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Comparative study of the burden associated with the management of open tibia shaft fractures using Ilizarov frame fixator and linear rail system in a resource poor country

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ABSTRACT

Background: Management of open tibia shaft fractures is frequently laden with complications. Hence this places an enormous burden on the patient and the surgeon alike. The use of Ilizarov frame fixator and Linear rail system [LRS] as the definitive fixation device minimized the number of surgeries, length of hospital-stay and financial burden on the patient whilst achieving fracture union and reduced concomitant complications associated with open fracture care. The study objective is to determine and compare the union rate, non-union rate, associated complications encountered as well as the mean total cost implication in the management of open tibia shaft fractures using the Ilizarov frame fixator and Linear rail system [LRS] in Ibadan, Nigeria.

Methods: This is a follow up study to our previous prospective study involving thirty (30) patients of both sexes, divided into two (2) groups; Ilizarov frame fixator group and LRS group. All patients had open tibia shaft fractures of Gustillo-Anderson Class [GA II-IIIB]. The union rate, non-union rate, associated complications noted while on the respective devices as well as the mean total cost implication of managing these open tibia fractures using the Ilizarov frame fixator and LRS respectively were all assessed.

Results: The union rate in the LRS group was 86.7% while the non-union rate was 13.3%. In the Ilizarov group, the union rate was 93.3% while the non-union rate was 6.7%. In this study, pin tract infection was the most common complication associated with using both devices. The mean cost price for purchasing the LRS was shown to be ₦175,933.3±12,775.0 while that of the Ilizarov frame fixator was ₦216,000.00±42,895.0. The mean total cost implication for the management of open tibia shaft fractures using LRS and Ilizarov frame fixators were ₦455,960.0±46,967.3 and ₦505,614.3±113,345.9 respectively. There is no significant difference noted in the union rate, non-union rate, associated complications encountered as well as in the mean total cost implication in the management of these open tibia shaft fractures using the fixators under review.

Conclusions: This study has shown that management of open tibial shaft fractures using either Ilizarov frame fixator or Linear rail system [LRS] is very cost effective especially in a resource poor country like Nigeria.

Keywords: Burden, Ilizarov frame fixator, Linear rail system, Open tibia shaft fractures

INTRODUCTION

High velocity trauma from road traffic accidents (RTA), gunshot injuries and falls from height are the leading causes of open tibia shaft fractures.[1] Urbanization and social development have further increased the incidence of this high velocity trauma in our environment.[2,3]

The recklessness of motorists, inconsistences in the enforcement of traffic laws, unqualified drivers as well as the use of unroadworthy vehicles, and the use of motorcycles as a commercial means of transportation, largely explain why RTA is a major player in the incidence of open tibia shaft fractures.[2-5] Studies have shown that motorcycle associated RTAs constitute a substantial percentage of these injuries.[2,3]

This could be partly because of their perceived affordability, rapidity and ease of accessibility as a means of transport and poor regulation of their use along many highways.[2,3]

More so, most of the cyclists, commercial or otherwise, are untrained or poorly trained at best, with some not even licensed to ride a motorcycle. The management of open fractures is usually tasking since the patient would need to undergo multiple procedures with the aim of achieving fracture union while averting the complications that are usually common with its management.[6] Such complications associated with open fracture management include pin tract infection, knee stiffness, wound dehiscence, delayed fracture union, infected non-union and chronic osteomyelitis. The management of open fractures is usually a great burden to the patient and the surgeon alike. The patient is faced with a heavy financial burden, due to the cost of management, emotional burden, if complications ensue and productivity burden, since the patient is usually off work for a long time hence a waste of manpower time and a considerable loss of income. The surgeon may encounter emotional burden when complications occur since the patient keeps coming back for their problems to be resolved, often insisting on holding the surgeon responsible even when such complications are not due to the actions, or otherwise, of the surgeon.

In our country, patients usually pay out of pocket to assess health care. Because of this, we then formulated a management protocol using Ilizarov frame fixator and the linear rail system as the definitive fixators of choice in the management of open tibial shaft fractures.[7]

This protocol was able to strike a balance between reducing the number of surgeries, reducing the financial burden, reducing hospital-stay, and achieving fracture union whilst still reducing the possibility of encountering the previously outlined complications.

This is a comparative prospective follow-up study that compares the burden associated with management of open tibial shaft fractures using the Ilizarov frame fixator and linear rail system as the primary definitive fixator of choice (our protocol) in a resource poor country.[7]

METHODS

This hospital-based prospective study of management of open tibial shaft fractures using the Illizarov frame fixator and LRS as the definitive fixator was conducted in the University College Hospital, Ibadan between July 2021 and June 2023. The study protocol was approved by the Hospital/University Ethics Committee and informed consent was obtained from all patients. In compliance with the Helsinki Declaration, the principles of beneficence, non-maleficence and autonomy were also adhered too. Thirty adult patients with open tibial shaft fractures classified as Gustilo-Anderson types II, IIIA, and IIIB were included in the study.

Inclusion criteria

The inclusion criteria were open comminuted diaphyseal fractures and open segmental diaphyseal fractures of the tibia.

Exclusion criteria

Patients were excluded if they had pathological tibial fractures, open tibial fractures with bone loss, open simple tibial fractures, bilateral open tibial shaft fractures, spinal cord injuries, pre-existing neurological conditions such as poliomyelitis, or multiple injuries.

All patients were resuscitated using the ATLS protocol. Prophylactic antibiotic and tetanus immunization were given; initial wound debridement was done in the emergency room. Prophylactic anticoagulation was commenced in patients at risk of deep vein thrombosis (DVT), as assessed with the standard DVT risk assessment tool used in the hospital.

The patients were divided into two groups by simple randomization techniques and definitive fixation done with either Ilizarov frame fixator or LRS. The resultant wounds were also managed at the same surgery either with primary closure by direct suturing, skin grafting or flap cover. Post operatively, all patients had antibiotics, analgesics, and prophylactic anticoagulation. The antibiotic of choice was ceftriaxone/sulbactam and levofloxacin for a period of 7-10 days depending on the extent of soft tissue injury. The choice of antibiotics was based on microbiological prevalence and sensitivity within our environment as is standard for all open fractures presenting to our institution. Analgesics were given until pain subsided. Prophylactic anticoagulation continued till patients could mobilize with bilateral axillary crutches. All patients were taught pin site care. Patients who developed pin tract infection were treated with antibiotics and extensive pin site care until symptoms resolved. Partial weight bearing commenced as pain could be tolerated.

Fracture healing was monitored with periodic radiographs done at important points; immediate post-operative period, sixth, twelfth, eighteenth, and twenty-fourth weeks during the follow-up period.

Full weight bearing only commenced when there was evidence of bone union. Bone union was assessed both clinically and radiologically; no pain or movement at fracture site and presence of bridging callus in at least three cortices on the radiographs respectively. The radiological union time was calculated as the time between surgery and confirmation of radiological union. Thereafter the fixator was then removed and the patient placed in a Sarmiento cast for a period of 4-6 weeks. After removal of the cast, all patients were then assessed using the ASAMI criteria to score the bony and functional outcomes.[8]

Data was collected with a well-structured proforma and thereafter analyzed by an independent statistician using SPSS version 23.0. Descriptive statistics such as frequency, percentages and mean were used to summarize and present the results. Graphs and tables were used where necessary. An independent t-test was used to compare the mean total cost implication in both Ilizarov frame fixator and LRS groups. For the comparison of associated complications, a chi-square test was used to compare the difference in both Illizarov frame fixator and LRS groups.

RESULTS

This study had a total of thirty (30) adult participants. Their mean age was 38.7±15.2 years. A total of nineteen (19) males and eleven (11) females participated in the study. Nine (9) males and six (6) females were in the LRS group while ten (10) males and five (5) females were in the Ilizarov group (Table 1).

Table 1: Demographic distribution of the participants showing the age and sex distribution of the patients in the LRS and Ilizarov groups.

Variables	Items	LRS, N (%)	Illizarov, N (%)	Total	t test /χ^2	P value
Age range (years)	18-34	9 (60.0)	4 (26.7)	13 (43.3)	5.234	0.155
	35-44	2 (13.3)	7 (46.7)	9 (30.0)		
	45-64	3 (20.0)	2 (13.3)	5 (16.7)		
	65 and above	1 (6.7)	2 (13.3)	3 (10.0)		
Age (years)	Mean±SD [range]	35.6±16.6 [18-75]	41.7±13.6 [21-66]	38.7±15.2 [18-75]	1.228	0.277
Sex	Male	9 (60.0)	10 (66.7)	19 (63.3)	0.144	0.705
	Female	6 (40.0)	5 (33.3)	11 (36.7)		

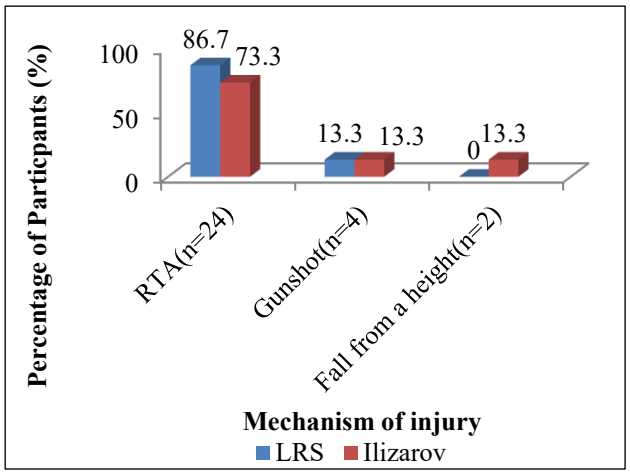


Figure 1: Distribution of injury mechanisms.

Road traffic accident (RTA) was noted as the most common mechanism of injury. In the LRS group thirteen (13) of the participants were involved in RTA while two (2) sustained gunshot injuries. In the Ilizarov group, eleven (11) of the participants were involved in RTA, two (2) sustained gunshot injuries while two (2) fell from height.

Thus, RTA accounted for 86.7% of the mechanism of injury in the LRS group while in the Ilizarov frame group it was about 73.3%. In the LRS group, the union rate was 86.7% while the non-union rate was 13.3 % whereas in the Ilizarov frame group, the union rate was 93.3% while the non-union rate was 6.7% (Figure 1 and 2).

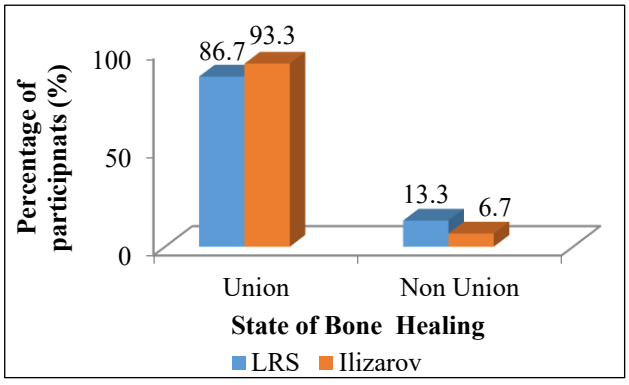


Figure 2: Distribution of bone union and non-union in the two fixator groups.

In this study, pin tract infection was noted as the most common complication noticed during the treatment in the

external fixators; 80% in the LRS group and 100% in the Ilizarov frame group. These pin tract infections mostly involved 2-3 pin tracts, usually grade 1 and 2 (Paley grading). The affected pin tracts were taken care of by regular cleaning with methylated spirit and administration of sensitive antibiotics till the infection subsided.

The second most common complication was knee stiffness; 13.3% in the LRS group and 20% in the Ilizarov frame group.

None of the participants had pin breakage. One (6.7%) participant in the LRS group had non-union following desiccation of the exposed tibia, following flap necrosis. One (6.7%) participant in each of the fixator groups developed chronic osteomyelitis and thereafter resulted in infected non-union. The differences in the distribution of the complications noticed during the treatment in the two fixator groups were not statistically significant (Table 2).

Table 2: Distribution of complications noticed while on treatment with their various p values.

Variables of complications	LRS, N (%)	Ilizarov, N (%)	χ^2	P value
Pin tract infection	12 (80.0)	15 (100.0)	3.33	0.068
Losing of pins	0	1 (6.7)	1.034	0.309
Non-union	1 (6.7)	0	1.034	0.309
Knee stiffness	2 (13.3)	3 (20.0)	.240	0.624
Ankle stiffness	0	2 (13.4)	2.143	0.143
Chronic osteomyelitis	1 (6.7)	1 (6.7)	0.000	1.000
Equinus deformity of foot	0	1 (6.7)	1.034	0.309

The mean cost price for the purchase of the external fixators was shown to be ₦175,933.3±12,775.0 for the LRS fixator while ₦216,000.00±42,895.0 for the Ilizarov fixator. This difference in the mean cost price of the external fixators was noted to be statistically significant [X^2 (15) - 3.467, p=0.002).

However, the mean total cost implication for the management of the participants with open tibia shaft fractures using LRS and Ilizarov frame fixators were ₦455,960.0±46,967.3 and ₦505,614.3±113,345.9 respectively. This difference in the mean total cost implication between the two fixator groups was noted not to be statistically significant [X^2 (15)-1.567, p=0.128) (Table 3).

Table 3: Comparison of the mean total cost implication for management of open tibia shaft fractures using LRS and Ilizarov frame fixators.

Variables of management	LRS, Mean±SD (Naira) ₦	Ilizarov, Mean±SD (Naira) ₦	t test	P value
Cost of fixator	175,933.3±12,775.0	216,000.0±42,895.0	3.467	0.002
Surgery fee	169,826.7±27,267.2	164,320.0±8,519.1	0.747	0.462
Total cost of X-ray	30,000.0±0	29,933.3±7,272.0	0.035	0.972
Cost of scotch cast material	5,900.0±0	5,506.7±1,523.3	1.000	0.326
Cost of cast application	4,200.0±0	3,920.0±1084.4	1.000	0.326
Total cost of feeding	28,673.3±16,400.6	44,200.0±68,280.9	0.856	0.399
Total amount spent on admission fees	33,426.7±20288.0	34,266.7±15198.1	0.128	0.899
Follow-up consultation fee	8,000.0±0	7,466.7±2065.6	1.000	0.326
Total cost	455,960.0±46,967.3	505,613.3±113,345.9	1.567	0.128

DISCUSSION

The aim of the study was to determine and compare the union and non-union rates, the associated complications and the mean total cost implication in the management of open tibia shaft fractures using Ilizarov frame fixator and linear rail system (LRS).

Our union rate was noticed not to have any statistically significant difference between the Ilizarov frame and LRS groups and was also noted to be comparable to the findings of Pal et al.[6]

Similarly, studies where LRS was the definitive fixator of choice such as Kale et al, Singh et al, Ajmera et al and Soni

et al also reported comparable union rates to those of our LRS group.[9-12]

Likewise, in studies where Ilizarov frame fixator was the definitive fixator of choice such as Vyas et al, Inan et al, Sidhathan et al, Wani et al and Aly et al also reported comparable union rates to those of our Ilizarov group.[13-17]

In our study, pin tract infection was noted to be the most common complication and there was no statistically significant difference between the Ilizarov frame and LRS groups. Most other studies also reported pin tract infection as the commonest complication while on the fixators.[6,9,10,13,16-19]

Our quest to compare the mean total cost implication for the management of open tibia shaft fractures using the fixators under review, was born out of the notion in our locality by some orthopaedic surgeons that the Ilizarov frames were more expensive, cumbersome and also not readily available even when there is need to use them.[18,20]

In view of the current standard of living within the country and also because patients pay out of pocket to access health care services, it became pertinent to compare the mean total cost implication for any significant difference when used to manage these patients with open tibia shaft fractures.

In this study, we found a statistically significant difference between the mean cost price for purchasing these external fixators. We realized that the retail vendors increased the prices of the Ilizarov frames far more than the price at which the wholesale vendors were selling thus creating a false impression of the Ilizarov frames being more expensive.

However, the mean total cost implication for the management of those patients with open tibia shaft fractures reported a difference which was not statistically significant.

The results from this study have shown that the Ilizarov frame fixator and the LRS fixator are the ideal devices needed in a resource poor country since their outcomes are similar, complication rates low and both still have comparable cost implication when either of the fixators are used.

The limitations of the study include the relatively small sample size and the use of multiple vendors in procuring the external fixators which could have played a part in bringing about the significant difference noted in the price of the external fixators. Also, since the patients were only followed up for six months, some complications could have been missed or could have occurred after the expiration of the follow up period and hence not reported.

CONCLUSION

This study has shown that the burden associated with the management of open tibia shaft fractures in a resource poor country can be relatively minimized by using either the Illizarov frame fixator or the LRS. Thus, it is important for orthopaedic surgeons to learn proficiency in the use of both devices in order to maximize the outcomes of patient care.

The government is hereby called upon to help minimize this rising incidence of road traffic accident (RTAs) since we are residing in a country with dwindling economy and patients need to pay out of pocket to access good health care.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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