Study of clinical and radiological outcome of augmentation plating with or without bone grafting in nonunion fracture of long bone with IMN in situ

DIWAKAR VIKRAM SINGH, RAMDHAN NARANIA, ANAND GUPTA, HARSHIT JAIN

Department of Orthopaedics, Krishna Mohan Medical College and Hospital, Mathura, Uttar Pradesh, India

© J ORTHOP TRAUMA SURG REL RES

19(9)2024

Research

Address for correspondence:

Dr. Diwakar Vikram Singh, Junior Resident, Department of Orthopaedics, Krishna Mohan Medical College and Hospital, Mathura, Uttar Pradesh, India

diwakar.singh13@gmail.com

Statistics

Figures	04
Tables	02
References	23

Received: 16.9.2024; Manuscript No. jotsrr-24-148072; Editor assigned: 22.9.2024, PreQC No. jotsrr-24-148072 (PQ); Reviewed: 29.9.2024, QC No jotsrr-24-148072 (Q); Revised: 20.10.2024, Manuscript No. jotsrr-24-148072 (R); Published: 30.10.2024, DOI.10.37532/1897-2276.2024.19(9).92

Abstract

Objectives: This study aims to study the outcome of plate augmentation with or without bone grafting in long bone non-unions with IMN in situ.

Design: Prospective clinical study with 9 months of follow-up.

Methods: Clinically proven 30 patients with atrophic or oligotrophic nonunion long bone fractures were included in study according to inclusion and exclusion criteria after getting written and informed consent, treated by augmentation plating with or without bone grafting. Patient progress was monitored at regular intervals through X-ray examinations and clinical evaluation with the Wu scoring system.

Result: Out of 30 patients, 29 patients achieved bony union at an average time of 4.9 months (range: 3.5 to 7 months), as assessed by Wu's score. The outcomes were rated as excellent in 9 cases (30%) and good in 13 cases (44%), and 7 cases showed fair result, with 1 persistent nonunion.

Conclusion: Augmentation plating with or without bone grafting provide a safe and reliable method of effective treatment of nonunited long bone fractures.

Keywords: Non-union fracture; Augmentation plating; Bone grafting; Wu criteria

INTRODUCTION

"Nonunion (NU) is defined as incomplete healing within 9 months of injury or no evidence of healing on successive radio graphs over 3 months" [1-3]. The Danish Orthopedic Trauma Society defines nonunion as "a fracture that will not heal without further intervention"[4]. There are number of fractures which can lead to nonunion. It includes cause related to patient and that to fracture fixation. Factors related to patient includes old age, systemic illness, osteoporosis, smoking, alcohol, etc [5]. Whereas related to fracture fixation includes distraction at fracture site, compression at fracture site, viability of fracture fragments and inadequate immobilization and adequate reduction [6]. Fracture healing is a complex physiological process involving a coordinate interaction of hematopoietic and immune cell within the bone marrow in conjunction with vascular and skeletal cell precursor. It requires a precise balance of biological stabilization during the healing process. In some circumstances, this process does not go as expected, and healing does not occur without adequate intervention. Achieving successful fracture healing necessitates a delicate balance of biological and mechanical factors, supported by four essential pillars: stability, osteogenic cells, scaffolding, and growth factors. However, in certain instances, this intricate process is disrupted, and additional interventions are required to facilitate healing.

The nonunion of long bones presents a persistent and challenging issue for surgeons, impacting treatment efficiency in terms of cost and time. This condition significantly affects patients' social, financial, physical, and mental well-being, with complications including soft tissue loss or bone loss, decrease bone density, stiffness of the adjacent bone, deformity, and limb length discrepancies [5]. Notably, approximately two hundred cases of long bone nonunion occur annually per million people, highlighting the need for effective management strategies [7]. Despite advances in surgical techniques and implant designs, nonunion remains a challenging problem, with reported rates ranging from 2% to 20%. The treatment of non-union fractures of long bones employs a diverse range of modalities, offering a variety of options to address this challenging condition [8]. Nail removal followed by internal fixation with a plate and screws, reamed and exchange nailing, retaining the nail and plate augmentation1 stable fixation with or without bone grafting, dynamization of the nail, and Ilizarov external fixation [9-13].

AUGMENTATION PLATING

Augmentation plating has emerged as a promising solution, involving the addition of supplementary plates or fixation devices to enhance stability and promote union. The addition of a compression plate and screws, with or without supplemental bone grafting, known as plate augmentation, has been established as a viable and effective treatment strategy for addressing nonunion, this technique optimizes the bio-mechanical conditions at the fracture site while minimizing further biological disruption [14]. It enables the surgeon to meticulously clean the fracture site, removing fibrous tissue and revitalizing the fracture ends, which can stimulate healing. Additionally, it offers the option for direct bone grafting, allowing the surgeon to tailor the treatment to the individual case.

Augmentation plating provide proper stabilization, reduces chances of rotational instability and mechanical stimulation. The cortical alignment of bone due to intramedullary nailing. Bone graft will fill the gap and enhance the bone healing process. These plates can also be used to supplement an existing intramedullary nail, providing rotational stability and enhancing the chances of successful union [15-18]. Open plating offers a direct approach to the fracture site, facilitating comprehensive debridement, decortication, and bone grafting, which are essential steps in promoting a healthy environment for bone healing and union [19]. By supplementing the nail with a plate, rather than revising the nail entirely, patients can benefit from early controlled weight-bearing, reducing the need for prolonged immobilization and accelerating the rehabilitation process [20, 21].

MATERIAL AND METHODS

The study was conducted on 30 patients with nonunion of long bones at the Department of Orthopedics, Krishna Mohan Medical College Mathura. It was a prospective study with the duration of the study being 18 months. Patients aged between 18 years-70 years of either sex were included in the study. The patients who had clinical and radiological signs of nonunion were included in the study. Patients with <18 years and infected nonunion were excluded from the study. The study design was discussed with every selected patient and his/her written consent was taken prior to commencement of the study. Patients were evaluated with Wu criteria and standard AP and lateral X-ray views.

SURGICAL TECHNIQUE: AUGMENTATION PLATING WITH OR WITHOUT BG

Femoral fracture nonunion:

Eight cases of femoral fracture nonunion were treated using the lateral approach. A longitudinal incision on the thigh exposed the vastus lateralis muscle, followed by careful incision of the ilio-tibial band. Two Hohmann retractors were inserted to expose the femoral shaft. The vastus lateralis was split, revealing the lateral femoral surface. Nonunited bone ends were refreshed and debrided, with fibrous tissue removed and the gap filled with bone graft. A plate was placed on the lateral femur, secured with screws around the intramedullary nail. This approach enabled effective treatment of femoral fracture nonunion (Fig. 1a-1c).

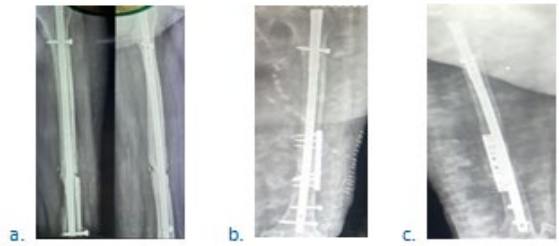

Fig. 1. (a)-showing femur non union with IMN in situ. (b)-showing after augmentation of the fracture with plate. (c)-bone graft.

Tibial fracture nonunion:

Twelve cases of tibial fracture nonunion underwent surgical treatment via medial and lateral approaches. A longitudinal incision allowed for periosteal stripping and muscle retraction, exposing the bone surface. The nonunion site was refreshed using decortication with osteotome and hammer, removing fibrous tissue. The fracture gap was filled with bone graft. A plate was placed on the lateral tibia, secured with screws around the intramedullary nail. This technique enabled effective treatment of tibial fracture nonunion. The dual approach allowed for comprehensive exposure and stabilization of the fracture site, promoting optimal bone healing and union. The procedure showcased a reliable method for addressing challenging tibial nonunions. (Fig. 2a and 2b).

Fig. 2. (a)-Post op after augmentation plating with bone grafting. (b)- Follow-up X-ray after 6-months showing complete union of the fracture.

Humerus fracture nonunion:

Ten cases of humeral nonunion were treated surgically using anterior or posterior approaches. The nonunited humerus was stabilized with a plate placed over the affected area, secured with screws around the intramedullary nail. Bone ends were refreshed and the gap filled with graft. This technique effectively promoted union and recovery in the humerus, addressing challenging nonunions (Fig. 3a-3c).

Fig. 3. (a)-Posterior approach humerus plating. (b)- Distal humeral ununited fracture with intramedullary nail in situ. (c)- showing humerus after augmentation plate and bone graft.

In 28 out of 30 cases, iliac bone grafts were successfully implanted within the nonunion gap, followed by intraoperative fluoroscopy to confirm optimal plate and screw placement. The screws were securely tightened over the graft before closing the wound in layers, ensuring a stable and precise repair. Dynamic compression was induced at the nonunion site by axial compression using eccentric placed screws (DCP). LCP was also used in 3 cases for augmentation. Small DCP were done in 12 cases, one third tubular was done in 13 cases. In 2 cases T-plate was used in augmentation.

Postoperative care:

Immediate postoperative x-ray was done in both AP and lateral views to check the position of the plate, screws, and bone graft and ensure good fixation of nonunion site. Patients were discharged from the hospital after removal of the suction and improvement of the wound. IV antibiotics and analgesics were given for five days post operatively.

Follow-up:

Patients will undergo regular post-operative follow-ups at 1 week, 1 month, 3 months, 6 months, and 9 months to monitor their progress. The Wu criteria will be applied at the final follow-up to evaluate patient outcomes across five critical domains: pain, range of motion, independence to walk, residual deformity and bone healing. Radiological criteria is also used to analyse the union of bones.

RESULTS

Final result according to radiological and Wu criteria shows, 97% of cases had achieved union. Residual deformity was present in 3% of case. 97% of cases were able to walk independently. Normal range of motion was seen in 83% of

cases. No residual pain in 90% of cases (Fig. 4, Table 1).

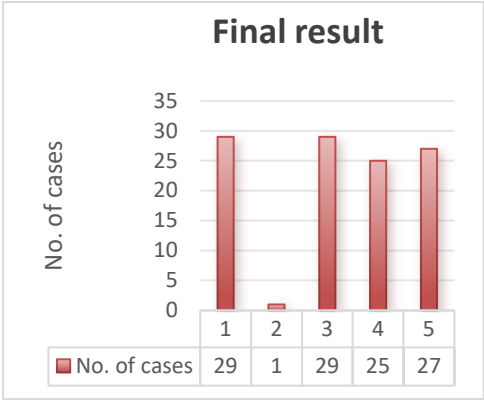

Fig. 4. Final result (Wu-criteria)

Table 1. Final result (n=30)

S No.	Final Result	No. of Cases	%
1	Union achieved	29	97
2	Residual deformity	1	3
3	Independence to walk	29	97
4	Normal range of motion	25	83
5	No pain	27	90

In this study, successful cases were defined as patients who achieved bone union by the end of the follow-up period. Thirty percent of patients (9 out of 30) achieved excellent bone union, indicating a highly successful outcome in nearly one-third of the study group, 13 patients had good union (44%), fair union is seen in 7 patients (23%). 1 patient who was chronic smoker and poor nutrition underwent nonunion (3%), with poor Wu score (Table 2).

Table 2. Union achieved (Wu criteria)

S No	Union (Wu criteria)	No of cases	%
1.	Excellent union	9	30
2.	Good union	13	44
3.	Fair	7	23
4.	Poor	1	3

DISCUSSION

Managing non-union fractures of long bones poses a significant challenge for orthopedic surgeons, requiring expertise, precision, and a comprehensive treatment approach to achieve successful outcomes. The treatment of non-union fractures of long bones employs a diverse range of modalities, offering a variety of options to address this challenging condition. Nail removal followed by internal fixation with a plate and screws, reamed and exchange nailing, retaining the nail and plate augmentation1 stable fixation with or without bone grafting, dynamization of the nail, and Ilizarov external fixation.

30 cases of nonunion of long bones were treated with augmentation plating with or without bone grafting in our study in the department of orthopaedics, K. M. medical college, Mathura from May 2022 to November 2023.

A union rate of 97% was observed at the conclusion of the follow-up period in our study. Overall, 97 % of cases can be termed as successful cases. 3% (n=1) cases who had been termed as failure in our study, did not achieved union after surgery and regular follow up (Table 1). Similarly in a study done by Park J, Kim SG *et al.* (2010) [20]. The nonunion rate was significantly higher in the EN group, with 5 out of 7 cases (72%) failing to achieve union, whereas the AP group achieved a 100% union rate, with all 11 pseudarthroses successfully obtaining osseous union. Ulliana *et al.* (2021), at an average follow-up of 23.5 months, 86% of patients (19/22) achieved bone union following augmentation plating [22]. Gelalis I.D. *et al.* (2012), 70 out of 70 patients (100%) experienced a union after plate augmentation plating with bone grafting Hakeos *et al.* [23]. All 7 patients (100%) shows union treated with AP with bone grafting.

In our study 9 patients (30%) had excellent union, 13 patients had good union (44%), fair union is seen in 7 patients (23%). 1 patient underwent nonunion (3%), with poor Wu score. These results are in agreement with Ulliana CS *et al.* (2021) where 8 patients showed excellent union and 14 patient showed good union.

CONCLUSION

Augmentation plating is an excellent solution for the management of nonunited nailed long bone fractures with or without BG, especially with instability at nonunion site. AP showed higher union rate with an advantage of early weight bearing and early mobilization.

REFERENCES

1. *Vaishya R, Agarwal AK, Gupta N, et al. Plate augmentation with retention of intramedullary nail is effective for resistant femoral shaft non-union. J Orthop. 2016 ; 1;13(4):242-5.*
2. *Bell A, Templeman D, Weinlein JC. Nonunion of the femur and tibia: an update. Orthop Clin. 2016 ;1;47(2):365-75.*
3. *Smith WR, Morgan SJ. Failure of internal fixation of the femoral shaft. Tech Orthop. 2002 ;1;17(4):448-57.*
4. *Schmal H, Brix M, Bue M, et al. Nonunion–consensus from the 4th annual meeting of the Danish Orthopaedic Trauma Society. EFORT Open Rev. 2020 ;3;5(1):46-57.*
5. *RAY RD, Sankaran B, FETROW KO. Delayed union and non-union of fractures. JBJS. 1964; 1;46(3):627-43.*
6. *Tsang ST, Mills LA, Baren J, et al. Exchange nailing for femoral diaphyseal fracture non-unions: risk factors for failure. Injury. 2015;1;46(12):2404-9.*
7. *Gardner MJ, Toro-Arbelaez JB, Harrison M, et al. Open reduction and internal fixation of distal femoral nonunions: long-term functional outcomes following a treatment protocol. J Trauma Acute Care Surg. 2008 ; 1;64(2):434-8.*
8. *Chiang JC, Johnson JE, Tarkin IS, et al. Plate augmentation for femoral nonunion: more than just a salvage tool? Arch Orthop Trauma Surg. 2016;136:149-56.*
9. *Jhunjhunwala HR, Dhawale AA. Is augmentation plating an effective treatment for non-union of femoral shaft fractures with nail in situ? Eur J Trauma Emerg Surg., 2016;42:339-43.*
10. *Hak DJ, Lee SS, Goulet JA. Success of exchange reamed intramedullary nailing for femoral shaft nonunion or delayed union. J Orthop Trauma. 2000 ; 1;14(3):178-82.*
11. *Litrenta J, Tornetta III P, Vallier H, et al. Dynamizations and exchanges: success rates and indications. J Orthop Trauma. 2015 ; 1;29(12):569-73.*
12. *Menon DK, Dougall TW, Pool RD, et al. Augmentative Ilizarov external fixation after failure of diaphyseal union with intramedullary nailing. J Orthop Trauma. 2002 ; 1;16(7):491-7.*
13. *Park KC, Oh CW, Kim JW, et al. Minimally invasive plate augmentation in the treatment of long-bone non-unions. Arch Orthop Trauma Surg. 2017;137:1523-8.*
14. *Weber BG, Cech O. Pseudarthrosis: pathophysiology, biomechanics, therapy, results. InPseudarthrosis: Pathophysiol Biomech Ther Results. 1976 (pp. 323-323).*
15. *Marti RK, Verheyen CC, Besselaar PP. Humeral shaft nonunion: evaluation of uniform surgical repair in fifty-one patients. J Orthop Trauma. 2002 ; 1;16(2):108-15.*
16. *Ring DA, Jupiter JB, Sanders RA, et al. Complex nonunion of fractures of the femoral shaft treated by wave-plate osteosynthesis. J. Bone Jt. Surg. Br. Vol. 1997 ; 1;79(2):289-94.*
17. *Ring D, Jupiter JB, Quintero J, et al. Atrophic ununited diaphyseal fractures of the humerus with a bony defect: treatment by wave-plate osteosynthesis. The Journal of Bone & Joint Surgery British Volume. 2000 ; 1;82(6):867-71.*
18. *Gerber A, Marti R, Jupiter J. Surgical management of diaphyseal humeral nonunion after intramedullary nailing: wave-plate fixation and autologous bone grafting without nail removal. J Shoulder Elb Surg.2003 ; 1;12(4):309-13.*
19. *Park J, Kim SG, Yoon HK, et al. The treatment of nonisthmal femoral shaft nonunions with im nail exchange versus augmentation plating. J Orthop Trauma. 2010 ; 1;24(2):89-94.*
20. *Khairy HM. Plate augmentation leaving the nail in situ and bone grafting for the treatment of nonunited diaphyseal fractures. Egypt Orthop J. 2016 ; 1;51(4):297-302.*
21. *Uliana CS, Bidolegui F, Kojima K, et al. Augmentation plating leaving the nail in situ is an excellent option for treating femoral shaft nonunion after IM nailing: a multicentre study. Eur J Trauma Emerg Surg. 2021;47:1895-901.*
22. *Gelalis ID, Politis AN, Arnaoutoglou CM, et al. Diagnostic and treatment modalities in nonunions of the femoral shaft. Rev Inj. 2012 ; 1;43(7):980-8.*
23. *Hakeos WM, Richards JE, Obremskey WT. Plate fixation of femoral nonunions over an intramedullary nail with autogenous bone grafting. J Orthop Trauma. 2011 ; 1;25(2):84-9.*