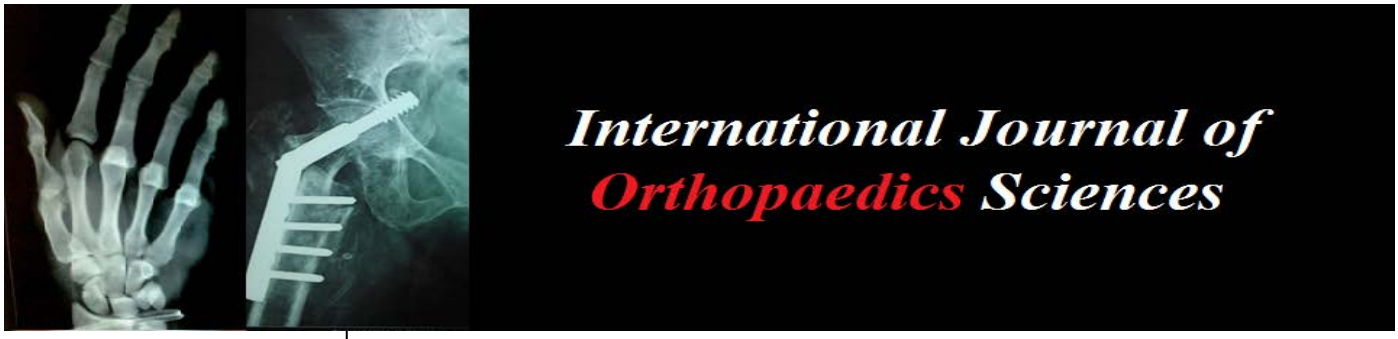

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When the center cannot hold in conventional orthopedic and trauma treatments, things will not fall apart with linear rail system: A hospital based retrospective study

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Abstract
Background: Distraction osteogenesis is a method of producing unlimited quantities of living bone directly from a special osteotomy (cortico to my). Advances in methods of external fixation have made limb lengthening a feasible option achieved by distraction osteogenesis. Complex trauma cases such as failure of fractures to unite after several attempts, significant soft tissue infection, significant bone loss ab initio, the presence of significant soft tissue loss, or chronic osteomyelitis that may warrant significant bone resection are a nightmare to the surgeon the patient and the patients relations as well. The linear rail system and the Ilizarov device oppose other methods of bone gap management permits the realization of compression, distraction, bone-lengthening, and deformity correction, as such improving the quality of life of the patients, good fracture union with insignificant complications.
Methods: A hospital based retrospective study conducted at The Potters Specialist Hospital Jos between January 2018 and December 2020. Patients were recruited following a perusal of the operation register. A proforma was filled which included the patient's demographics, clinical characteristics. Clinical outcomes during the treatment such union at fracture site, length gained and complications during treatment were included in the proforma. Patient's quality of life after the treatment was also assessed. Data was analyzed using SPSS version 23.
Results: Thirty-six patients were enrolled into the study. Patients mean age was 39.36±10.64. Age group 31-40 accounted for 47.2% of those recruited. Males were 83.3% and complications of fracture management were noticed to account for 22 (61.1%) of the indications for surgery. Those who had two surgeries done during treatment were 27.8% with interval corticotomy counting as a separate surgery. Limb lengthening was done in 52.8% of the patients and the leg was found to be operated limb 75% of cases. Though 72.6% did not develop any problems, among those with problems, pin tract infection was noticed in 13.9%. Similarly, 88.9% had no complications but amongst complications noted limb length discrepancy in 5.6%. All of them had their fractures united and limb lengths equalized to an acceptable level. Regarding quality of life most patients (44.4%) rated it as good and the other 22.2% very good and when asked about the satisfaction their current health 50% said they were satisfied and another 19.4% were very satisfied.
There was significant association noticed between quality of life and indications for surgery, between complication and aim of surgery and noticed between complication and length gained.
Conclusion: The use of the linear rail system in the treatment of complex major limb fractures yielded satisfactory results with improved quality of life and less problems and complications.

Keywords: Complex fractures, linear rail system, distraction osteogenesis, limb salvage, quality of life

Introduction
Distraction osteogenesis is a method of producing unlimited quantities of living bone directly from a special osteotomy site by controlled mechanical distraction which bridges the gap and rapidly remodels to a normal macrostructure for the local bone capable of bearing load [1, 2].
Advances in methods of external fixation have made limb lengthening a feasible option achieved by distraction osteogenesis, however, there are drawbacks. Complications such as nonunion, Infection and nerve palsy may be disastrous; and the cosmetic effect of long legs

fixators for the management of long bone fractures and deformities in children but later found useful in the management of limb length inequalities by way of lengthening the bone [3, 4]. It is said that living tissues subjected to slow steady traction becomes metabolically activated in both the biosynthetic and proliferative cellular pathways: this is referred to as the law of tension-stress [5, 6]. Correction of limb length discrepancies (LLD) is a time consuming, challenging and highly rewarding procedure as such requires patience and full co-operation of the patient as well as the family [7, 8]. Discomfort exists at all stages of the bone transport process, which significantly impairs quality of life [9, 10]. This study sets to assess the ability of the linear rail system in managing complex trauma cases such as failure of fractures to unite after several attempts, significant soft tissue infection, significant bone loss ab initio, the presence of significant soft tissue loss, or chronic osteomyelitis that may warrant significant bone resection that are a nightmare to the surgeon the patient and the patients relations as well. Its sets to do this via both clinical and radiological evidences such as infection control, gap covered, x-ray evidence of union, length gained and regenerate consolidation and post removal of device to assess the quality of life of patients who had the device.

The discovery of the biological law of tension stress or distraction histogenesis by Ilizarov and its principles has been applied to treat a wide variety of conditions such as nonunion, osteomyelitis, dwarfism, congenital deformities, some bone tumours, bone defects, fractures and bone shortening. Error! Bookmark not defined. [11, 12, 13, 14]. Throughout the world, trauma is a leading cause of death and disability for all age groups except persons older than 60 years and is one of the top three causes of death for persons between 5 and 44 years [15, 16]. When normal treatment of fractures fails, a presence of infection ensues or a significant gap exist after fractures of especially the extremities, significant morbidity and mortality does occur in patients. Limb salvage techniques are the main stay in current management of large bone defects and limb shortening and in such aforementioned complex fractures [11]. The mean age of limb lengthening varies between 30-35yrs as most writers noted. Error! Bookmark not defined. [12, 17, 18], using Paley's classification, 28 minor complications were listed as problems that did not require additional surgery; major complications were listed as obstacles that resolved with additional surgery, and true complications or sequelae are those complications that remained unresolved at the end of the treatment period using Paley's classification, 28 minor complications were listed as problems that did not require additional surgery; major complications were listed as obstacles that resolved with additional surgery, and true complications or sequelae are those complications that remained unresolved at the end of the treatment period using Paley's classification, 28 minor complications were listed as problems that did not require additional surgery; major complications were listed as obstacles that resolved with additional surgery, and true complications or sequelae are those complications that remained unresolved at the end of the treatment period minor complications were listed as problems that did not require additional surgery; major complications were listed as obstacles that resolved with additional surgery, and true complications or sequelae are those complications that remained unresolved at the end of the treatment period Males undergo distraction osteogenesis far more frequent than female. Error! Bookmark not defined. [19, 20, 21], With distraction osteogenesis, bone union is almost guaranteed no matter the method employs once the patient, patient relations and the doctor have a good knowledge of the procedure and are ready to go all way [22]. Various devices have been employed aimed at achieving adequate distraction with minimal complications, ranging from the unilateral external device to circular external devices and currently popularized intra-medullary device but not without its setbacks [23]. The linear rail system and the ilizarov device oppose to other methods of bone gap management permits the realization of compression, distraction, bone-lengthening, and deformity correction to mention but a few. They are valid alternative treatment modalities compared to internal fixation, especially when internal fixation is complicated by bone loss, deformity, or failure of previous internal fixation [24]. Even though it is a known fact that internal methods of lengthening exist, the technicality of the procedure and the additional cost of surgery for removal of these device after lengthening make it unpopular in this environment than the external method such as the linear rail system and the ilizarov device. More distractions are done for tibia than femur [11, 23]. Although both unilateral and circular-type external fixators can be used during the treatment, the patients may better tolerate unilateral fixators, especially at the femur. The time between osteotomy and removal of LRS on the patient was more in those patients who had diaphyseal osteotomy than those that had metaphyseal osteotomy. However, Aron so *et al*. in his article "Mechanical force as predictors of healing during tibial lengthening by distraction osteogenesis" found the opposite [25]. Mean follow up period of about 30-36 months is noted by many writers even though it depends on the average lengths achieve [26, 27]. Mean external fixator time was found to be between 13-15 months by some writers [11, 28, 27, 29] the mean length gained by most writers on distraction osteogenesis is between 6 and 7cm however Hubert *et al* found it lower. Error! Bookmark not defined. [11, 14, 19, 21, 23, 24, 30], Complications that occur during distraction osteogenesis can be divided into three: Minor as those that does not require surgery to correct, major as those that requires another surgery to correct while true complications as those that remain unresolved at the end of surgery. The most common complication noted by most writers is pin tract infection Error! Bookmark not defined. [25, 29, 31], Hantes and colleagues in their study on "complications in limb lengthening procedures: a review of 49 cases" found out that the incidence and severity of complications after limb lengthening procedures are significantly influence by the relative lengthening of the bone. [32] Wang H. and friends in their article "Quality of life and complications at different stages of bone transport infected nonunion of the tibia" noted that most patient underwent about 2.9 operations on an average [12]. Association for the Study and Application of the Methods of Ilizarov (ASAMI) Score is a clinical and radiographic functional scoring scale used to assess outcome [33]. ASAMI score in most cases of distraction osteogenesis is good [21].

Methodology

This study is a retrospective study was carried out at The Potters Specialist hospital Jos Nigeria between January 2018 and December 2020.

The operation register was perused for patients who had linear rail system applied on them to aid the management of their complex orthopedic and trauma conditions vis: Those that failed initial attempts, or ab initio has significant bone loss, those with severe soft tissue loss at presentation that will need some bone resections or even those with severe infections

such as chronic osteomyelitis that will require bone resection with subsequent gap management.

Included in the study are patients 18yrs to 65yrs who gave consent to be part of the study, those who have infected nonunion, those who had previous surgical interventions to no avail, and those presenting with bone gab of more than 2cm. Those excluded were the multiply injured, those with cognitive impairments, those with previously ankylosis joints and those with other co-morbidities that will affect proper intervention or assessment. Thirty-six patients who meet the criteria for enrolled. A proforma was used to extract information partly from the patient and partly from the folder such as the biodata, clinic-radiological characteristics (indications for the procedure, aim of procedure, additional procedures done, duration of procedure, problems and complications noticed, length gained (measured from the radiograph), certainty of union at fracture site and patient's quality of life afterward (via a quality of life questionnaire). The linear rail system was used to transport, lengthen, or achieve acute docking following the standard principle guiding the application of an external device.

Data obtained was analyzed using SPSS version 23 and plotted into charts and tables. Variables were compared and the significance of their relationships ascertained.

Conclusions were then made.

Results

There were 30(83.3%) males and 6(16.7%) females giving a male: female ratio of 5:1. Fig 1

Of the thirty-six enrollees most were between 31-40years (47.2%) followed by those greater than 45years with about 36.1%. Fig 2

Complications of fracture management were the most common indication, with 22(61.1%) followed by a trauma with a bone loss 12(33.3%). Fig 3

With interval corticotomy inclusive most of the enrollees 10(27.8%) had two surgeries, followed closely by those who had three surgeries 8(22.2%). Fig 4

Among the thirty-six enrollees, most had limb lengthening 19(52.8%) and those that had the surgery for both limb lengthening and bone transport were the least with only 3(8.3%). Fig 5

The part of the body that had the linear rail system used most is the leg in 27(75.0%) of the thirty-six enrollees and the least operated is the thigh 2(5.6%). Fig 6

Those with no problems were the most 26(72.6%) but pin tract infection was the problem mostly noticed 5(13.9%) followed by wound breakdown 3(8.3). Fig 7

Most of the enrollees had no complications 32(88.9%) however among those with complications limb length discrepancy is the most noted 2(5.6%). Fig 8

Regarding quality of life most patients (44.4%) rated it as good and the other 22.2% very good and when asked about the satisfaction their current health 50% said they were satisfied and another 19.4% were very satisfied. Table 1

There was no significant association between complication and indication for surgery (χ^2=3.034, p-value= 0.805). A similar finding was obtained between problems and indications for surgery (χ^2=9.629, p-value= 0.141). There was significant relationship between quality of life and indications for surgery (χ^2=9.464, p-value=0.009).Table 2

Significant association was noticed between complication and aim of surgery (χ^2=13.060, p-value= 0.043). There was no association obtained between problems and aim of surgery (χ^2=8.675, p-value= 0.193). Similarly, there was no significant difference in the proportion between quality of life and aim of surgery (χ^2=0.276, p-value=0.871). Table 3

Significant association was noticed between complication and length gained (χ^2=13.623, p-value= 0.034). There was no association obtained between problems and length gained (χ^2=9.164, p-value= 0.165). Similarly, there was no significant difference in the proportion between quality of life and length gained (χ^2=0.538, p-value=0.764). Table 4.

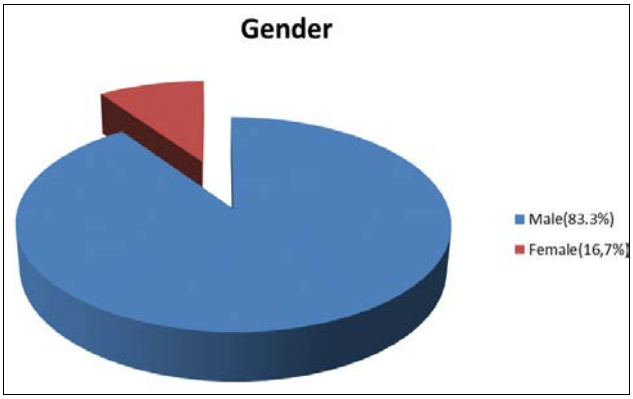

Fig 1: Distribution by Gender

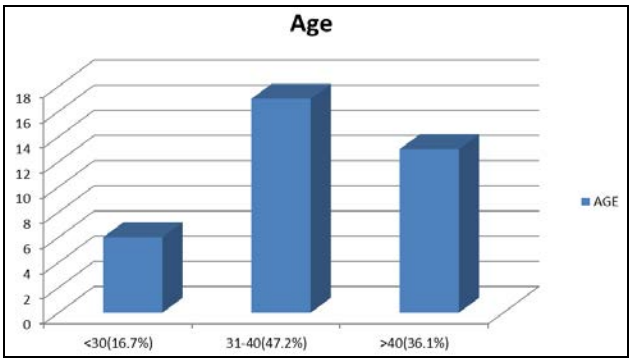

Fig 2: Distribution by Age

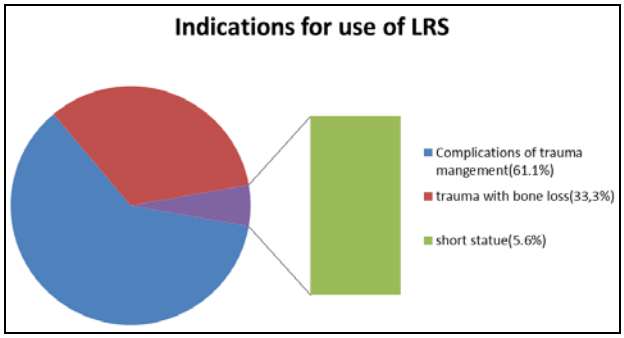

Fig 3: Indication for the Use of the Linear Rail System

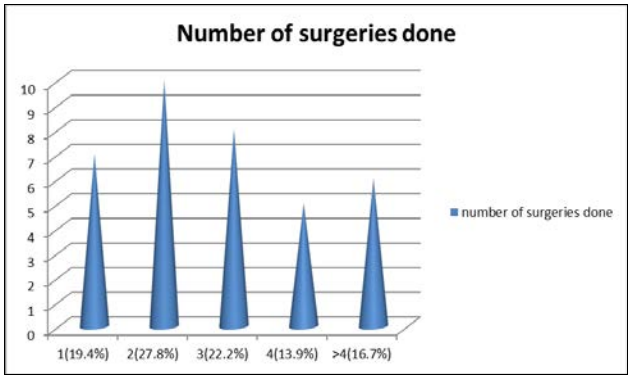

Fig 4: Number of Surgeries Done

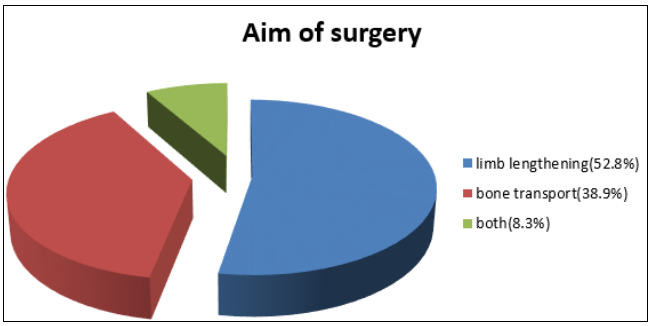

Fig 5: Aim of Surgery

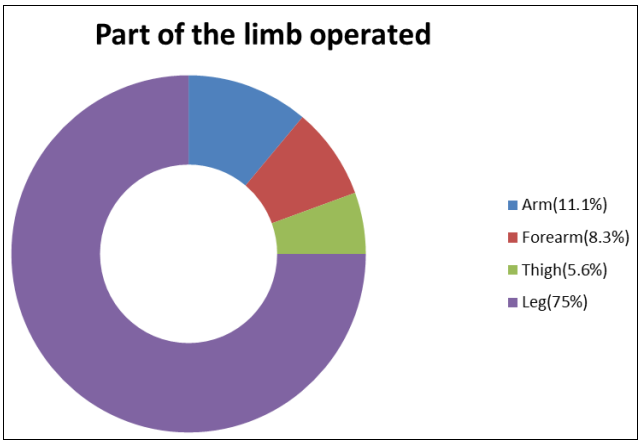

Fig 6: Part of the Limb Operated

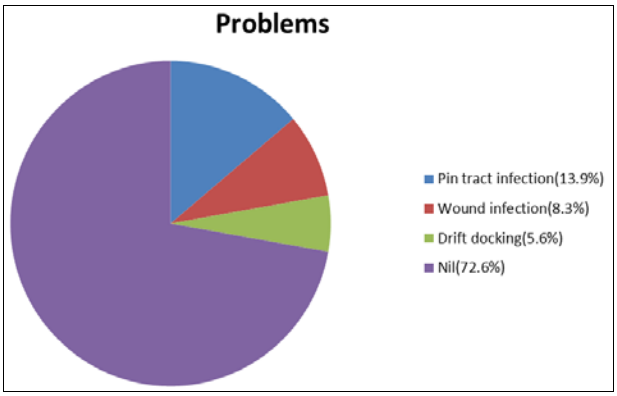

Fig 7: Problems Encountered

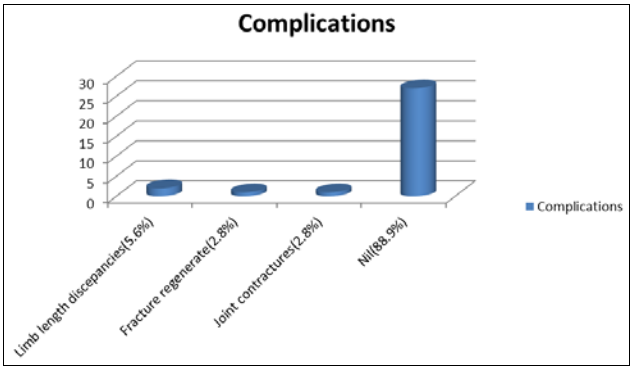

Fig 8: Complications

Table 1: Assessment of Quality Of Life of Patients Who Had Treatment for Complex Lower Limb Fractures with a Linear Rail System: Rating/Satisfaction with Quality Of Life and Health Satisfaction

Variables	Frequency (n=36)	Percentage	X^2	p-value
How would you rate your quality of life?				
Poor	5	13.9	7.778	0.051
Neither very poor nor poor	7	19.4		
Good	16	44.4		
Very good	8	22.2		
How satisfied are you with your health?				
Dissatisfied	7	19.4	12.667	0.005
Neither very dissatisfied nor dissatisfied	4	11.1		
Satisfied	18	50.0		
Very satisfied	7	19.4		

Table 2: showed the association between complication, problems and quality of life with indications for surgery.

Variables	Indication(s) for surgery			X^2	p-value
	Complications of fracture management	Trauma with bone loss	Short stature		
Complication					
Limb length discrepancy	1(4.5)	1(8.3)	0(0.0)	3.034	0.805
Fracture regenerate	1(4.5)	0(0.0)	0(0.0)		
Joint contractures	0(0.0)	1(8.3)	0(0.0)		
Nil	20(90.0)	10(83.3)	2(100.0)		
Problems					
Pin tract infection	2(9.1)	3(25.0)	0(0.0)	9.629	0.141
Wound breakdown	1(4.5)	2(16.7)	0(0.0)		
Drift docking	0(0.0)	2(16.7)	0(0.0)		
Nil	19(86.4)	5(41.7)	2(100.0)		
Quality of life					
Good	16(72.7)	3(25.0)	0(0.0)	9.464	0.009
Poor	6(27.3)	9(75.0)	2(100.0)		

Table 3: Showed the association between complication, problems and quality of life with aim of surgery

Variables	Aim of surgery			χ^2	p-value
	Limb lengthening	Bone transport	Both		
Complication					
Limb length discrepancy	1(5.3)	1(7.1)	0(0.0)	13.060	0.042
Fracture regenerate	0(0.0)	0(0.0)	1(33.3)		
Joint contractures	0(0.0)	1(7.1)	0(0.0)		
Nil	18(94.7)	12(85.8)	2(66.7)		
Problems					
Pin tract infection	0(0.0)	4(28.6)	1(33.3)	8.675	0.193
Wound breakdown	1(5.3)	2(14.3)	0(0.0)		
Drift docking	1(5.3)	1(7.1)	0(0.0)		
Nil	17(89.5)	7(50.0)	2(66.7)		
Quality of life					
Good	10(52.6)	7(50.0)	2(66.7)	0.276	0.871
Poor	9(47.4)	7(50.0)	1(33.3)		

Table 4: Showed the association between complication, problems and quality of life with length gained

Variables	<7 cm	8-14 cm	>14 cm	χ^2	p-value
Complication					
Limb length discrepancy	1(4.8)	1(10.0)	0(0.0)	13.623	0.034
Fracture regenerate	0(0.0)	0(0.0)	1(20.0)		
Joint contractures	0(0.0)	0(0.0)	1(20.0)		
Nil	20(95.2)	9(90.0)	3(60.0)		
Problems					
Pin tract infection	2(9.5)	1(10.0)	2(40.0)	9.164	0.165
Wound breakdown	0(0.0)	2(20.0)	1(20.0)		
Drift docking	1(4.8)	1(10.0)	0(0.0)		
Nil	18(85.7)	6(60.0)	2(40.0)		
Quality of life					
Good	11(52.4)	6(60.0)	2(40.0)	0.538	0.764
Poor	10(47.6)	4(40.0)	3(60.0)		

Discussion

Some orthopedic and trauma cases are difficult to sort with conventional treatments, such cases as a nonunion of a prolonged duration, infected injuries especially those with significant soft tissue loss, fresh injuries with bone gab more than 3 cm to mention but a few. The linear rail system uses the Ilizarov technique to either compress or distract bones together giving an additional advantage satisfactory union.

In this study most of the enrollees were males with a male to female ratio of 5:1, which is a common finding in the demography of several traumas related studies. Theophilus M.D. *et al.* found the ratio of males: females as 4:1. Error! Bookmark not defined. [21, 22] This is not farfetched, the fact that men are much more involved in outdoor activities and as bread winners go out of the way to look for things to make ends meet there by exposing them to trauma cannot be overemphasized. They are also more involved at conflict fronts to defend or be defended against.

The working age groups of 30yrs and above are much more affected in this study. 47% are those 20-30yrs and 36.1% for those >40 with a total of 83.1%. The mean age is 39±10.64. Wang H. and colleagues in their article titled "Quality of life and complications at the different stages of bone transport for treatment infected nonunion of the tibia" found a mean age of 36.9% [12, 19, 20].

This is the age group who are called the working age group. They do all they could to feed the younger and the older ages exposing them to a lot of dangers.

Trauma with bone loss or complication of trauma management forms the most common indications for limb lengthening as found by quite a number of writers [17, 18] Indication for surgery has been found to be significantly associated with quality of life. Table 2.

Most of the enrollees (27.8%) had two surgical sessions with interval corticotomy inclusive. This means there is likelihood that at presentation the surgery site is complicated with infection.

Length gained by 58.3% of patients was less than 7cm. this could be explained by the fact that previous paradigms limit uni-focal lengthening to 7cm or bone lost in most is less than 7cm in most cases of bone loss [11, 14, 32].

The leg (tibia) was involved in 75% of cases and the limb least operated was the femur. Study by Kesemenli and Colleagues found twelve out of the nineteen enrollees having limb lengthening in the tibia [11, 23].

A larger number of them had no problems however among the problems encountered by the enrollees; pin tract infection is the most common (13.9%) [25, 29, 33].

There were very few complications among which limb length discrepancies was the most common accounting for about 5.6% of the entire enrollees. Complications of surgery were found to have a significant association with the aim of surgery. Table 3. Its association with length gained was also significant. Table 4. Hantes and colleagues in their study on "complications in limb lengthening procedures: a review of 49 cases" found out that the incidence and severity of complications after limb lengthening procedures are significantly influence by the relative lengthening of the bone [33].

Conclusion

The linear rail system has been found to make a significant positive impact in managing complex orthopedic and trauma when conventional treatment options fail with low complication rate and very good quality of life thereafter.

Conflict of Interest
Not available

Financial Support
Not available

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