics, and to writing and revision of the manuscript.

The authors thank the staff of the Department of Surgery and the main operating theaters at Kamuzu Central Hospital for all their hard work, making it possible to treat trauma victims in Malawi and to do research despite huge staff shortages, very busy schedules, and difficult working conditions. SY received a PhD grant (No. 911638) from the Western Norwegian Regional Health Authority (Helse-Vest). None of the other authors received funding for this study. No specific funding was received to carry out this study.

No competing interests declared.

Ahonkhai A A, Gebo K A, Streiff M B, Moore R D, Segal J B. Venous thromboembolism in patients with HIV/AIDS: a case-control study. *J Acquir Immune Defic Syndr* 2008; 48 (3): 310-4.

Ansaloni L, Brundisini R, Morino G, Kiura A. Prospective, randomized, comparative study of Misgav Ladach versus traditional cesarean section at Nazareth Hospital, Kenya. *World J Surg* 2001; 25 (9): 1164-72.

Bates J, Mkandawire N, Harrison W J. The incidence and consequences of early wound infection after internal fixation for trauma in HIV-positive patients. *J Bone Joint Surg (Br)* 2012; 94 (9): 1265-70.

- Bedford K J A, Chidothi P, Sakala H, Cashman J, Lavy C. Clubfoot in Malawi: treatment-seeking behaviour. *Trop Doct* 2011; 41 (4): 211-4.
- Berkes M, Obremsky W T, Scannell B, Ellington J K, Hymes R A, Bosse M, Southeast Fracture Consortium. Maintenance of hardware after early postoperative infection following fracture internal fixation. *J Bone Joint Surg (Am)* 2010; 92 (4): 823-8.
- Doorgakant A, Mkandawire N C. The management of isolated closed femoral shaft fractures in a district hospital in Malawi. *Trop Doct* 2012; 42 (1): 8-12.
- Fehr J, Hatz C, Soka I, Kibatata P, Urassa H, Bategay M, et al. Antimicrobial prophylaxis to prevent surgical site infections in a rural sub-Saharan hospital. *Clin Microbiol Infect* 2006; 12 (12): 1224-7.
- Gosselin R, Lavalay D. Perkins traction for adult femoral shaft fractures: a report on 53 patients in Sierra Leone. *Int Orthop* 2007; 31 (5): 697-702.
- Gosselin R A, Heitto M, Zirkle L. Cost-effectiveness of replacing skeletal traction by interlocked intramedullary nailing for femoral shaft fractures in a provincial trauma hospital in Cambodia. *Int Orthop* 2009; 33 (5): 1445-8.
- Gross T, Huettl T, Audigé L, Frey C, Monesi M, Seibert F J, Messmer P. How comparable is so-called standard fracture fixation with an identical implant? A prospective experience with the antegrade femoral nail in South Africa and Europe. *Injury* 2010; 41 (4): 388-95.
- Gustilo R B, Anderson J T. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Joint Surg (Am)* 1976; 58 (4): 453-8.
- Harrison W J. HIV/AIDS in trauma and orthopaedic surgery. *J Bone Joint Surg (Br)* 2005; 87 (9): 1178-81.
- Harrison W J, Lewis C P, Lavy C B. Open fractures of the tibia in HIV positive patients: a prospective controlled single-blind study. *Injury* 2004; 35 (9): 852-6.
- Ibeziako P A, Scott-Emuakpor M B, Ayeni O. Post-operative wound sepsis following obstetrical and gynaecological laparotomies in Nigeria. *J Trop Med Hyg* 1977; 80 (12): 238-42.
- Kigera J W M, Straetemans M, Vuhaka S K, Nagel I M, Naddumba E K, Boer K. Is There an increased risk of post-operative surgical site infection after orthopaedic surgery in HIV patients? A systematic review and meta-analysis. *PLoS One* 2012; 7 (8): e42254.
- Kobusingye O, Guwatudde D, Lett R. Injury patterns in rural and urban Uganda. *Inj Prev* 2001; 7 (1): 46-50.
- Malik M H, Harwood P, Diggle P, Khan S A. Factors affecting rates of infection and nonunion in intramedullary nailing. *J Bone Joint Surg (Br)* 2004; 86 (4): 556-60.
- Mathers C, Fat D M, Boerma J T. The global burden of disease: 2004 update. World Health Organization 2008.
- Mock C N, Gloyd S, Adjei S, Acheampong F, Gish O. Economic consequences of injury and resulting family coping strategies in Ghana. *Accid Anal Prev* 2003; 35 (1): 81-90.
- Ozgediz D, Riviello R. The "other" neglected diseases in global public health: surgical conditions in sub-Saharan Africa. *PLoS Med* 2008; 5 (6): e121.
- Patton G C, Coffey C, Sawyer S M, Viner R M, Haller D M, Bose K, et al. Global patterns of mortality in young people: a systematic analysis of population health data. *Lancet* 2009; 374 (9693): 881-92.
- Peden M. World report on road traffic injury prevention. World Health Organization Geneva 2004.
- PLoS Medicine Editors. *PLoS Med*. *PLoS Med* 2008; 5 (8): e182.
- Qureshi J S, Young S, Muyco A P, Borgstein E, Charles A G, Mulwafu W, et al. Addressing Malawi's surgical workforce crisis: A sustainable paradigm for training and collaboration in Africa. *Surgery* 2013; 153 (2): 272-81.
- 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 (19): 1811-8.
- Shearer D, Cunningham B, Zirkle Jr L G. Population characteristics and clinical outcomes from the SIGN online surgical database. *Tech Orthop* 2009; 24 (4): 273.
- Weiser T G, Regenbogen S E, Thompson K D, Haynes A B, Lipsitz S R, Berry W R, Gawande A A. An estimation of the global volume of surgery: a modelling strategy based on available data. *Lancet* 2008; 372 (9633): 139-44.
- Westberg M, Snorrason F, Frihagen F. Preoperative waiting time increased the risk of periprosthetic infection in patients with femoral neck fracture. *Acta Orthop* 2013; 84 (2): 124-9.
- WHO. The World Health Report 2006: Working Together For Health. 2006, World Health Organization, Geneva.
- Young S, Lie S A, Hallan G, Zirkle L G, Engeseter L B, Havelin L I. Low infection rates after 34,361 intramedullary nail operations in 55 low- and middle-income countries. *Acta Orthop* 2011; 82 (6): 737-43.
- Young S, Beniyasi F J, Munthali B, Banza L. Infection of the fracture hematoma from skeletal traction in an asymptomatic HIV-positive patient. *Acta Orthop* 2012; 83 (4): 423-5.
- Young S, Lie S A, Hallan G, Zirkle L G, Engesæter L B, Havelin L I. Risk factors for infection after 46,113 intramedullary nail operations in low- and middle-income countries. *World J Surg* 2013; 37 (2): 349-55.
- Yu JK-L, Chen SC-C, Wang K-Y, Chang C-S, Makombe S D, Schouten E J, Harries A D. True outcomes for patients on antiretroviral therapy who are "lost to follow-up" in Malawi. *Bull World Health Organ* 2007; 85 (7): 550-4.
- Zirkle L G. Injuries in developing countries—how can we help? The role of orthopaedic surgeons. *Clin Orthop* 2008; (466) (10): 2443-50.