Nigerian Journal of Clinical Practice
Dec. 2010 Vol. 13 (4):436-440

OSSEOUS UNION IN CASES OF NONUNION IN LONG BONES TREATED BY OSTEOSYNTHESIS

IC Nwagbara
National Orthopaedic Hospital, Enugu

ABSTRACT

Objective: To determine the incidence of osseous union in cases of nonunion of long bones managed by open reduction and compression plating.

Patients and methods: Between November, 2003 and June, 2005, 53 patients with nonunion of long bones were treated by open reduction and internal fixation and followed up. The follow up period for each case was 6 months. Immediate post- operative x-ray was done in each case. Patients were seen in the post- operative period at 4 weeks, 6 weeks, 12 weeks, and 6 months. At each visit, clinical and radiological assessments were done.

Result: The male to female ratio was 3:2, and the average age at presentation was 39.7 years (range: 19-64years). The average time from injury to presentation was 19.98 months (range: 6-132months). The commonest bone involved was the humerus (18), followed by the femur (17), the Tibia (11), the ulna (5), and the radius (2). Osseous union was achieved in 44 patients (83%). There was no significant difference in incidence of osseous union among the various bones. It was observed that previous infection at the fracture site adversely affected osseous union.

Conclusion: The management of nonunion in long bones by compression plating was found to be satisfactory.

Key Words: Nonunion, Long bones, Osteosynthesis *(Accepted 22 February 2010)*

INTRODUCTION

The healing of fractures is one of the most remarkable of all the repair processes in the body since it results, not in a scar, but in the actual reconstitution of the injured tissue to the original form[1,2]. Bone fractures initiate a complex overlapping sequence of events, including inflammation, repair, and remodeling[1]. How long does a fracture take to heal and to consolidate? No precise answer is possible. Approximate prediction as shown by the Perkins' timetable is delightfully simple. A spiral fracture in the upper limb unites in 3weeks; for consolidation multiply by two, for the lower limb multiply by two again; for transverse fractures multiply again by two[3]. Despite the potential for successful healing, certain types of fractures end in complications such as delayed union and nonunion. For a fracture of the diaphysis of a long bone in an adult, at least 6 months must elapse after injury before the diagnosis of nonunion can be made [1]. The failure of a fracture to heal prolongs the patient's disability and may have a greater negative impact on the quality of life than renal dialysis and ischaemic heart disease[4].

In the management of nonunion, attention is given to the probable cause of the problem, as failure to attend to this will result in treatment failure and recurrence. Thus a thorough history, detailed physical examination and investigations prior to treatment will often lead to a solution to the problem[1].

Treatment is aimed at achieving a solid union of the fracture that will endure and allow the patient to regain a good level of function. Treatment can be non-operative as in cast-bracing immobilization, electrical stimulation, and shock wave therapy; it can also be operative as in the use of plate fixation, bone grafting, intra-medullary nailing, exchange nailing and external fixation. The simplest and most easily tolerated method is chosen in each specific case and treatment rarely consists of only one method.

The main objective was to assess the outcome of treatment based on osseous union in cases of nonunion in fractures of long bones managed by open reduction and compression plating. The study was also aimed at identifying the factors that adversely affected union in such cases.

PATIENTS AND METHODS

This was an epidemiological study carried out between November 2003 and June 2005 at the National Orthopaedic Hospital, Enugu, Nigeria. The hospital is a tertiary health centre located in the capital city of Enugu state.

Patients with nonunion of the diaphysis of long bones who were managed by open reduction and internal fixation with plate and screws were included in the study. The exclusion criteria included pathological fractures, fractures with intra-articular component, and children below the age of 18 years.

Correspondence: Dr I C Nwagbara

History taking, physical examination, plain radiographs and laboratory investigations were done to make a pre-operative diagnosis. The diagnosis was however confirmed at surgery.

The surgery was done under general anaesthesia for the upper limb and spinal anaesthesia for the lower limb. Prophylactic antibiotic was given. The patient was positioned in such a way that the appropriate source of bone graft could be accessed without re-positioning during surgery. Bone graft was harvested from either the iliac crest or the upper tibia. The operation site was prepared in the routine way and the nonunion site exposed. Any existing implant was removed and the bone ends freshened. The medulary canal was fully opened on both sides of the fracture. The fracture was then reduced and held with plate and screws to achieve compression at the fracture site. Cancellous bone grafts were applied to the exposed bone surface.

For fractures with history of infection, surgery was done at least 6 months after any evidence of infection as shown by cessation of drainage of pus, and normalization of the lymphocyte count and erythrocyte sedimentation rate. For these cases, specimens were taken from the fracture site at operation to confirm the absence of infection.

Post- operatively, antibiotics were continued for 48hours. Wound drain was removed after 48hours depending on the output. Physiotherapy was commenced as soon as pain could allow. Patients were followed up for 6 months. X-ray was done in the post-operative period at 72hours, 4-6weeks, 3months and 6months.

The outcome was categorized into two groups based on the clinical signs and radiological findings of union [5, 6, 7]. The clinical parameters were painless weight bearing and negative findings on varus-valgus and antero-posterior stress test. The radiological parameters were presence of bridging callus across the nonunion site in at least three cortices in two orthogonal radiographic views. The treatment thus resulted in either osseous union- when all the above parameters were met, or nonunion- when one or more of the conditions were not satisfied.

Data presentation was by tables. The data were analyzed using the SPSS (Statistical Package for Social Sciences), version 11. The observed relationships were subjected to Chi- Square test and the level of statistical significance was set at 0.05.

RESULTS

In the period under study 55 patients fulfilled the criteria for inclusion into the study. Each patient was followed up for a period of 6months except for two cases that were lost to follow up. One never showed up after discharge and the other was last seen 6weeks after surgery. This left 53 cases for the final analysis.

The age range of the patients was from 19years to 64years; with a mean age of 39.7 $\pm$ 12.2years. The highest number of cases was in the 42-53 years age group. Table1.

Thirty patients (56.6%) were males and 23 patients (43.4%) were females with a male to female ratio of 3:2. The time interval between injury and presentation ranged from 6 months to 132 months, with a mean of 19.98 $\pm$ 22.6 months.

The commonest bone involved was the humerus: 18(34.0%). The frequency in the other bones is shown in table 2.

Most of the cases, 38(71.7%) were atrophic nonunion while the remaining 15(28.3%) were hypertrophic non-union.

Forty-three cases (81.1%) had no previous infection at fracture site while 10cases (18.9%) had a history of previous infection at fracture site. None had active infection at the time of surgery. Forty three cases (81.1%) had bone grafting while 10 cases (18.9%) did not. Autogenous cancellous bone chips were used in all cases.

Complications following surgery occurred in 54.7% of cases. See table 3. Four of the cases of infection occurred in patients with prior history of infection at the fracture site. Joint stiffness occurred in 4 cases. Three occurred in the knee with range of motion of 0 20^{o}, 0 90^{o}, and 20^{o} 90^{o}, respectively while one occurred in the elbow with a range of motion of 0 90^{o}. One case of tibial fracture was recorded following the use of the tibia as a bone graft donor site. The one case of angulation occurred in the ulna in a patient with monteggia fracture dislocation who was treated by compression plating of the ulna and radial head excision. The patient had a 30^{o} posterior angulation but a good functional outcome. Limb shortening was recorded in 5 cases. These included one case of tibial shortening; and 4 cases of femoral shortening. The range of shortening was 3cm to 4cm.

Fifty two cases had satisfactory reduction in the immediate post operative X ray.

Osseous union was achieved in 44 cases (83%), while 9 cases (17%) failed to unite.

Age: Out of the 19 cases seen in the 42-53 years age category, 14(73.7%) united while 5(26.3%) failed to unite. The outcome in the other age categories is as shown in table 4. There was no statistically significant difference in union rate among the various age categories.

Sex: Twenty- four (80%) of the 30 male cases united while 6(20%) failed to unite; while 20(87%) of the 23 female cases united and 3(13%) failed to unite. There was no statistically significant difference between the two groups $P = 0.5$

Bone involved: Out of the 18 cases of humeral nonunion, 15(83.3%) united while 3(16.7%) failed to unite. The outcome in the other bones is as shown in

table 5. There was no statistically significant difference in the outcome of treatment among the various bones.

Type of nonunion: Thirty-three cases (86.8%) of the 38 cases of atrophic nonunion united while 5(13.2%) failed to unite. Also of the 15 cases of hypertrophic nonunion, 11(73.3%) united while 4(26.7%) failed to unite. P=0.24.

Use of bone graft: Of the 43 cases of nonunion in which bone grafting was used, 35 (81.4%) united while 8(18.6) failed to unite. Of the 10 cases in which bone grafting was not used, 9(90%) united while 1(10%) failed to unite. P = 0.5.

History of previous infection at fracture site: Of the 10 cases with history of previous infection at fracture site, 5(50%) united while the remaining 5(50%) failed to unite; and of the 43 cases with no history of infection, 39(90.7%) united while 4(9.3%) failed to unite. P = 0.002.

Table 1: **Age Distribution.**

Age category (yrs)	Frequency	Percentage (%)
18 – 29	14	26.42
30 – 41	12	22.64
42 – 53	19	35.85
54 – 65	8	15.09
Total	**53**	**100.00**

Table 2: **Bone Involved.**

Bone	Frequency	Percentage (%)
HUMERUS	18	33.96
RADIUS	2	3.77
FEMUR	17	32.08
TIBIA	11	20.75
ULNA	5	9.43
Total	**53**	**100.00**

Table 3: **Complications of Surgery.**

Complication	Frequency	(%)
Infection	7	13. 2
Shortening	5	9.4
Angulation	1	1.9
Joint stiffness	4	7.5
Recurrence of nonunion	9	17.0
Radial nerve palsy	1	1.9
Radioulna synostosis	1	1.9
Tibia fracture (Following use as a bone graft donor site)	1	1.9
None	24	45.3
Total	**53**	**100. 0**

Table 4: Treatment outcome versus age categories.

Treatment outcome	Age Categories (Years)				Total
	18 – 29	30 – 41	42 – 53	54 – 65	
Failed to unite	1(7.1%)	2(16.7%)	5(26.3%)	1(12.5%)	9(17.0%)
United	13(92.9%)	10(83.3%)	14(73.7%)	7(87.5%)	44(83.0%)
Total	**14(100.0%)**	**12(100.0%)**	**19(100.0%)**	**8(100.0%)**	**53(100.0%)**

Table 5: **Treatment outcome versus bone involved.**

Bone Involved	Treatment outcome		Total
	Failed To unite	United	
HUMERUS	3 (16.7%)	15 (83.3%)	18 (100.0%)
RADIUS	0 (0.0%)	2 (100.0%)	2 (100.0%)
FEMUR	2 (11.8%)	15 (88.2%)	17 (100.0%)
TIBIA	2 (18.2%)	9 (81.8%)	11 (100.0%)
ULNA	2 (40.0%)	3 (60.0%)	5 (100.0%)
Total	**9 (17.0%)**	**44 (83.0%)**	**53 (100.0%)**

DISCUSSION

The management of nonunion of long bones is a great challenge to both the orthopaedic surgeon and the patient.

In this study, 36 cases (56.6%) were males while 23 cases (43.4%) were females. This gave a male to female ratio 3:2. This is close to the result obtained by a number of other authors in the literature, most of whom reported a male preponderance [8, 9,] Rubel et al [6] however observed a female preponderance in their work on humeral nonunion.

The age distribution ranged from 19 years to 64 years with a mean age of 39.7 years. This compares with other reports [8, 10,]

Majority of the patients (64.2%) presented between 6 and 18 months of the injury. The time interval between injury and presentation however ranged from 6 months to 132 months with a mean of 19.98 months. This compares closely with works done elsewhere [6, 7, 11].

The commonest bone involved was the humerus (34%), followed by the femur (32.1%), the tibia (20.8%), the ulna (9.4%), and the radius (3.8%). This is in contrast to the often-reported preponderance of the tibia, followed by the femur [9, 12.] The reason for this difference is not clear from the study.

Most of the cases 38(71.7%) were atrophic nonunion. This conforms to the findings of most authors [10, 11]. Babhulkar et al[12] however reported a preponderance of hypertrophic nonunion.

All cases were managed by compression plating. The choice of this treatment option is at variance with the work of most authors in the literature [8, 10,] It has been argued that the extensive dissection involved in plate fixation will cause soft tissue and bone de-vascularization thus further worsening the precarious vascularity at the fracture site in atrophic nonunion. Thus the use of reamed intramedullary nailing is advocated in atrophic nonunion. This in addition to minimizing soft tissue dissection also releases the reaming products, which act as a bone graft at the fracture site [13]. Generally, however the trend now is towards disturbing the tissues as minimally as possible [8, 10]. Thus whether in hypertrophic or atrophic nonunion, the use of intramedullary nailing, especially closed nailing is advocated [8, 10,]. Some authors however believe in the use of compression plating in the management of both atrophic and hypertrophic nonunion [13, 14].

Forty-four cases (83%) united while 9 cases (17%) failed to unite. There was no statistically significant difference in union among the various bones. This finding is comparable to works done elsewhere. Kumar et al[16] in their work observed a union rate of 91%. Rubel et al[6] had a union rate of 92% in their study on humeral nonunions while Ring et al[7] had a union rate of 98% in their study on complex nonunion of the femoral shaft. Similar result was recorded by a number of other authors [17,]

It was observed that the history of previous infection at fracture site is a poor prognostic factor in the treatment of nonunion. Only 50% of these cases united as against the 83% over-all union rate (P = 0.002). The other factors considered did not significantly affect the outcome in terms of union, viz patient's age and sex, type of nonunion, use of bone grafting, time interval before presentation, and bone involved.

CONCLUSION

Treatment of nonunion in long bones at the National Orthopaedic Hospital, Enugu by open reduction and internal fixation produced osseous union in 83% of cases, which is comparable to results achieved elsewhere. The commonest bone involved in nonunion in this centre was the humerus, followed by the femur, the tibia, the ulna, and the radius. There was no statistically significant difference in the incidence of osseous union among the various bones.

Previous infection at the fracture site was a poor prognostic factor to union in cases of nonunion treated by compression plating.

The age and sex of the patients, the type of nonunion, the use of bone grafting, and the time interval between injury and presentation did not significantly affect osseous union.

ACKNOWLEDGEMENT

My gratitude goes to Dr U N Enweani for his advice and the consultants at the National Orthopaedic Hospital, Enugu who allowed me to use their patients in the study.

REFERENCES

1. **March JL, Buckwalter JA, Evans CC.** Delayed union, Nonunion, Malunion, and Avascular Necrosis. In: Charles HE editor. Complications in Orthopaedic surgery. 3rd ed. Philadelphia: JB Lippincott; 1994; p183-211.

2. **Mckibbin B.** The Biology of Fracture Healing in Long Bones. J Bone & Joint Surg. 1978; 60B (2): 150-161.

3. **Solomon L, Warwick D, Nayagam S.** Principles of Fractures. In Apley's System of Orthopaedic and Fractures, 8th ed. London: Arnold; 2001; p539-582.

4. **Chapman MW.** Principles of Treatment Nonunion and Malunions. In Chapman MW editor. Chapman's Orthopaedic Surgery, 3rd ed. (ON CD-ROM). Philadelphia: Lippincott, Williams, and Wilkins; 2001.

5. **Perren SM.** Physical and Biological Aspects of Fracture Healing with Special Reference to Internal Fixation. Clinic Orthop. 1979; 138: 175-176.

6. **Rubel IF, Kloen P, Campbell D, Schwartz M, Liew A, Myers E, et al.** Open Reduction and Internal Fixation of Humeral Nonunion. J Bone Joint Surg. 2002; 84A (8): 1315-1322.

7. **Ring D, Jupiter JB, Sanders RA, Quintero, J, Santoro MV, Ganz R, et al.** Complex Nonunion of Fractures of the Femoral Shaft Treated by Wave Plate Osteosynthesis. J Bone Joint Surg. 1997; 78 (2): 289-294.

8. **Beredjikhian PK, Naranja RJ, Heppenstall RB, Brighton CJ, Esterhai JL.** Result of Treatment of 111 Patients with Nonunion of Femoral Shaft Fractures. The University of Pennsylvania Orthopaedic Journal (online). 1999; 12:52-54. Available from URL http://www.uphs.upenn.edu/ortho/oj/1999/htm1/oj12sp99p52.htm.

9. **Wilkins RM, Chimenti BT, Rifkin RM.** Percutanous Treatment of Long Bone Nonunions : The use of Autologous Bone Marrow and Allograft Bone Matrix (online) (access 2005 March). Available from URL http://www.orthobluejournal.com/supp/0503/wilkins1.asp.

10. **Chi-Chuan W, Wen-Jen C.** A Revised Protocol for More Clearly Classifying Nonunion. J Orthop Surg. 2000; 81(A): 45-22. (online) (access 2005 March). Available from URLhttp://www.josonline.org/PDF/v8:1p45.pdf.

11. **Rosen R.** Compression Treatment of Long Bone Pseudoarthrosis. Clinic Orthop. 1979; 138: 154-166.

12. **Babhulkar S, Pande K, Babhulkar S.** Nonunion of The Diaphysis of Long Bones. Clinic Orthop. 2005; 431: 50-56.

13. **Wojcik K, Gazdzik TS, Jaworski JM, Gajda T.** Locked Intramedullary Nailing in Treatment of Femur and Tibia Delayed Union and Pseudoarthrosis. Chir Narzadow Ruchu Orthop Pol. 2004; 69(2): 91-95.

14. **Barguet A, Fernadex A, Luvizio L, Masliah R.** A Combined therapeutic protocol for aseptic nonunion of the humeral shaft. J Trauma. 1989; 29(1): 95-98.

15. **Patel M, McCathy, J.** Tibial nonunions (online) (access 2005 May) Available from URL http://www.eMedicine.com/ortho/Tibianonunion.htm.

16. **Kumar A, Sadiq SA.** Nonunion of the Humeral Shaft Treated by Internal Fixation. Int Orthop. 2002; 26(4). Epub 2002 April.

17. **Zaslav KR, Meinhard BP.** Management of Resistant Pseudoarthrosis of Long Bones. Clin Orthop Relat Res. 1998; 233:234-242.