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Early Treatment Outcome of Humeral Shaft Fracture Non-Union in Adults: Comparative Study of Plating versus Interlocking Nailing

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Abstract

Background: Fractures of humeral shaft in adults are common injuries. Humeral shafts non-union either from late presentation after initial treatment by traditional bone setters or failed non-operative orthodox care is a major problem in this part of the world. This non-union is a major treatment challenge with increased cost of care and morbidity in this part of the world. Humeral shaft non-union can be treated with locked intra-medullary nailing (LIMN) or dynamic compression plating (DCP). Study on comparison of these methods of fixation in this part of the world is scarce in literature search, hence the reason for this study. **Objective:** The objectives of this study are: (1) to compare early clinical outcome following fixation of humeral shaft fracture nonunion with DCP versus LIMN; (2) to compare the time of radiologic fracture union of DCP with LIMN; (3) to compare complications following fixation of humeral shaft fracture nonunion with DCP versus LIMN. **Patients and Methods:** This was a randomized control study done for 2 years in which fifty adult patients with humeral shaft non-union were recruited. The patients were grouped into 2 (P = DCP & N = LIMN). Forty five of the patients completed the follow up periods of the study and then analyzed. The P group had ORIF with DCP while the N group had ORIF with LIMN. Both groups had grafting with cancellous bones. Each patient was followed up for a period of 6 months at the time which radiographic union is expected. Any patient without clinical and/or radiographic evidence of union after six months of surgery was diagnosed as having recurrent non-union. The data generated was analyzed using SPSS Version 23. The results were presented in charts and tables. The paired t-test was used while considering p value < 0.05 as statisti-

cally significant. **Result:** Forty five patients completed follow up. There was a male preponderance (4:1), right humerus predominated (3:2). Motor vehicular accidents were the commonest cause of the fractures (62%). Most non-union fractures occurred at the level of the middle 3rd of the humeral shaft (60%). Failed TBS treatment was the commonest indication for the osteosynthesis (71%). More patients had plating (53%) compared to 47% who had LIMN. Most patients (93.4%) had union between 3 to 6 months irrespective of fixation type with no significant statistical difference between the union rate of DCP and LIMN (p value 0.06) with similar functional outcome and complication rates irrespective of the type of fixation. **Conclusion:** This study showed that the success rates in term of fracture union, outcome functional grades and complication rates were not directly dependent on the types of the fixation: plating or locked intra-medullary nailing.

Keywords

Humeral Shaft, Non-Union, Dynamic Compression Plating,
Locked Intra-Medullary Nailing, Early Treatment Outcome, Early Outcome

1. Introduction

Fractures of humeral shaft in adults are common injuries, accounting for about 3% of all fractures in the developed world [1]. Fractures of the shaft of the humerus have been treated conservatively for ages with good results with union in over 90% of cases [1]. In our environment, a good percentage of the patients will present first to the traditional bone setters, and later present to the orthopaedic surgeons, usually when the fracture has failed to unite [1] [2]. The incidence of non-union in humeral shaft fractures has been suggested to be 5 - 10% and 4 - 9% in the United Kingdom and United States respectively [1] [2]. Data on non-union rates is difficult to find in this part of the world but are likely to be higher than the rates in the developed climes as a result of the ubiquitous nature of traditional bone setter's intervention, poverty et cetra [3].

Successful management of non-union of long bones continues to be a challenge to orthopaedic surgeons despite improvement in the understanding of fracture repair and treatment techniques [3]. The outcome of treatment of these non-unions thus depends on a range of factors, including the expertise and devices available to the surgeon as well as the nature of the non-union. Despite these advances in care, the incidence of non-union remains a concern especially in this part of the globe which is largely due to intervention by traditional bone setters [4] [5]. Non-union is an outcome that is difficult to predict at the time of injury and during the healing process and although an established complication of any fracture in clinical practice with both clinicians and patients deem it a poor outcome. There may be persistent pain and failure to return to pre-injury levels of function [6].

With varying repair times for individual fractures and healing potentials and patients, there is no uniform definition for non-union. According to American

food and drug administration, a non-union is established when a minimum of nine months has elapsed since injury and the fracture shows no visible progressive signs of healing for three consecutive months [7]. It is also said to exist when repair is not complete within the period expected for a specific fracture and when a cellular activity of the fracture site ceases and there is no progressive signs of healing for three months [8]. The treatment options involve open reduction of the fracture non-union and stabilization with LIMN, DCP or devices of external fixation augmented by biological, ultrasonic or electrical stimuli. LIMN is a weight sharing device that is used for humeral shaft fractures as a reliable means to achieve fracture union by stabilizing the fracture fragments through an intramedullary nail and locking at both ends prevents rotational forces while allowing early motion. Osteosynthesis of humeral shaft with DCP is a weight shielding device that is regarded as a standard for fracture fixation. It entails the use of plate and screws to stabilize reduced fracture fragment to encourage healing in an acceptable anatomy. The incidence of humeral shaft non-union is reducing in the study centre with most of the cases being a result of treatment by traditional bone setters and failed non-operative orthodox care. The use of the LIMN and DCP is common practice in the study centre for fresh fractures. However, many surgeons prefer the use of DCP for humeral fracture non-union fixation with potentiality of compression of the fracture fragments and also there is paucity of studies on the comparisons of the two devices in this part of the world. This study is set out to examine the early outcome of the above two devices in the management of humeral shaft fracture non-union.

2. Patients and Methods

Ethical clearance was obtained from the research ethics committee of the hospital and informed consent obtained from all patients involved in the study. This was a prospective randomized control study carried out for 2 years based on the patient presentation at both emergency room and outpatient clinic department between January 2020 and December 2021 in which fifty adult patients with humeral shaft non-union were recruited. The inclusion criteria are adult patients with isolated closed humeral shaft fracture nonunion while patients with pathological fractures, open fractures, chronic osteomyelitis of humerus, fracture with bone loss which required bone lengthening or major bone grafting, coagulopathies, on drugs like steroids, anti-neoplastic that may interfere with healing and those with significant co-morbidities such as Diabetes Mellitus, Neoplasia were all excluded from the study.

A double blind randomised sampling method was used with help of study assistant who allotted the patients numbers (1 to 50) that were grouped into P and N groups. Those who picked papers labeled with certain number were belong to P or DCP and those who picked papers labeled another certain number were in N group and had LIMN fixation for their fractures respectively. Patient was evaluated through the tripods of detailed clinical history, clinical examination and appropriate investigations including radiological imaging. Assessment was done

at or before the determination of the definitive management. Pre-operative radiographs were done for all patients to confirm diagnosis and classification of the humeral shaft non-union fracture. Operation was carried out in aseptic conditions under general anaesthesia. The surgeons were blinded from known which patient belongs to group P or N until the time to use the implant after the initial freshening of fracture fragments ends. For DCP, the fractures in the upper and middle 1/3 s were reached via the anterolateral approach while those in the distal 1/3 were reached via the posterior approach. All LIMNs were done in ante-grade fashion. All patients had humeral fracture ends freshened including drilling the marrows and grafted with cancellous bone graft from iliac crest during the osteosynthesis. All patients had standard intra- and post-operative care including wound care and physiotherapy. Appropriately sized LDCP (with minimum of 6 cortices on either side of the fracture), were used for the plating, and an appropriately sized LIMN for the nailing.

Orthogonal view radiographs were done immediate post operatively and at every six weekly intervals until radiologic union were achieved or up to 6 months follow up period. All patients were followed up for a period of 6 months at which time radiologic union is expected to have occurred. Any patients without radiologic union at 6 months were regarded as having recurrent non-union. All the participants were followed up six weekly intervals where progress in clinical union, radiologic union and general well-being of the patients were noted and recorded. Clinical and radiological outcome assessments were done. The patients with complications were evaluated and treated accordingly. At the final visit (6 months after surgery), the radiologic union and functional outcome were evaluated using Radiographic Union Scale for Tibial fractures (RUST) scale and American shoulder and elbow surgeons (ASES) score respectively. All post operative findings including imaging feature of fracture healing were collected and recorded by another study assistants and the data collected were analyzed using SPSS Version 23 and the statistical inferences were made. The patients who belong to group N or P were made known during the analysis. The results were reported in words, tables, chai square was used while considering P value < 0.05 as statistical significant.

3. Results

Fifty adult patients with humeral shaft fracture nonunion who underwent osteosynthesis with either plating or locked IM nailing were studied. Five (10%) of the 50 participants were lost to follow up, hence were excluded from the final analysis. There were 36 males and 9 females (Table 1); therefore, the Male to Female ratio was 4:1. There were 28 cases of right humeral shaft nonunion and 17 cases (Table 2) on the left with a laterality ratio of R (3): L(2). Thirty eight of the 45 patients were right handed. The complication rate was 16% and that for nailing was 14.3%. All complications were treated and respectively improved with satisfactory results as at the last visit of follow up (Table 3). The mean duration of surgery for plating was 113.5 minutes and that for nailing 120 minutes (p value 0.58).

Table 1. Sociodemographic characteristics of the subject.

Variables	Number	Percentage
Age group (years)		
21 - 30	16	35.6
31 - 40	15	33.3
41 - 50	6	13.3
51 - 60	3	6.7
61 - 70	5	11.1
Sex		
Male	36	80.0
Female	9	20.0
Occupations		
Business/trading	21	46.7
Student	7	15.6
Civil Servant	9	20.0
Farming	8	17.7

Comments:

- Active age groups is the most common
- Male: female ratio is 4:1

Table 2. Characteristics of the fracture before surgery.

Variables	Frequency	Percentage
Mechanisms of injury		
Motor vehicular accident	35	77.8
Falls from Height	3	6.7
Simple falls	2	4.4
Sport	2	4.4
Others	3	6.7
Side distribution		
Right	28	62.2
Left	17	37.8
Dominant Arm		
Right	38	84.4
Left	7	15.6
Type of fracture (AO Classification)		
A_1	5	11.1
A_2	5	11.1
A_3	35	77.8

Continued

Anatomic level of the fracture		
Upper third	8	17.8
Middle third	27	60.0
Lower third	10	22.2
Indication for Surgery		
Traditional bone setting	30	66.7
Non-operative treatment	9	20.0
Plating	6	13.3
Type of corrective surgery performed		
BDCP	20	44.4
T-Butress	4	8.9
IM Nailing	21	46.7

Comment:

- Most fracture occurred at mid-shaft
- Most common indication for surgery was non-union from traditional bone setter treatment
- IM nailing was the most used ORIF

Table 3. Cross tabulation between surgical techniques an treatment outcome (DCP vs LIMN).

Variable	Surgical Techniques	
	Plating n (%)	**Nailing n (%)**
Duration of surgery (hours)		
<1 = 4	2 (8.3)	2 (9.5)
1 – 2 = 35	19 (79.2)	16 (76.2)
>2 = 6	3 (12.5)	3 (14.3)
Duration of Union (months)		
>3	9 (37.5)	8 (38.1)
3 – 6	13 (54.2)	12 (57.1)
>6	2 (8.3)	1 (4.8)
Functional outcome score		
Excellent	3 (12.5)	4 (19.0)
Good	18 (75)	16 (76.2)
Fair	2 (8.3)	1 (4.8)
Poor	1 (4.2)	0

Continued

Complication rate		
Infection	1 (4.2)	0
Delayed union	1 (4.2)	0
Non-union	0	1 (4.8)
Radial nerve Palsy	1 (4.2)	1 (4.8)
Shoulder stiffness	0	1 (4.8)

Table 4. Comparison of treatment outcome between plating and nailing surgical techniques.

Variables	Plating	Nailing	
	Mean ± SD	Mean ± SD	Paired t test
Mean duration of surgery (minutes)	113.5 ± 24.2	120 ± 21.2	T = −0.56, p = 0.58
Mean duration of Union (Months)	3.2 ± 0.44	4.3 ± 1.52	T = −2.11, p = 0.06
Mean functional outcome score	1.15 ± 0.78	2.2 ± 0.45	T = 1.27, p = 0.90

Table 5. Classification of non-union and fracture outcome grade.

Classification of Non-union	Grades				Total
	Excellent	Good	Fair	Poor	
Atrophic	6	21	1	0	28 (62.2%)
Oligotrophic	1	8	1	0	10 (22.2%)
Hypertrophic	0	5	1	1	7 (15.6%)
Total	**7 (15.6%)**	**34 (75.5%)**	**3 (6.7%)**	**1 (2.2%)**	**45**

Comment:

- Atrophic non-union is the most common
- There is no statistical significance in outcome (p value 1.7)
- 41 Patients (91.1%) has satisfactory outcome

4. Discussion

The male to female ratio and limb laterality in our study (Table 1) are similar to previous works. [3] [5]. The right humerus was most involved in the current research (Table 2) which is explained by the fact that functional dominance is dependent on the side of cerebral hemisphere with most people being right handed [3].

Motor vehicular accidents were the commonest cause of fracture which accounted for 77.8% of our patients (Table 2). This is in agreement with the study of Olasinde *et al.* [9] with the motor vehicular accidents accounting for 86.4% and other numerous studies published worldwide [10]. Furthermore, in the present research, young adult males had the highest frequency (Table 2). This finding is similar to the results from other parts of the world [3] [10] [11], Tra-

ditional bone setters' intervention accounted for 66.7% of the non-union in this study (**Table 2**) comparing well with the finding of 81.8% in the study by Olasinde *et al.* where it was stated that the splints used by the local bone setters are usually too tight, jeopardizing the blood supply to the affected limb which may result in non-union or even gangrene from compartment syndrome [12].

This study also showed that the mean time of radiographic union for plating was 3.2 months and that for nailing 4.3 months (p value 0.06) in **Table 3** compared to 6 months and 5 months for plating and nailing respectively by Madu K.A *et al.* and other studies [12] [13] with statistically significant difference between the clinical outcome of plating and Locked IMN as shown in **Table 4**. The reasons for this may be partly due to the techniques used during osteosynthesis which may include adequacy of freshening of the fracture fragment ends till healthy and bleeding edges were reached, cancellous grafting of the fracture fragment ends or both. This is in concordance to the finding by *Chen et al.* in the outcome study of humeral shaft treatment with nailing versus plating [14].

It is found from the study also that 87.5% of those who had plating and 75% of those who has nailing has satisfactory functional grading outcome (p value 0.90) as shown in **Table 3**. The functional grading outcome is satisfactory in 91.1% of the participants (**Table 3**). This suggests that functional outcome may depend directly or indirectly on the union rate which determines the duration of immobilization and commencement of range of motion exercise and function.

Atrophic non-union accounted for 62.2% of the cases seen in the study (**Table 3** and **Table 4**). This is comparable to a study by Olasinde *et al.* with atrophic type accounting for 81.8% [11] and Tannura *et al.* [15]. This study demonstrated (**Table 5**) that the union rate and functional outcome grades (as above) were not dependent on the type of the non-union as earlier found by Madu *et al.* [3]. The reason may be as stated above that union may be dependent on the technique of fixation and bone grafting rather than mainly on the fracture fragment status and types of fixations (plating or nailing).

Transverse fracture pattern was the commonest type in humeral shaft non-union as found by Olasinde *et al.* and it was commoner in the middle 1/3 of the shaft as demonstrated by Ring *et al.* [16]. The complications rate of 16% for plating and 14.3% for mailing recorded in the study (**Table 3**), are in tandem with reports of 32.4% and 6.2% for plating and nailing respectively by Madu *et al.* Radial nerve palsy was the most prevalent (25% in plating and 30% in nailing) which mirrows earlier findings in the orthopaedic literature. The similarity between this study's complication rate and most findings in other regions of the world [17] [18] could be attributed to the general complexity of the arm in terms of its neurovascular structures, their locations and the natures of the adjacent joints (elbow and shoulder) which may progressively get stiffened following a prolonged immobilization that usually follow treatment humeral non-union fractures especially due to pain or if stabilization is not curtained. However, many comparative study of plating versus LIM fixation of humeral shaft fracture have revealed higher complication rates in ranges of 2 - 5 folds among fixation with

LIM nailing when compared with DCP [19] [20].

Several studies had compared the outcome of locked IM nailing with plating for humeral shaft fracture treatments with varying reports. *Kiran* and *Mohit et al. in* a meta-analysis of compression plating versus intramedullary nailing of humeral shaft fractures reported that plating gave a lower relative risk of reoperation than intramedullary nailing (RR = 0.26) with reduction of 74% for reoperation when plate fixation was employed [11] [21]. *Kiran* and *Mohit et al.* also noted that plating reduced the risk of shoulder problems (like impingements) in comparison to intra-medullary nails (p = 0.002) [11] [21] [22]. The impingement syndrome may be as results of the length of the nail outside the bone at the entry point. None of the participants in this had the complication of impingement syndrome. *Amit et al.,* in a comparative study of functional outcomes, union and complication rates in patients treated with locked intra-medullary nailing or dynamic compression plating for humeral shaft fractures revealed similar good functional outcomes and union rates from both modalities, however with a higher complication rate in the IMN group [19]. This is unlike in this study, where the success and complication rates are not statistically different.

5. Conclusion

This study showed that the union and complication rates following fixation of humeral shaft nonunion with plating or LIMN were similar. So, irrespective of the fixation methods, the functional outcome and union rate were not dependent on the type of non-union or type of osteosynthesis but on the patient selection and surgical skills with principles including bone grafting that determine the humeral fracture union.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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