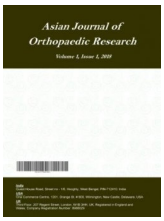

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Locked Intramedullary Nailing of Fractures. Experience from a Trauma Centre in Nigeria: A Prospective Observational Study

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Background: Locked intramedullary nailing of fracture has evolved as the gold standard for the treatment of fractures of the shaft of the long bones. It provides axial loading, controls length, alignment and rotational deformities of the injured limb. It also allows for early mobilisation of the patient. The procedure of locked intramedullary nailing is associated with many changes including logistics, expertise and cost for the instrumentation and the implants.
This study aimed to highlight the experience of locked intramedullary nailing of long bones fractures from a regional trauma centre in Nigeria.
Methods: Prospectively collected data on long bone fractures treated by locked intramedullary nailing from January 2007 to December 2012 were analysed and presented.
Results: Eight hundred and seventy-three long bone fractures were treated by locked intramedullary nailing during the period. Majority of the patients were males with the mean age of 28.6 years ± 12.2 years. Most of the fractures resulted from road traffic crashes 657 (75.3%), and the majority of the fractures were closed 648, (74.2%). Eight hundred and eleven (92.9%) of the fractures were reduced using the open approach. Six hundred and eighty of the fractures treated by this method had shown radiological evidence of fracture union at six months after surgery, and the

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recorded infection rate was 46 (4.8%).
Conclusion: Locked intramedullary nailing is a good option for treatment of the shaft of long bones in a resource-scarce environment. The method showed good outcome with acceptable complication rates.

Keywords: Locked intramedullary nailing; long bone fractures; Port Harcourt; Nigeria.

1. INTRODUCTION

Locked intramedullary (IM) nailing has evolved as the gold standard for treatment of diaphyseal fractures of long bones and results in union rates in greater than 95% of the cases when adequately done [1]. The impressive results obtained with this method of fixation for the long bone diaphyseal fractures has led to its extension for treatment of selected metaphyseal fractures including some fractures of the proximal and neck of femur [1]. Shaft fractures especially of the lower limb long bones commonly result from high energy injuries often following significant traumatic events, such as motor vehicle or motorcycle crashes, falls from height, and gunshot injuries. Other types but less common mechanism of femoral shaft fracture includes pathological fracture, low energy torsional fracture in elderly patients, bisphosphonate related stress fractures, and fractures resulting in a bone weakened by diseases such as tumours and metabolic disorders [2].

The treatment goal in fracture fixation is an early fracture union with the restoration of length, alignment, rotation of the injured limb and rapid return of the wounded to pre-injury condition. These are the benefits of locked intramedullary mailing [1,3]. Locked intramedullary nailing allows for early mobilisation of the injured limb without loss of fracture fixation thus readily acceptable to the patient.

Locked IM nailing of shaft fractures can be done by closed approach to the fracture site and indirect reduction of fracture fragments or by limited open approach to the fracture site to enable direct fracture reduction and proper guidance of the IM nail across the fracture fragments. Whereas the closed approach is the gold standard and always preferable, closed IM nailing requires the use of intra-operative imaging systems such as C-Arm fluoroscopy or mobile X-rays and often traction tables. Incidentally, these systems are often not available in the majority of the hospitals in most developing nations because of the enormous cost of acquiring and maintaining the systems [4]. In the closed method of locked IM nailing, the fracture is approached from a point distant from the fracture site; therefore, there is a lower risk of infection and blood loss when compared with the open method of IM nailing and other fracture fixation methods such as the use of plates and screws [3].

One of the challenging steps in locked IM nailing of fracture is the precise placement of locking screws that stabilize the fragment [4,5]. Various techniques are in use, ranging from fluoroscopy guided freehand locking which remains the gold standard, to the use of external Jig as targeting device for insertion of proximal and distal locking screws. Other tools to aid the insertion of the locking screws include the use of radiolucent drills [6], the use of distal targeting Jigs [7], laser-assisted devices [8], grid and flag devices [9], magnetic navigational aids [10] and the use of custom designed nails with specially designed slots [11]. None of these has generally been accepted [12] as the standard of care as all of the mentioned devices have identifiable challenges with their use. Most of the mechanical devices fail because of failure of the systems to account for the deformational torque and rotational forces the nail undergoes during insertion [13]. The freehand technique with the use of C- arm remains the most popular method used globally. However, in the absence of available intra-operative imaging, the chances of successful insertion of the locking screws especially the distal holes is increased by various ingenious techniques which are also used in confirming correct screw placement intra-operatively [14a]

With the high number of patients presenting with fractures especially high energy fractures resulting from road traffic crashes, gunshot injuries from increasing civil and armed conflicts, falls from height and low energy osteoporotic fractures, and the limited number of available orthopaedic surgeons with requisite skills and experience to treat the fractures in Nigeria, the need to use effective, accessible and affordable

treatment methods with fewer complication rates becomes imperative.

In the centre where this study was undertaken, various interlocking systems were available including the Synthes and Stryker Systems, both which required the use of C-arm image intensifier, the Synthes modular distal aiming device (MODAD) and Surgical Implant Generation Network (SIGN) systems which utilise distal aiming devices for insertion of locking screws.

This prospective study aims to present the experience with locked intramedullary nailing of long bone fractures from a trauma centre in Nigeria.

2. METHODS

Information of the patients presenting with long bone shaft fractures treated with locked intramedullary nailing between January 2007 and December 2012 in a dedicated regional trauma centre in Nigeria jointly run with an International Non-for profit, a non-governmental organisation was collected prospectively and analysed. Since treatment of all patients at the centre was free of charge, the cost of care did not influence the choice of implant and type of surgery for fracture fixation. Information relating to age, gender, the cause of injury, location and type of fracture and interval to the presentation were analyzed. The type of locked IM nailing system used, duration of surgery, intra-operative blood loss, the precision of insertion of locking screws, postoperative complications, lengths of hospitalisation and duration of fracture union evidenced clinically by the absence of pain at fracture site, good radiological union and return to pre-injury activities were determined and presented.

Obtained data were analyzed using statistical package for Windows version 20 (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY IBM Corp.). Descriptive statistics were generated and presented as considered appropriate and inferential statistics when necessary. Categorical variables presented as proportions and percentages and numerical variables presented as means and standard deviation (SD) and median with interquartile ranges (IQR) as considered appropriate. Chi-Square χ^2 was used to test for observed differences among categorical variables. P values less than 0.05 were accepted as statistically significant.

3. RESULTS

During the period under study, 873 locked intramedullary nailing of fractures of the shaft of long bone was done at the trauma centre. The age range of the patients was 16 years to 78years, and the mean age of the patients was 28.6 years ± 12. 2 years. There were 588 males (67.4%) and 285 females (33.6%) giving a male to female ratio of about 2:1. The following IM nailing systems were used for various fractures; Stryker nails (66), Synthes nails (26), Synthes MODAD nails (54), and SIGN nails (727).

Most of the fractures were as a result of road traffic crashes n = 657 (75.3%), followed by gunshot injuries n = 89 (10.2%). Pathological fractures were 24 (2.7%) of the fractures treated by this method, Table 1.

Majority of the patients (n= 529, {60.6%}) presented after 24 hours of the injury and about 6% of the patients presented within eight hours of the injury, Table 2.

3.1 Location of the Fractures

Most of the fractures treated by this method involved the femur n= 679 (77.8%), while 185 (21.2) of the fractures involved the tibia. Only nine cases (1%) of the fracture of the humerus were treated by this method. Some of the patients had multiple fractures involving different long bones of the body, Fig. 1.

Table 1. Cause of fracture

Cause of fracture	Frequency (Nos)	Percentage (%)
Road Traffic Crashes	657	75.3
Gunshot injuries	89	10.2
Assault	46	5.3
Falls from height	30	3.4
Domestic / Industrial Accident	27	3.1
Pathological Fractures	24	2.7
Total	**873**	**100**

χ^2= 1676.971. P- < 0.001.

Table 2. Intervals between injury and presentation to the hospital and surgery

Interval to presentation	Nos.	%	Interval to surgery	Nos.	%
Less than 8 hours	422	48.4	Within 24 hours	50	5.7
8 hours to 24 hours	159	18.2	1 – 3 days	294	33.7
One day to 3 days	292	33.4	After 3days	529	60.6
Total	**873**	**100**	**Total**	**873**	**100**

χ^2 = 118.852 P < 0.001

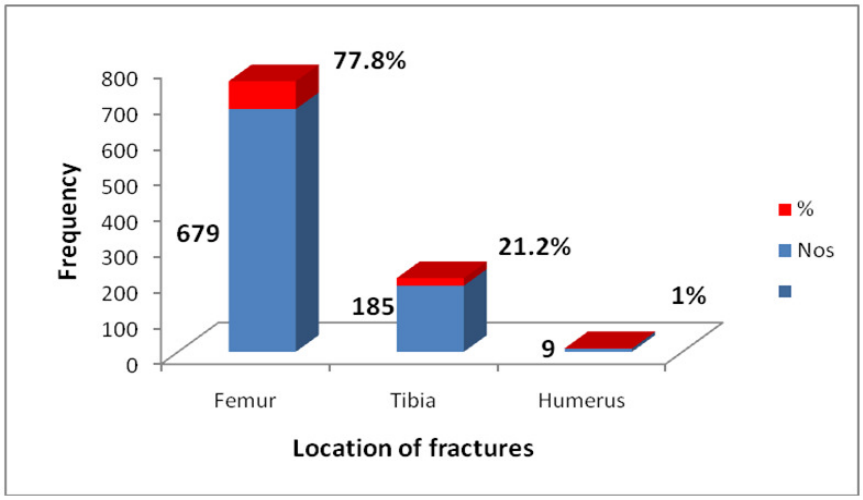


Fig. 1. Location of fractures
χ2 = 829.223

3.2 Types and Classification of the Fractures

Table 3 shows that majority of the fractures were of the closed type n= 648, (74.2%) while 225 (25.8%) of the fractures were open. One hundred and twenty-eight (14.7%) of the open fractures, were of the Gustilo-Anderson type 1,73 (8.4% of the fractures were of Gustilo-Anderson type 2, while 4 of the fractures about (0.5%) treated by this method were of the Gustilo-Anderson type C [15].

Table 4 showed the intra-operative demographics and surgical outcome of treatment. Majority of the fractures n= 811 (92.9%) were reduced using the open approach to the fracture site while only 62 (7.1%) of the fractures were reduced using the closed method. The mean duration of surgery was 1 hour 57 minutes ± 37 minutes with a range of 40 minutes to four hours twenty minutes. Majority of the patients 748 (85.7%) of the patients did not require a blood transfusion before, intra-operation or after the surgery. Locking screws were successfully inserted in 1152 (87.2%) of the cases.

Table 3. Types and classification of the Fractures

Fracture Type	Frequency (Nos.)	Percentage (%)
Closed	648	74.2
Open	225	25.8
Open type I	128	14.7
Open Gustilo Type II	73	8.4
Open Gustilo Type III A	20	2.3
Open Gustilo Type III B	nil	nil
Open Gustilo type IIIC	4	0.5
Total	**873**	**100**

χ2 = 1659.783 P < 0.001

Table 4. Intra-operative demographics and treatment outcome

Variable	Sub-type/ classification	Frequency (Nos.)	Percentage (%)
Method of Fracture Reduction	Open	811	92.9
	Closed	62	7.1
Duration of surgery (from Incision to close of Skin)	Mean duration	1 hour, 57 mins. Std Dev. (37mins)	
	range	40 minutes - 4hrs, 20mins	
Average Blood loss including fracture haematoma		452 mls ± 180 mls	
Blood transfusion requirement (Some patients had pre-op, Intra-Op, and post-op transfusion combined)	Nil transfusion	748	85.7 %
	Pre-Op transfusion	45	5.2 %
	Intra-Op transfusion	72	8.2%
	Post-Op transfusion	42	4.8%
Target hit rate of Distal hole screw insertion	Available distal holes	1746	
	Intentionally not locked	427	
	Intended Distal locking	1321	100%
	Successfully locked (Target hits)	1152	87.2%
	Target misses	169	12.8%
Duration of Hospitalisation (LOS)	Median LOS (Range)	10.5 days (2 – 72) days	
	Inter-quartile range (IQR)	Nine days	
Duration of surgical wound healing	Mean duration	2.5 weeks	
	Std. Dev.	1.5 weeks	

Fig. 2 shows that by the end of 3 months after surgery, 396 (45.3%) of the fractures had demonstrated good callus on radiograph and 680 fractures (77.8%) had shown evidence of radiological union by the end of 6 months. Only 51 fractures (5.8%) had not united by 18 months after surgery amongst which include 20 fractures (2.3%) which progressed to outright non-union.

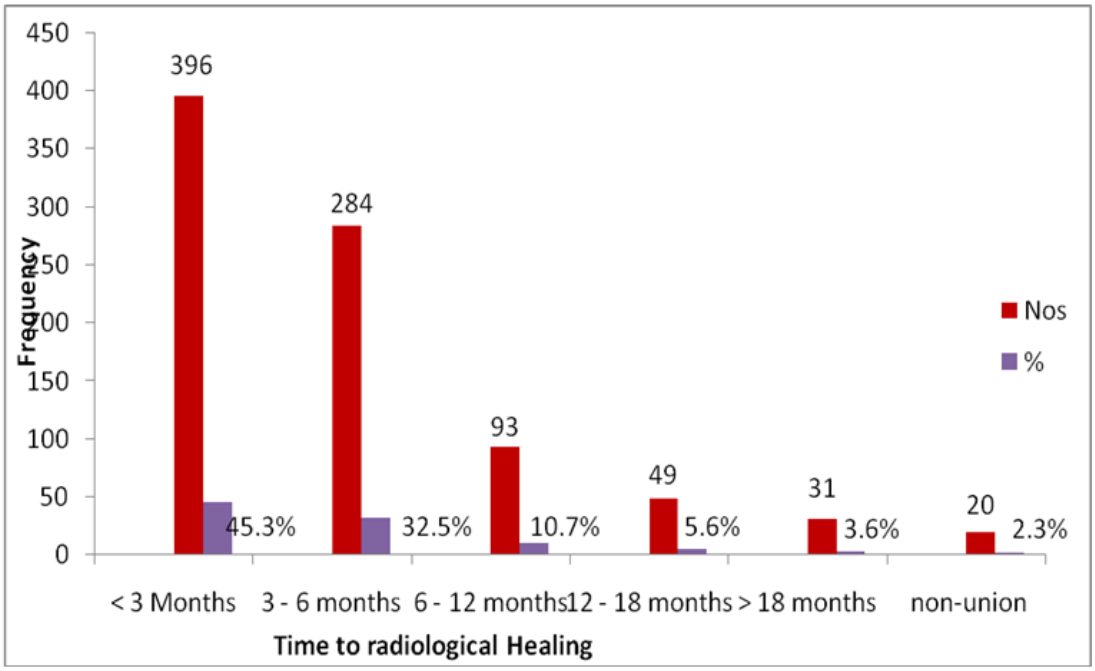


Fig. 2. Time to radiological Union

χ^2 = 567.711, P <0.001

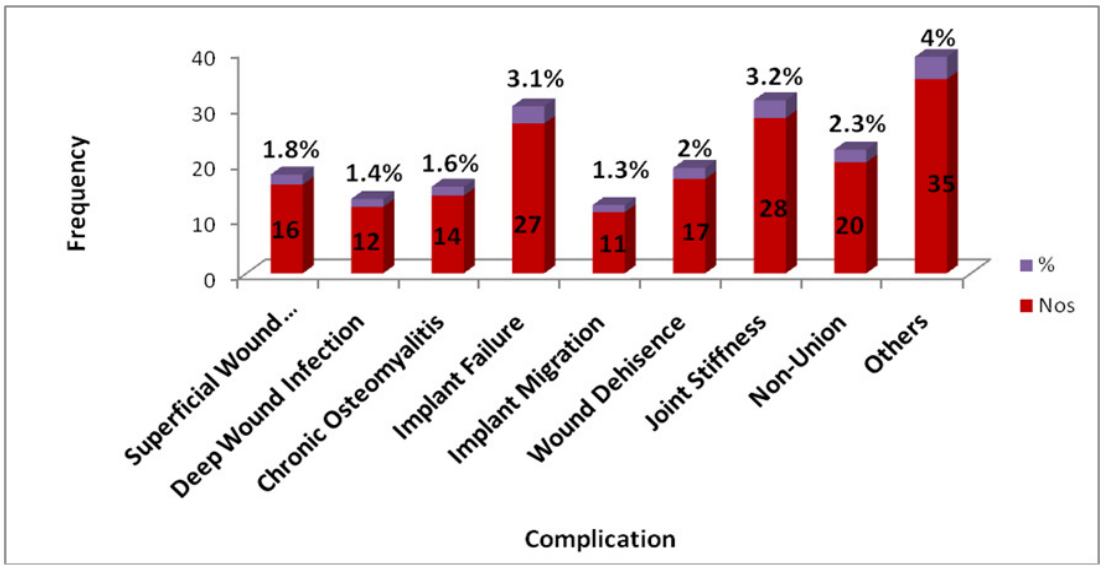


Fig. 3. Post Operative Complications
Some of the patients had multiple complications.

3.3 Post Operative Complications

Forty-two of the fracture (4.8%) developed infection including superficial wound infections 16 (1.8%), deep wound infections, 12 (1.4%) and outright chronic osteomyelitis 14 (1.6%). Other complications observed included fracture non-union 20 (2.3%) and implant failures such as nail breakage, screw breakage in 27 cases (3.1%) Fig.3.

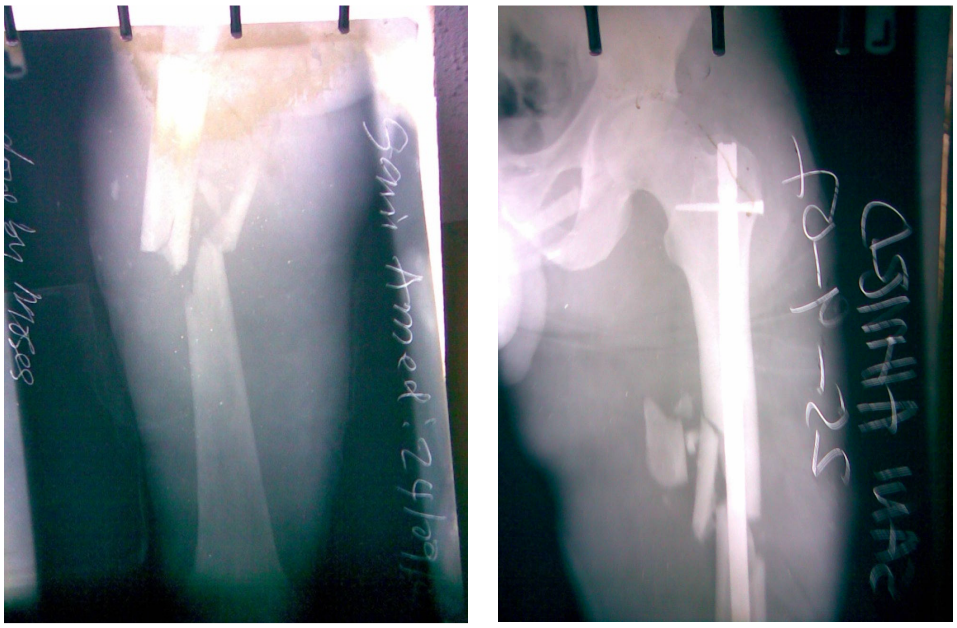
4. DISCUSSION

The results of this study confirm that long bone fracture is relatively common in the region. The relative high number of fracture treated in the

Pre-Operation radiographs Tibia/fibula

Post- Op Radiographs

Figs. 4, 5 and 6. Radiographs of a patient with bilateral fractures of the Tibia/ fibula and fracture of left femur



Figs. 7 and 8. Pre-Op and post Op radiographs of multi-fragmentary fracture of the femur

centre may be attributed to the fact that treatment in the centre was free of charge to the patient as long as the patient met the admission criteria which included arriving at the hospital within 3 days of injury and if the patient had not started treatment of the fracture in another hospital before coming to the trauma centre. This policy ensured that patients arriving at the facility received appropriate treatment without delays for lack of funds which is part of the reasons some patients give for not seeking treatment early.

The mean age and the gender distribution of the patients confirm that trauma remains a problem

of the active young males [16,17]. The male to female ratio of 2:1 is in keeping with the 1.9:1 reported by Court Brown [18] but differs from the 6.4:1 reported by Mohammed et al. from the Northern part of Nigeria. The variation in gender distribution of the injury between this study and that reported from Northern Nigeria may be attributed to the fact of more restrictions of female activities in Northern Nigeria based on religious and cultural beliefs compared with Southern Nigeria. This reason exposes the females in the South of Nigeria to more hazards especially road traffic crashes which were the most frequent cause of the injuries. The menace of road crashes in the region is well established [19].

Majority of the fractures treated by locked IM nailing from this study were closed fractures 648 (74.2%) involved the femur 679 (77.8%). This pattern may not be surprising as most of the fractures involving the shaft of the tibia are often open fractures because of deficient soft tissue cover of the tibia, especially on its anteromedial surface. Such open fractures are usually treated by other fixation methods such as external fixation if the associated soft tissue injury is severe. Closed fractures of the tibia and humerus are amenable to non-operative treatment by closed manipulation and cast application. The Open fractures treated by locked IM nailing were of less severe grades, i.e. Gustilo - Anderson grade I to grade IIIA were mostly those involving the femur which had adequate soft tissue coverage of the fracture site [15].

Majority of the fractures were reduced using the open method n = 811 (92.9%). This option of fracture reduction may be attributable to the fact that majority of the fractures were treated using the SIGN and the Synthes MODAD nailing systems which are designed for insertion without the aid of intra-operative imaging. In spite of the fact that there was a functional C-arm image intensifier available in the facility, limited expertise available in the centre limited the routine use of the equipment hence the adoption of the easier and more practical open method of fracture reduction [20]. Various authors have argued that opening the fracture site exposes the fracture haematoma to the exterior and converts a closed fracture to open fracture with a higher risk of infection [21].

The observed duration of surgery which ranged from 40 minutes to 4 hours 38 minutes was an indication of a steep learning curve of the process of locked IM nailing. The prolonged duration of surgery for the initial procedures done improved over time with the improved experience of the surgeons. The observed need for blood transfusion, length of hospital stay, duration of surgical wound healing and radiological fracture union confirms that locked IM nailing of long bone fractures provides a comparatively favourable outcome for treatment of fractures of the shaft of long bones when compared to other methods of fracture fixation such as the use of plated and screws [22]. The recorded infection rates 42 (4.8%) was within the acceptable range especially when some of the fractures were open [23].

The duration to radiological healing of the majority of the fractures at 12 weeks post surgery n= 396 (45.3%) was in keeping with the findings of Haonga et al. [24] but differs with the conclusions from Henderson et al. [25] which had only 20% of his cases having visible callus at 12 weeks after surgery. This early healing of the fractures allowed an early return of the patients to pre-injury activities with few complications of treatment. Other postoperative complications recorded indicate that locked IM nailing may not be without associated problems especially if patient's selection, fracture selection and implant selection are not properly done. Surgeons with necessary expertise and experience are required for good outcome.

5. CONCLUSION

Locked intramedullary nailing of fractures of the shaft of long bones is a viable option for treatment of such fractures in a well-selected patient. The none availability of expensive equipment such as C-arm image intensifiers and traction table, should not be a reason for none use of such globally acceptable method of fracture care in resource-scarce regions going by the result of this study.

CONSENT

It is not applicable.

ETHICAL APPROVALS

Study was approved by the Research and Ethical Review Committee of International Centre for Advanced Medical Care and Development (ICAMCAD) who are the developers of the registry.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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