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Early Outcome of Treatment of Open Tibial Shaft Fractures Using External Fixators in Resource-Poor Setting

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Early Outcome of Treatment of Open Tibial Shaft Fractures Using External Fixators in Resource-Poor Setting

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Abstract
To document the outcome of treatment in the first six months for open tibial shaft fractures managed with external fixators in resource-poor economy and the pattern of presentation of open tibial shaft fractures, a 12-month prospective observational study was conducted from January 2010 to December 2010. All the patients were recruited from the accident and emergency department of the University of Calabar Teaching Hospital. The demographic data of each patient, the type of injury, the mechanism of injury, and the outcomes were assessed. Moreover, 42 patients with open tibial shaft fracture were recruited for this study with forty (95.2%) patients successfully followed up for six months while two patients (4.8%) were lost to follow-up. Their ages ranged from 18 to 65 years with a mean age ± standard deviation of 33.5 ± 12.8 years. Majority of the patients (77.5%) were aged 20-50 years. There was a male to female ratio of 3:1. A total of 7 (17.5%) fractures healed after 20 weeks, Type IIIB fractures were 3 (7.5%), Type IIIA fractures were 4 (10%), but all Type II fractures had united between 12 and 15 weeks. The middle third fractures 9 (22.5%) had the highest number of fracture union within 16-20 weeks. The major cause of the injuries was from motorcycle accidents, which were 30 (75%), and others were from cars 7 (17.5%) and buses 3 (7.5%). This was largely due to the utilization of motorcycles as the major means of commercial transportation in the city until it was banned recently. However, they are still in use in the suburbs. The higher the Gustillo and Anderson grading of the open fracture of tibia, the more severe the wound and bone infection that occurred, and a significant interval between the injury time, wound debridement, and the time the external fixator was applied showed poor outcome for those who presented late (after two weeks of injury).

Keywords: Tibial fractures; External fixator; Resource-poor economy.

1. INTRODUCTION

Fracture of a tibial shaft constitutes a major trauma mostly sustained by young adults during high-energy injuries. The tibial shaft's superficial location and the subcutaneous characteristics of its anteromedial aspects make it vulnerable to open fractures [1].

Nigeria, with one of the highest rate of road traffic accidents in the world, has fractures of the tibial shaft as one of the commonest musculoskeletal injuries in its hospitals [2, 3]. The primary objective of the treatment includes prevention of infection, promotion of fracture healing, and full functional recovery of the limb.

In Groote Schuur Hospital, Cape Town, there was a record of 20% soft tissue sepsis rate and 9% incidence of osteitis in patients with open tibial fractures in the late 1970s using conventional plaster of Paris technique or cast and transfixing pins method. Hence, the introduction of external fixator was decided to assess the applicability of external fixation in the busy Groote Schuur setting.

The use of methylmethacrylate as an economical form of external fixation in the management of tibial fractures recommended by Aron and Inoue *et al*. was attractive. This is because, in overcoming the problems of mechanical stability, other modern external fixation systems have become increasingly sophisticated and expensive [4].

In most hospitals in the developed and developing countries, majority of these patients are best managed by the use of various types of external fixators. However, these external fixator devices are by no means cheap, and oftentimes most patients in our environment are unable to afford them since the country's health care system operates with the patients being solely responsible for the payment of their health care bills [5].

Long bone fracture is one of the common presentations in the accident and emergency ward of University of Calabar Teaching Hospital (UCTH) with lower limb fractures accounting for 69.5% and of these, 53.3% are open fractures. Fractures of tibia and fibula are the most common, accounting for 38.5% of all fractures [6].

In treating these fractures, meticulous wound debridement was done immediately with copious irrigation using normal saline, the fracture stabilized, and adequate wound cover achieved with early parenteral administration of broad spectrum antibiotics and bone grafting where it was necessary [4, 6-8]

The wound classification system of Gustilo and Anderson was used for this study because this enables us to compare the results of scientific analysis, provides guidelines for prognosis, and helps to establish certain principles of treatment [4, 5].

To this end, a prospective study on the early outcome of treatment for open tibial shaft fractures managed with external fixator in University of Calabar Teaching Hospital is aimed at contributing to the ever expanding scope of work performed on this highly important subject. The study seeks to offer treatment of the soft tissue injury and at the same time provide skeletal stabilization, hence improving the level of care of the patient with eventual better outcome in the overall management of the patient.

2. MATERIALS AND METHODS

This is a prospective, observational, and purely descriptive hospital based study of open tibial shaft fractures observed at the orthopedic and trauma unit of University of Calabar Teaching Hospital, Calabar. The study spanned a period of twelve (12) months—January 2010-December 2010.

The local ethics committee approved the study protocol, and written consent was obtained from all patients before participation in the study. A structured questionnaire was filled, which contained demographic data of patients, date and time of injury, type of injury, mechanism of injury, radiological findings, classification of the fracture after debridement, and assessment of the patient on the following criteria: duration of clinical fracture healing, duration of radiological healing, duration of hospital stay, and complications following treatment. The sample size estimation was based on the following formula:

$$N = \frac{Z^2pq}{d^2}$$

where
N = Minimum sample size required
Z = Constant, a confidence level of 95% = 1.96
P = Measured of prevalence of proportion of event in % = 2.1% = 0.021
Q = Opposite of P = 1 - p = 1 - 0.021 = 0.98
D = Precision value (95% confidence interval) = 0.05
Therefore,

$$N = \frac{1.96 \times 1.96 \times 0.021 \times 0.98}{0.05 \times 0.05} = 31.6$$

$$20\% \text{ nonrespondent value} = \frac{20}{100} \times 31.6 = 6.32$$

Add 20% nonrespondent value = 31.6 + 6.32 = 37.92

Hence, minimum sample size = 38

Patients with open tibial fractures were all included in the study except those who had severe medical conditions such as uncontrolled Diabetes Mellitus or with bone pathologies, intra-articular fractures of the tibia, late presentations who could not ascertain the time of their injuries or previously treated by traditional bone setters, and those with Gustillo IIIC fractures who needed vascular repairs or multiply injured patients. Those who did not fulfill the inclusion criteria were treated based on their different conditions. The challenges encountered were unavailability of the external fixators because patients could not readily afford them, and others resisted this form of treatment because of cultural beliefs that application of external fixator has an adverse effect on the bone and may result in amputation.

A total of 42 patients who fulfilled the inclusion criteria were recruited for this study, but 2 were lost to follow-up. Recruited patient's management at presentation followed the established principles and guidelines for treatment of such injuries as follows:

Initial resuscitation and early treatment of fractures in the casualty or accident and emergency room was based on the ATLS protocol, temporary splinting of affected limb, wound swabs for microscopy, culture, and sensitivity, and covering of the soft tissue with saline-soaked gauze; commencement of parenteral antimicrobial and antitetanus prophylaxis, the use of analgesics, and reduction of associated dislocations. This was followed by thorough and meticulous wound debridement, initial skeletal stabilization, soft tissue cover, and definitive skeletal stabilization with external fixators; rehabilitation and follow-up.

Following resuscitation and splinting of limb, secondary evaluation involved a detailed history, Physical examination was performed with more emphasis on the injured limb, looking for evidence of neurovascular injury, extent of soft tissue injury, and presence of compartment syndrome. Blood was taken for urgent packed cell volume (PCV), and possible grouping and cross matching and urinalysis were performed to exclude glycosuria.

Plain films of the limb in anterior–posterior and lateral views were taken showing the knee joint, ankle joint, and the pelvis (because patients with tibial shaft fracture may suffer other injuries since oftentimes it is a high-energy injury). The patient's plain radiograph films were reviewed. Open fracture classification was based on the Gustillo-Anderson method [8].

2.1. Treatment

All open tibial shaft fractures were treated as surgical emergencies with thorough debridement done in the operating theatre for the open tibial fractures under general anesthesia and some under subarachnoid block with tourniquet. During this process, the fracture was categorized using Gustillo and Anderson classification [8].

While debriding the wound, those with healthy margins and without wound contamination were sutured primarily. Dirty wounds were left open and dressed regularly for delayed primary or secondary closure. Larger wounds had other forms of skin cover done such as skin graft and flaps. Patients with Gustillo Type IIIA and Type IIIB and some poorly displaced II had skeletal stabilization with the use of uniplanar external fixator. Primary amputation was offered to those with Gustillo IIIC injuries with severe vascular compromise. Post-operative/reduction radiograph were performed to assess the reduction or the stabilization with external fixator, wound care, and antibiotics continued in the ward.

Rehabilitation of the patients started while patients were on admission with active and passive movement of non-immobilized joints, and this continued even after discharge until full recovery was achieved.

2.1.1. Patients' Discharge

The discharge of the patient was based on healing of soft tissue injury or when the wound was contracted to a very small size (2-4 cm for patients who did not have any form of wound cover) with the external fixator removed. Patients were discharged after application of a cast and were followed up on out-patient clinic for six months till there was clinical and radiologic evidence of fracture union.

2.1.2. Assessment of Outcome of Treatment

Early outcome of treatment was assessed for a period of six months from the time the external fixation was applied to when it was removed and cast applied afterward. This was focused on the length of time for the healing of the wound and fracture, associated complications, and duration of hospital stay. Assessment of late outcome of treatment is typically focused on clinical and radiological alignment, limb length equality, and functional recovery of the limb. This takes at least 1.5 years for proper assessment [9, 10].

Parameters for assessment of early outcome of treatment were as follows: duration of hospitalization (from admission to discharge); duration of soft tissue healing was defined as the time it took for the wound to close after the first debridement, that is, when the wound was fully contracted to approximately 2-4 cm in size for those patients who did not have any form of wound cover; duration of fracture healing was evaluated by clinical and radiological examination at first six weeks to asses any mal-alignment of the bone, then at three months, and subsequently monthly for the next three months.

The fracture was considered united when it was no longer tender, there was no abnormal movement at the fracture site when the bar of the external fixator was removed, and there was no presence of visible bridging callus in three to four cortices on plain orthogonal radiographic views.

The following complications were assessed: Compartment syndrome was assessed using clinical parameters such as patient complaining of increased pain, which the patient himself considers to be more than when he sustained the fracture, reduced capillary refill with pallor on the feet and paresthesia. Adequate instrumentation to measure intracompartmental pressure would have been used if available. Moreover, a pressure above 30 mmHg of the diastolic blood pressure is considered significant; soft tissue infections were diagnosed clinically and confirmed by culture; osteomyelitis (clinical, microbiological, and radiological diagnosis); delayed union was diagnosed when immobilization was required for more than 16 weeks in children and 20 weeks in adults [11], mal-union-residual angulation of greater 8° in any plane and shortening greater than 12 mm [12], nonunion—when clinical and radiological healing failed to progress after six months of immobilization. However, the study was for six months, so this was not fully assessed; leg length discrepancy measured from tibia tubercle to the medial malleolus and above 2 cm was considered significant shortening.

2.1.3. Score System for the Outcome

Comparing the short form 36, musculoskeletal functional assessment scale used for measuring outcome, a score system was developed based on the parameters for measuring the outcome for this study. The Calabar score system was developed and used for this study as follows.

It involves four parameters: duration of hospital stay, duration of fracture healing, duration of wound healing, and complications.

Parameters	**Scores**
Duration of hospital stay	
12-16 wks.....	1
9-11 wks.....	2
2-8 wks	3
Duration of fracture healing	
>20 wks.....	1
16-20 wks.....	2
12-15 wks.....	3
Duration of wound healing	
8-16 wks.....	1
5-7 wks.....	2
2-4 wks.....	3

Complications	
Pin tract + other complications.....	1
Pin tract only.....	2
Nil complication.....	3
Total.....	**12**

GRADING OF OUTCOME

Scores 1-4.....	Poor outcome
5-8.....	Moderate
9-12.....	Good

3. DATA ANALYSIS

The results of early outcome following the treatment were analyzed using Microsoft excel and IBM Statistical Package for Social Sciences (SPSS), software version 20.0. The results were presented in frequency distribution tables, bars, and pie charts.

Tests of association were performed using a chi-squared test for proportions and analysis of variance for differences in the means. Statistical significance was assessed using the *p*-value, and values ≤ 0.05 were considered statistically significant.

4. RESULTS

Among the 42 patients with open tibial shaft fracture who were recruited for this study, forty (95.2%) patients were successfully followed up for six months while 2 (4.8%) patients were lost to follow-up. Their ages ranged from 18 to 65 years with mean age 33.5 $\pm$ 12.8 years. Majority of the patients (77.5%) were aged 20-50 years. There was a male to female ratio of 3:1 (Table 1). Various occupations are represented with businessmen and women 11 (27.5%) and students 6 (15%) most commonly affected.

Road traffic accidents were the leading cause of open tibial shaft fractures 38 (95%), while falls were 2 (5%). Among these, motorcycle accidents were 30 (75%), and others were cars 7 (17.5%) and buses 3 (7.5%). This was largely due to the utilization of motorcycles as the major means of commercial transportation in the city until it was banned recently. However, they are still in use in the suburbs.

Half of the patients 20 (50.0%) were classified as Gustillo Type IIIA fractures, while the remaining fell under Type II and Type IIIB were 6 (15.0%) and 14 (35%), respectively (Table 2).

A total of 7 (41.4%) fractures healed after 20 weeks, Type IIIB was 3 (21.4%), Type IIIA was 4 (20%) but more than three quarters 5 (83.3%) of Type II fractures had united between 12 and 15 weeks. There was no significant relationship between radiological healing and the fracture type ($p = 0.185$), as shown in Table 3. Furthermore, only the middle third fractures 9 (69.2%) had the highest number of fracture union within 12-15 weeks, while the distal third had 5 (21.7%) union above 20 weeks (Table 3).

Some gram positive cocci and gram negative rods were isolated in the casualty ward at presentation. In general, *Staphylococcus aureus* $n = 21$ (52.5%) was the most common organism isolated. The most common gram negative rods isolated were *Klebsiella* $n = 5$ (12.5%) and *Pseudomonas aeruginosa* $n = 4$ (10%). The organisms isolated in the ward were *Staphylococcus aureus* $n = 9$ (22.5%) and *Pseudomonas aeruginosa* $n = 6$ (15.0%). Some isolates were a combination of *Staphylococcus aureus* and *Pseudomonas aeruginosa* $n = 3$ (7.5%), while others were considered mixed infections with a combination of many of the organisms $n = 14$ (35%). Almost all of the organisms were sensitive to Cefuroxime and Flagyl, and were resistant to Ciprofloxacine.

It was also observed from the score system devised for this study that the patients who had their external fixators applied to more than 2 weeks after presentation had poorer outcome while the least number of poor outcomes were among those who were done less than 1 week after presentation.

From Table 4, there was statistically significant relationship between good outcome and a short duration of hospital stay of 2-8 weeks, soft tissue healing at a short period of 4 weeks, and a very short period of fracture healing at 15 weeks ($p = 0.000$, $p = 0.001$, and $p = 0.000$). However, there was no significant relationship between outcome and complications.

As shown in Table 5, most of the tibia fractures were comminuted. Moreover, there is no significant relation between line of fracture and part of tibia ($p = 0.605$).

5. DISCUSSION

Open tibial fracture is a significant challenge in our environment as they are easily infected, slow to heal, and there is a dearth of facilities for adequate medical care.

A total of 42 patients with open tibial shaft fracture were recruited for this study with forty (95.2%) patients successfully followed up for six months, while two patients (4.8%) were lost to follow-up. Their ages ranged from 18 to 65 years with

Table 1: Sociodemographic characteristics of respondents.

Variable	Frequency	Percentages
Age		
10-20	5	12.5
21-30	17	42.5
31-40	76	15.0
41-50	7	17.5
51-60	3	7.5
61-70	2	5.0
Total	40	100.0
Mean = (33.5 ± 12.8)		
Gender		
Male	30	75.0
Female	10	25.0
Total	40	100.0
Occupation		
Farmer	2	5.0
Business	11	27.5
Artisan	5	12.5
Student	6	15.0
Applicant	4	10.0
Public servant	5	12.5
Civil servant	3	7.5
Teacher	1	3.5
Military/paramilitary	3	12.5
Total	40	100.0
Marital status		
Married	17	42.5
Single	23	57.5
Total	40	100.0
Tribe		
Ugep	8	20.0
Ekoi	11	27.5
Yoruba	3	7.5
Hausa	1	2.5
Ibo	6	15.5
Cameroun	1	2.5
Efik	6	15.0
Ibibio	4	10.0
Total	40	100.0

Table 2: Gustillo classification of tibial fracture.

Variable	Frequency	Percentages
Type II	6	15.0
Type IIIA	20	50.0
Type IIIB	14	35.0
Total	40	100.0

mean age ± standard deviation of 33.5 ± 12.8 years. The majority of the patients $n = 31$ (77.5%) were aged 20-50 years. This represents the active and productive group in the society who constitute the greatest natural resource to any nation. There is therefore a socioeconomic challenge to the family and the entire nation; the family spends money treating the patient, while the nation loses man-hours. There was a male to female ratio of 3:1, which is in good agreement with the results of similar study in our center [6] and within the country [1].

Table 3: Relationship between radiological healing and type of fracture.

Gustillo	Duration of healing (weeks) 12-15	16-20	>20	Total	Fishers exact	*P*-value
Type II	5 (83.3)	1 (16.7)	0 (0.0)	6 (100.0)	FE	0.185
Type IIIA	7 (35.0)	9 (45)	4 (20)	20 (100)		
Type IIIB	3 (21.4)	8 (57.1)	3 (21.4)	14 (100)		
Tibial part					FE	**0.56**
Prox. 3rd	1 (25.0)	2 (50.0)	1 (25.0)	4 (100.0)		
Mid. 3rd	9 (69.2)	3 (23.1)	1 (7.7)	13 (100.0)		
Dist. 3rd	5 (21.7)	13 (56.5)	5 (21.7)	23 (100.0)		
Total	15	18	7	40		

Table 4: Factors affecting fracture outcome.

Variables	Outcome measurement					
	Good	Moderate	Poor	Total	Fishers exact	*P*-value
Hospital duration (weeks)						
2-8	10 (47.6)	8 (38.1)	3 (14.3)	21 (100.0)	**FE**	**0.000**
9-11	1 (12.5)	3 (37.5)	4 (50.0)	8 (100.0)		
12-16	0 (0.0)	0 (0.0)	11 (100.0)	11 (100.0)		
Soft tissue healing (weeks)						
2-4	7 (53.8)	3 (23.1)	3 (23.1)	13 (100.0)	**FE**	**0.001**
5-8	4 (26.7)	7 (46.7)	4 (26.7)	15 (100.0)		
8-16	0 (0.0)	1 (8.3)	11 (91.7)	12 (100.0)		
Fracture healing (weeks)						
12-15	10 (62.5)	5 (31.3)	1 (6.3)	16 (100.0)	**FE**	**0.000**
16-20	1 (8.3)	6 (50.0)	5 (41.7)	12 (100.0)		
>20	0 (0.0)	0 (0.0)	12 (100.0)	12 (100.0)		
Complications						
Leg length discrepancies	0 (0.0)	0 (0.0)	1 (100.0)	1 (100.0)	**FE**	**0.538**
Wound infection	2 (18.2)	2 (18.2)	7 (63.6)	11 (100.0)		
Pin tract infection	6 (27.3)	6 (27.3)	9 (40.9)	22 (100.0)		
Nil	3 (50.0)	3 (50.0)	1 (16.7)	6 (100.0)		

Table 5: Patterns of fracture.

Line of fracture	Part of tibia fractured Proximal 3rd	Middle 3rd	Distal 3rd	Total	Fishers exact	*P*-value
Transverse	0 (0.0)	1 (50.0)	1 (50.0)	2 (100.0)		0.605
Oblique	1 (10.0)	1 (10.0)	8 (80.0)	10 (100.0)		
Spiral	0 (0.0)	1 (50.0)	1 (50.0)	2 (100.0)		
Comminuted	2 (9.5)	9 (42.9)	10 (47.6)	21 (100.0)		
Segmental	1 (20.0)	1 (20.0)	3 (60.0)	5 (100.0)		

Majority of the victims in this study were traders constituting eleven patients (27.5%), students were six (15.0%), while artisans and civil servants were 10 (25%), farmers and applicant were 2 (5%) and 4 (10%), respectively, executives and professionals constituted six patients (15%), and the least affected were teachers that accounted for only one patient (2.5%). This agrees with the findings of Alabi [9] in Ilesha and Ibeanusi *et al*. [13] in Port Harcourt. This pattern may not be unrelated to the fact that these groups of patients are those most likely to use public transportation; predominantly motorcycles are used as means of transportation. Although, the utilization of motorcycle as means of commercial transportation has been banned in

Calabar Urban, it is still used in the suburbs and some streets of Calabar municipality. Hence, motorcycle injuries accounted for the most frequent forms of injury, and this would have been a higher incidence but for the ban [6]. This may also explain the low incidence of such injuries among the professional and the business executive groups who often drive in their private or official cars and most times are in their offices rather than on the roads where the hazard of these injuries is high.

Road traffic accident was the leading cause of open tibial shaft fractures accounting for 38 (95%) of cases. This trend is also observed by other workers in this country [9, 11] and abroad [14]. Passengers either in cars or pillion rider on motorcycles were more at risk of being injured $n = 21$ (52.5%) followed by motorcyclists 9 (22.5%) and Pedestrians 8 (20.0%) while the drivers had the lowest risk of injury $n = 2$ (5.0%). This agrees with the findings in the series by Ibeanusi *et al*. [13].

A review of the pattern of open tibial shaft fractures encountered in this study shows that comminuted fractures were predominant $n = 21$ (52.5%). Oblique fractures $n = 10$ (25%), segmental fractures $n = 5$ (12.5%), and transverse fractures $n = 2$ (5%) in descending order. The distal third of the tibia was more affected 23 (57.5%) than the middle third $n = 13$ (32.5%) and proximal third $n = 4$ (10%). This agrees with the work done by Ikem *et al*. [1]. The comminution suggested that it is as a result of high-energy trauma [9, 15], which reflects a direct blow to the bone and the relatively subcutaneous nature of the tibia [16]. Anatomically, the distal third of the tibia is subcutaneous with precarious blood supply [16], which may have accounted for the high rate of fracture. There were associated fractures of the fibula in all the cases studied and left limbs were more frequently affected in the trauma 26 (65%) than right limbs 14 (35%). This is similar to findings by other workers [1, 17], but different from the findings in the series by Onabowale *et al*. [14] and Onuminya [18] where they documented the right limbs as being more involved.

The majority of the fractures were Type III open tibial shaft fractures 34 (85%); out of which twenty (50%) of these were Type IIIA and 14 (35%) were Type IIIB. Six (15%) patients of all the recruited cases were Type II. Patients with Type IIIC fractures with other injuries were excluded from this study as many of them had primary amputation for their early recovery and return to activities. Yinusa and Ogirima [19] had 5.6% of their patients treated by primary amputation, while Onabowale *et al*. [14] had 6 (12%) of their patients treated by amputation.

Meticulous wound debridement and irrigation with copious fluid are essential for care of all the patients with open tibial fractures. The objective is to reduce the bacterial load and increase the chances of primary wound closure [1, 14, 20]. The mean duration of soft tissue healing was 2.97 ± 0.8 weeks, and patients with Type IIIB fracture had prolonged soft tissue healing lasting 8-16 weeks $n = 7$ (17.5%) while Type II fractures recorded soft tissues healing within 2-4 weeks $n = 4$ (10%). This shows a correlation between the type of fracture and soft tissue healing and can be attributed to the degree of soft tissue injury and contamination in Gustillo Type IIIB fractures as compared to Type II or Type IIIA.

A total of 7 (17.5%) fractures healed after 20 weeks, Type IIIB fractures were $n = 3$ (7.5%), Type IIIA fractures were $n = 4$ (10%) but all Type II fractures had united between 12 and 15 weeks. This is similar with the duration of bony union recorded in the series by Ikem *et al*. [1]. Fractures of the distal third had the longest duration of fracture union lasting longer than 20 weeks $n = 5$ (12.5%) with most of them uniting between 16 and 20 weeks $n = 13$ (32.5%). The highest number of fracture union within 16-20 weeks occurred at the middle third, $n = 9$ (22.5%).

Fracture union was longer for fractures of the distal third of the tibia than in the middle and proximal thirds. This is so because a higher proportion of fractures occurring at this site were severe open fractures. Open tibial fractures occur more at the distal third of the tibia with precarious blood supply. This is similar with the study by Alabi [9] and Ikem *et al*. [1].

It was also observed from the score system devised for this study that the patients who had their external fixators applied more than 2 weeks after presentation had poorer outcome while the least number of poor outcomes were among those who were done less than 1 week after presentation.

The mean duration of hospital stay was 3.70 ± 1.3 weeks. This depended largely on the duration of wound healing. Patients were discharged home as soon as their wounds were considered healed. External fixation has a high rate of pin-tract infections which also added to patients stay in the hospital as this should be removed before the patients were discharged home. Alabi [9] and Yinusa [12] in their respective studies also observed prolonged hospitalization. It was however not the same with Onuminya [18] who observed a shorter hospital stay when he compared this with the use of plaster of Paris in the treatment of open tibial shaft fracture.

The complications observed in this study include pin tract infection 16 (40%). This is a known complication of treatment of fractures with external fixators [1, 15, 21]. Moreover, it is similar to the findings of Onuminya in Enugu [18] and Udosen *et al*. [22] in Calabar. However, meticulous pin site care by regular dressing or sometimes twice daily dressing of the pin tract helped in reducing the rate of pin tract infection and also hastened the healing process.

Other complications include wound infection, which had a high rate as it occurred in 10 (25%) cases of the open tibial shaft fractures. Fractures of the distal third of the tibia are often severely comminuted, devitalized, and infected. Some had a combination of pin tract infection with wound infection $n = 6$ (15%) and 8 (20%) had no complication at all.

The Gustillo and Anderson [8] grading of open fractures helped to establish the severity of the open fracture. The higher the grade of the fracture, the more the severity of the injury and the higher the rate of wound and bone infection [1, 14, 17]. Type IIIB fractures had more complications $n = 24$ (60%) followed by Type IIIA fractures that had 10 (25%) of complications, and the least were the Type II fractures with 6 (15%). Wound infection was more in Type IIIB fractures $n = 7$ (17.5%).

In this study, only two (5%) cases had loss of reduction where the external fixators had to be readjusted. Seven (17.5%) cases experienced delayed union. Union was considered delayed union when fracture healed between four and six months.

However, no case of osteomyelitis was observed throughout the study. This agrees with the work done by Onuminya [18] in Enugu where those who had chronic osteomyelitis were patients treated by the use of plaster of Paris cast rather than external fixators.

In this study, using the Gustillo and Anderson classification, Type IIIA and IIIB open tibial fractures were more frequently encountered than Type I and Type II. This indicated that most patients recruited into the study had severe open tibial shaft fractures, which were due to high-energy trauma.

The higher the Gustilo and Anderson grading of the open fracture of tibia, the more severe the wound and bone infection that occurred. The interval between the injury time, wound debridement, and time the external fixator was applied affected the treatment outcome.

The common pattern of the open tibial shaft fracture at the University of Calabar Teaching Hospital, Calabar, is Type IIIA and B with comminuted configuration involving the distal third of the left tibia and fibula. In this series, the rate of infection with the use of external fixator device was low. This devise is effective in the management of severe open tibial shaft fractures and affords the managing team the opportunity for wound care and skeletal stabilization. This enhanced wound healing reduces the incidences of osteomyelitis and hospital stay with an overall satisfactory.

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Author Contributions
IE Abang – Substantial contributions to the conception and design, acquisition of data, drafting the article, revising it critically for important intellectual content, final approval of the article for publication.
JE Asuquo – Substantial contributions to the conception and design, drafting the article, revising it critically for important intellectual content, final approval of the article for publication.
EA Mpama – Substantial contributions to the conception and design, analysis of data, drafting the article, revising it critically for important intellectual content, final approval of the article for publication.
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