RESEARCH ARTICLE

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 16, Issue, 06, pp.331-336, June 2025

International Journal of Recent Scientific Research

ISSN: 0976-3031

Subject Area :Orthopaedic Surgery

RESTORING UNION IN HUMERAL SHAFT NON UNION USING FIBULAR GRAFTS AND LOCKING PLATES : A PROSPECTIVE STUDY

Rituj Agarwal and Prajwal M C

Department of Orthopaedics, King George's Medical University

DOI: http://dx.doi.org/10.24327/ijrsr.20251606.0064

ARTICLE INFO

Article History:

Received 14th May 2025
Received in revised form 28th May 2025
Accepted 14th June 2025
Published online 28th June 2025

Key words:

Humeral non-union, non-vascularized fibular graft, locking compression plating, DASH score, surgical outcomes, complications.

ABSTRACT

Introduction: Humeral non-union, which can occur in conservatively treated fractures and surgically managed cases, presents significant challenges. Combining non- vascularized fibular autografts (NVFG) with locking compression plates (LCP) may offer a reliable method for achieving bone union and restoring function in such patients. Therefore, this study aims to evaluate the functional outcomes of autologous NVFG and LCP for failed fixation of humeral shaft with atrophic gap non-union. **Methodology:** This prospective study included 17 patients treated for humeral fracture nonunion, with a minimum follow-up of 24 months. Clinical evaluation included preoperative and postoperative Disabilities of the Arm, Shoulder, and Hand (DASH) scores, while radiographic union was monitored during follow-up. Surgical techniques involved harvesting fibular grafts, debridement, and fixation using LCP with NVFG. **Results:** The mean age of patients was 51.23 years, with a duration of nonunion averaging 13.53 months. Preoperative DASH scores averaged 61.18 ± 6.49, improving significantly to 27.76 ± 6.12 postoperatively ($p < 0.0001$). Radiological union was confirmed in all cases, with no pain reported at fracture sites. Two patients experienced surgical site infections, while one developed transient peroneal nerve palsy, indicating a low complication rate. **Conclusion:** The combination of NVFG and LCP for treating humeral shaft non-union with an atrophic gap resulted in excellent functional outcomes and high union rates. This technique is a reliable option for complex humeral non-union, offering effective structural support and significant functional recovery.

Copyright© The author(s) 2025,This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Humeral non-union is observed in fewer than ten percent of conservatively managed fractures and under thirty percent of those treated surgically. This discrepancy arises because nonoperative management is generally reserved for low-energy, stable fractures, while surgery is often needed for more complex, high-energy fractures. The surgical approach, involving implants and the risk of contamination, may also increase the likelihood of infection, contributing to non-union. [1,2]Managing humeral non-union requires a clear understanding of its cause and characteristics. [3] Although diaphyseal humeral non-unions are typically atrophic, they often respond well to stable compression plating combined with bone grafting. [4] However, open fractures or those with significant bone loss are more prone to develop resistant non-union. [5] Additionally, repeated surgical attempts can result in recalcitrant non-union, which occurs after at least three failed surgeries, due to factors such as de-vascularized bone, fibrosis, sclerotic bone ends, and potential infection. [6]Previous implant use may further complicate treatment by causing cortical defects and stress shielding, making fixation more challenging. Several surgical options have been suggested for these cases, including locked compression plating (LCP), dual plating, exchange nailing, or distraction-compression techniques using an Ilizarov fixator with bone grafts. [7,8] Vascularized bone grafts (VBG) are recommended in cases with significant bone loss or infection, though they require specialized microsurgical skills. [9]Alternatively, non-vascularized fibular auto grafts (NVFG) can be used after thorough debridement to fresh bone, providing stable fixation through quadricortical screw purchase. [10] The combination of LCP with ANVFG raises the question: can this approach reliably achieve bony union and satisfactory function in cases of resistant humeral shaft nonunion? Thus, this study aims to

*Corresponding author: **Dr. Prajwal M C**

Department of Orthopaedics, King George's Medical University

evaluate the outcomes of using autologous NVFG with LCP in treating failed humeral shaft fractures with atrophic gap nonunion.

MATERIAL AND METHODS

Study Design, Sample Size, and Duration: This prospective study was done in Department of Orthopaedics, King George's Medical University, Lucknow. A total of 17 patients were included, who were treated for humeral fracture nonunion between 2022 and 2024. The study spanned a minimum follow-up period of 24 months postoperatively. Patients were identified through institutional records and the surgeon's operative logbook.

Preoperative Data Collection: Preoperative data included patient demographics (age, gender) and clinical aspects such as previous surgeries, fracture characteristics, and duration of nonunion. All patients were assessed for functional impairment using the DASH score.

Surgical Technique: All surgeries were performed under general anaesthesia. The approach to the humerus was tailored based on prior surgical scars. One surgical team harvested a segment of the fibula from the ipsilateral leg using a lateral approach under tourniquet control, leaving at least 7 cm of fibula intact proximally and distally to minimize nerve injury risk. Grafts measured between 9 and 15 cm. Simultaneously, another surgical team removed the humeral hardware, performed neurolysis of the radial nerve, when necessary, debrided the fracture site, and recanalized the medullary canal using rigid reamers. The fibular graft was sized to fit the reamed humeral medullary canal and inserted as an intramedullary strut. Compression was applied with dynamic screws, and iliac crest autograft was placed at the graft-humerus interface. Fixation was achieved using a 10-holed 4.5 mm LCP. In all cases, at least two screws passed through the fibular graft for additional stability.

Postoperative Management and Follow-Up: Postoperatively, the limb was immobilized in a sling for four weeks. Active-assisted shoulder and elbow exercises were initiated four weeks after surgery. Patients were followed up at four-week intervals until radiological union was confirmed, followed by three-month intervals. The functional outcome was measured using the DASH score preoperatively and at the final follow-up.

Inclusion and Exclusion Criteria: Patients with complex humeral nonunion were included, defined as established non-union with a significant gap (minimum 5 mm), osteolysis at the screw-bone interface, and atrophic fracture ends. The exclusion criteria consisted of infected non-union and aseptic non-union following conservative treatment.

Statistical Analysis: Descriptive statistics were used to analyse patient demographics and clinical outcomes. Preoperative and postoperative DASH scores were compared using paired t-tests. Results were presented in figures and tables, with statistical significance set at $p < 0.05$.

RESULTS

Among 17 patients, the average age was 51.23 years, with a nearly equal gender distribution (47.06% male and 52.94% female). The duration of non-union prior to surgery averaged 13.53 months. [Table-1] In terms of socioeconomic status, the largest proportion of patients came from the lower middle class (35.29%), followed by the upper middle class (29.41%). [Figure-1].

Table 1. Patient Demographics and Clinical Characteristics

Characteristics (n=17)	N (%) or Mean ± SD
Age (years)	51.23 ± 7.34
Gender (Male/Female)	8 (47.06%) / 9 (52.94%)
Risk Factors	
Smoking	5 (29.41%)
Diabetes Mellitus	4 (23.53%)
Hypertension	3 (17.65%)
Osteoporosis	2 (11.76%)
Fibular Graft Length (cm)	11.45 ± 2.13
Duration of Non-union (months)	13.53 ± 6.41

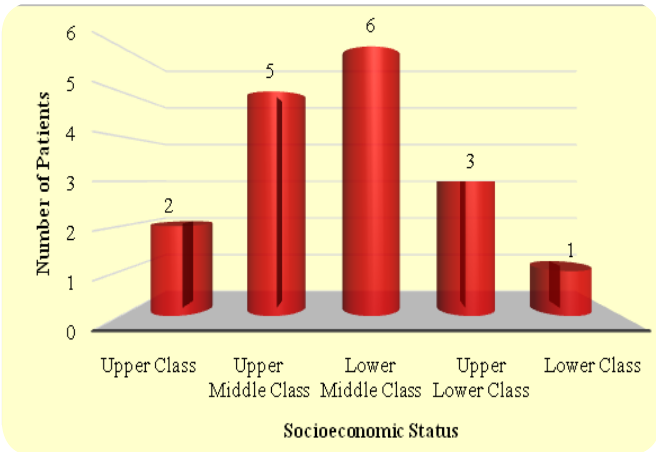


Figure 1. Socioeconomical status of patients included.

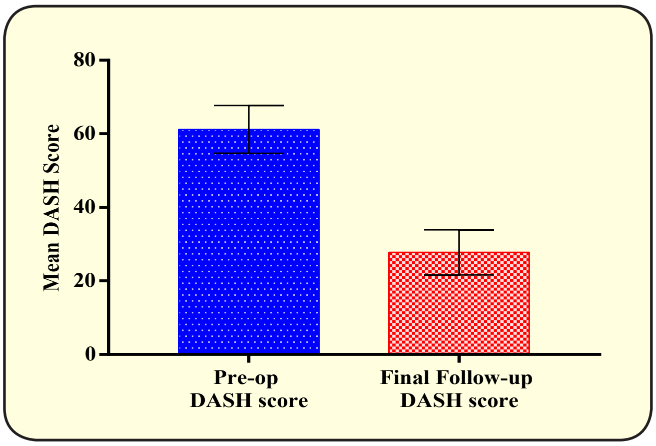


Figure 2. Pre- and Postoperative DASH Scores.

The preoperative DASH score, which measures disability and symptoms of the arm, was 61.18 ± 6.49, indicating substantial impairment before surgery. Postoperatively, the score improved to 27.76 ± 6.12, showing a significant functional recovery. [Figure-2] The statistical significance of this improvement is confirmed by the p-value ($p < 0.0001$), indicating a highly significant difference between pre- and postoperative scores. [Table-2]. Each patient was monitored for a minimum follow-up period of two years, with all cases showing both clinical and radiological healing.

Table 2. Pre- and Postoperative DASH Scores and Union Times.		
Characteristics (n=17)	Mean ± SD (Range)	P-Value
Pre-op DASH score	61.18 ± 6.49 (47.30-72.30)	t= 15.45 p<0.0001*
Final Follow-up DASH score	27.76 ± 6.12 (14.10-33.20)	
Improvement in DASH score	33.42 ± 8.38 (23.80-42.60)	
Time to Union (months)	4.29 ± 0.86 (3.00-6.00)	
*Significant		

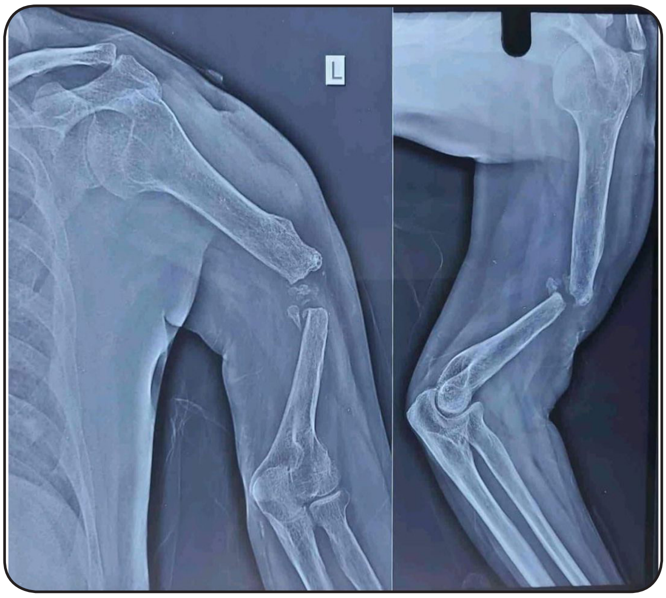
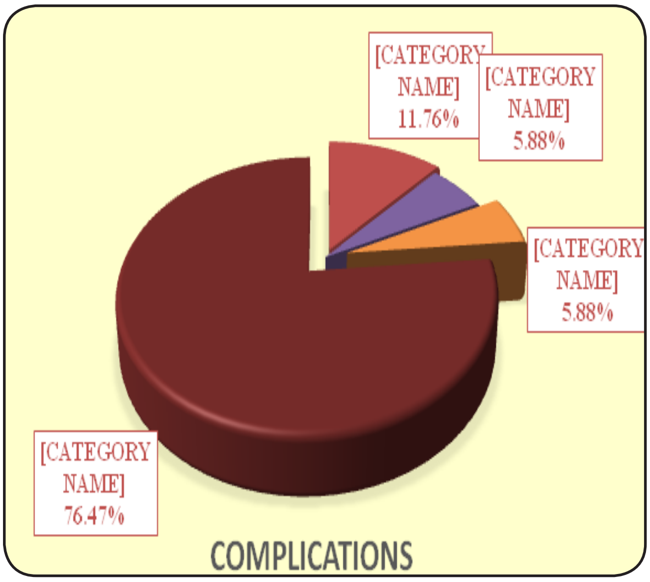


Figure 3. Preoperative radiograph showing atrophic nonunion of the left humeral shaft



Radiological union was determined by evidence of fracture healing in at least three of the four cortices on orthogonal X-ray images. [Figure-3] Notably, none of the patients experienced any pain at the fracture site throughout the follow-up period. Regarding complications, two patients experienced surgical site infections, one patient had a superficial infection, and one developed transient peroneal nerve palsy. Most patients had no complications, suggesting that the procedure is generally safe with a low rate of major complications. [Figure-4]

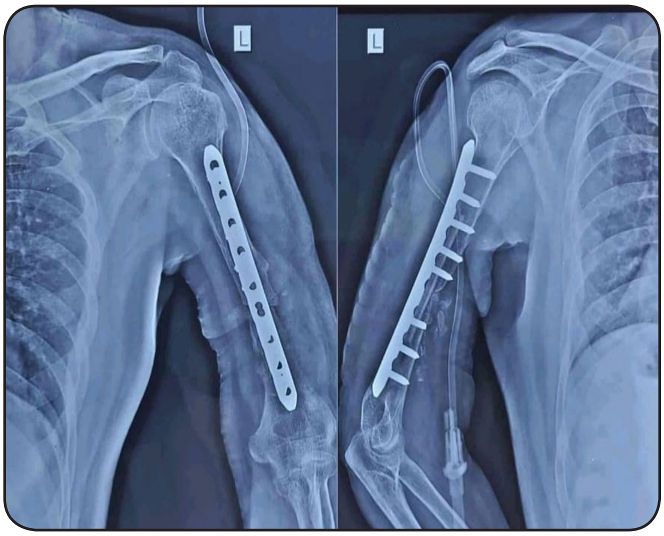


Figure 5. Immediate Post op X-ray

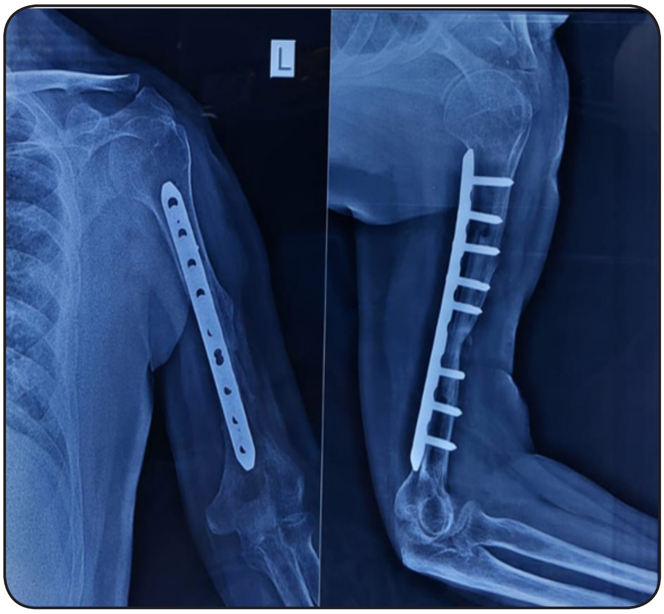


Figure 6. 6 Month follow up

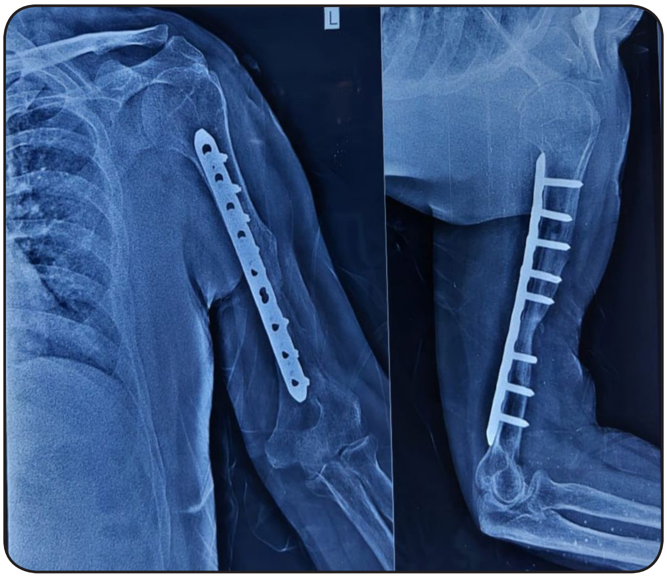


Figure 7. 12 month follow up

DISCUSSION

In this study, patients with atrophic gap nonunion and failed osteosynthesis faced reconstructive challenges due to local osteoporosis, implant failure, and cortical weakening. Several techniques, including plating, nailing, and bone grafting, have been explored for managing humeral nonunion with bone defects. [7,8] LCP was selected for fracture stabilization due to familiarity, while intramedullary nailing (IMN) was less favored for distal fractures because of its effect on rotator cuff integrity and need for imaging. [9] Bone transport via Ilizarov fixators, though effective, is limited by cost and technical complexity. [10,11]In this study, the average age of patients was 51.23 ± 7.34 years, with a majority being female. The most frequent risk factor was smoking (29.41%), followed by diabetes mellitus (23.53%), hypertension (17.65%), and osteoporosis (11.76%). In terms of socioeconomic status, the majority of patients were from the lower middle class (35.29%), followed by the upper middle class (29.41%). The average duration of nonunion before surgery was 13.53 ± 6.41 months. Similarly, Shetty K et al. [12] studied 12 patients with an average age of 50.7 ± 6.92 years, where most were female, and smoking and diabetes were prominent risk factors. The duration of nonunion in their study ranged from six months to three years. In contrast, Bandaru and Shanthappa [13] included 25 patients with a mean age of 33.32 ± 8.93 years, mostly male, and found diabetes and hypertension as common risk factors in 32% and 28% of cases, respectively. Various studies have highlighted that humeral shaft nonunion, especially in complex cases, is influenced by factors like fracture pattern, soft tissue interposition, and the quality of initial fixation [14], along with risk factors like smoking, obesity, alcohol use, and diabetes. [15] Sadek A et al. [16] studied 33 patients with a mean age of 40.3 ± 12.4 years and reported a predominance of males. Kale S et al. [17] included 10 patients with an average age of 46.9 ± 6.52 years, most of whom were male, and found the average nonunion duration since initial surgery to be approximately 1.2 years. In the present study, fibular grafts were used in all cases to enhance mechanical stability. The mean length of the fibular graft was 11.45 ± 2.13 cm, and an autologous iliac crest graft was added at the fracture site. No deliberate shortening was performed. In comparison, Shetty K et al. [12] reported fibular graft lengths ranging from 9-15 cm, while Kale S et al. [17] noted a mean graft length of 7.8 ± 1.8 cm. Similarly, Sadek et al. observed a graft length of 7.8 ± 1.8 cm. The concept of quadricortical plating using an intramedullary fibular strut graft was initially described by Wright TW [18] The NVFG is easy to harvest with minimal donor site morbidity and does not require microsurgical expertise. Although free NVFGs risk necrosis and resorption, immediate fixation to the recipient bone helps preserve the graft's osteogenic properties by allowing it to draw oxygen and nutrients from surrounding tissues. [19]The fibula, acting like a triflanged nail, provides immediate structural stability, making it a reliable donor bone for long-bone defects. [20] Despite concerns about limited vascularity affecting cortical bone graft incorporation, no resorption was observed in our cases. Compared to alternatives like allografts, bone transport, and BMPs, NVFG remains a cost-effective option, especially in settings with limited bone banking and micro surgical expertise. While its superiority over vascularized grafts is unproven, NVFG is a practical choice in resource-limited environments. The primary drawbacks include disruption of blood supply and potential, though minimal, donor site morbidity. [20,21]In this study, the preoperative DASH score averaged 61.18 ± 6.49, which significantly improved postoperatively to 27.76 ± 6.12. The mean DASH score improvement was 33.42 points, with union achieved in an average of 4.29 ± 0.86 months. The difference between pre- and postoperative scores was highly significant ($p<0.0001$*), and all patients, followed for a minimum of two years, demonstrated both clinical and radiological healing without any pain at the fracture site. Similarly, Shetty K et al. [12] reported a DASH score improvement from 61.0 ± 6.7 preoperatively to 28.8 ± 4.4 at final follow-up, showing a mean improvement of 32.23, with union achieved within 3-5 months. Kale S et al. [17] recorded a preoperative DASH score of 59.2 ± 7.3, improving to 24.6 ± 4.8, reflecting a mean change of 34.6, with union taking 7.2 ± 0.97 months. No pain was noted, and the average time to radiological union was seven months. Sadek A et al. [16] also found a significant improvement, with a mean postoperative DASH score of 7.7 ± 8.9 ($p<0.001$), and union occurred within 7.5 ± 2.6 months. Studies utilizing external fixators and autogenous bone grafting for distal humeral nonunion reported union times between 4.6-5.2 months. [22,23] Lawal Y et al. [24] and others demonstrated high union rates with non-vascularized fibular grafting, ranging from 80% to 88%, emphasizing its simplicity and effectiveness. [24,25] Bandaru and Shanthappa [13] observed a notable reduction in DASH scores at six weeks, three months, and six months (55.24 ± 10.721, 31.20 ± 9.097, and 11.88 ± 4.781, respectively), showing a significant improvement over time. In this study, two patients (11.76%) developed surgical site infections, with one patient (5.88%) experiencing a superficial infection and another (5.88%) suffering from transient peroneal nerve palsy. The majority of patients (76.47%) experienced no complications, indicating that the procedure is generally safe and associated with a low incidence of significant complications. According to Shetty K et al. [12], all patients were satisfied with their treatment, with only one case of superficial wound infection, which resolved with debridement and intravenous antibiotics. Another patient also developed transient peroneal nerve palsy, which showed improvement within seven weeks and fully resolved by six months. No morbidity was reported at the graft site during the final follow-up. Kale S et al. [17] noted negligible complications, reinforcing the technique's feasibility in resource-limited settings. Sadek A et al. [16] identified eight patients with postoperative complications; four had infections managed through serial debridement and antibiotic therapy based on culture and sensitivity results. One case required a two-stage reconstruction procedure involving primary radical debridement followed by a free vascularized fibular autograft (FVFG). A patient experienced transient radial nerve palsy, which resolved spontaneously within three months, while two others failed to achieve union after 24 months of follow-up and opted for continued bracing. Bandaru and Shanthappa [13] reported a 12% complication rate, including infections and nerve damage. Other complications associated with this technique included stress fractures, radial nerve palsy, iatrogenic splinters during implant removal, transient peroneal nerve injury, and adhesive capsulitis of the shoulder. [18,26,27] However, these minimal complications support this technique as a straightforward and dependable option.

CONCLUSION

In conclusion, the use of autologous nonvascularized fibula graft combined with locking compression plating for the management of failed fixation of humeral shaft nonunion with an atrophic gap demonstrated excellent functional outcomes and high rates of union. Patients showed significant improvement in arm function, as indicated by a substantial decrease in DASH scores postoperatively. The average time to union was 4.29 months, reflecting the efficacy of this approach in achieving bone healing. While complications such as surgical site infection and transient peroneal nerve palsy were observed in a minority of patients, the overall complication rate was low, and most patients recovered without major issues. This technique is a reliable and effective option for addressing complex humeral nonunion, providing both structural support and functional restoration. However, limitations of this study include its small sample size and retrospective design, which may limit the generalizability of the findings. Additionally, the lack of a comparison group restricts the ability to directly assess the technique's superiority over other methods. Future studies with larger cohorts, prospective designs, and randomized comparisons are recommended to further validate the effectiveness and long-term outcomes of this procedure.

Conflict of interest: All authors declare no conflict of interest.

Source of funding: None

Consent: As per international standards or university standards written participant consent has been collected and preserved by the authors.

Ethical approval: As per international standards or university standards written ethical permission has been collected and preserved by the author(s).

References

1. Garnavos C. Humeral shaft fractures. In: Court-Brown CM, Heckman JD, McQueen MM, Ricci WM, Tornetta P, editors. Rockwood and green fractures in adults, 1, 8th ed. Wolter Kluwer; 2015. p. 1287–340.
2. Harkin FE, Large RJ. Humeral shaft fractures: union outcomes in a large cohort. Journal of Shoulder and Elbow Surgery. 2017 Nov 1;26(11):1881-8.
3. Calori GM, Phillips M, Jeetle S, Tagliabue L, Giannoudis PV. Classification of non-union: need for a new scoring system?. Injury. 2008 Sep 1;39:S59-63.
4. Epps CH. Fractures of the shaft of the humerus. Fractures in adults. 1991:843-53.
5. Mulier T, Seligson D, Sioen W, Van dan Bergh J, Reynaert P. Operative traitment of humeral shaft fractures. Acta orthopaedicabelgica. 1997 Sep 1;63:170-7.
6. del Pino JG, del Valle EB, Graña GL, Villanova JF. Free vascularized fibular grafts have a high union rate in atrophic nonunions. Clinical Orthopaedics and Related Research®. 2004 Feb 1;419:38-45.
7. Badman BL, Mighell M, Kalandiak SP, Prasarn M. Proximal humeral nonunions treated with fixed-angle locked plating and an intramedullary strut allograft. Journal of orthopaedic trauma. 2009 Mar 1;23(3):173-9.
8. Brinker MR, O'Connor DP, Crouch CC, Mehlhoff TL, Bennett JB. Ilizarov treatment of infected nonunions of the distal humerus after failure of internal fixation: an outcomes study. Journal of orthopaedic trauma. 2007 Mar 1;21(3):178-84.
9. Soucacos PN, Kokkalis ZT, Piagkou M, Johnson EO. Vascularized bone grafts for the management of skeletal defects in orthopaedic trauma and reconstructive surgery. Injury. 2013 Jan 1;44:S70-5.
10. Wright TW, Miller GJ, Vander Griend RA, Wheeler DO, Dell PC. Reconstruction of the humerus with an intramedullary fibular graft. A clinical and biomechanical study. The Journal of Bone & Joint Surgery British Volume. 1993 Sep 1;75(5):804-7.
11. Hierholzer C, Sama D, Toro JB, Peterson M, Helfet DL. Plate fixation of ununited humeral shaft fractures: effect of type of bone graft on healing. JBJS. 2006 Jul 1;88(7):1442-7.
12. Shetty K, Cheppalli N, Kaki D. Autologous nonvascularized fibula graft and locking compression plating for failed fixation of humeral shaft with atrophic gap nonunion. Cureus. 2022 Apr;14(4):e24293.
13. Bandaru H, Shanthappa AH. Evaluation of Functional and Radiological Outcomes of Humeral Shaft Fracture Treated With Locking Compression Plate. Cureus. 2023 Apr;15(4):e37197.
14. Dimitriou R, Mataliotakis GI, Angoules AG, Kanakaris NK, Giannoudis PV. Complications following autologous bone graft harvesting from the iliac crest and using the RIA: a systematic review. Injury. 2011 Sep 1;42:S3-15.
15. Pascarella R, Ponziani L, Ferri M, Ercolani C, Zinghi GF. Aseptic nonunion of the humeral shaft. La Chirurgia Degli Organi di Movimento. 2000 Jan 1;85(1):29-34.
16. Sadek AF, Fouly EH, Allam AF, Mahmoud AZ. Non-vascularized fibular autograft for resistant humeral diaphyseal nonunion: Retrospective case series. Orthopaedics & Traumatology: Surgery & Research. 2021 Dec 1;107(8):102843.
17. Kale S, Vatkar A, Srivastava A, Baruah RR, Patnaik J, Shah V. Functional Outcomes of Gap Non-Union Humerus Fractures Treated with Fibular Strut Graft, Iliac Crest Graft, and Locking Compression Plate. Journal of Orthopaedic Case Reports. 2024 Sep 1;14(9):183-8.
18. Wright TW. Treatment of humeral diaphyseal nonunions in patients with severely compromised bone. Journal of the Southern Orthopaedic Association. 1997 Jan 1;6(1):1-7.
19. Yadav SS. The use of a free fibular strut as a "biological intramedullary nail" for the treatment of complex nonunion of long bones. JBJS Open Access. 2018 Jun 28;3(2):e0050.
20. Willis MP, Brooks JP, Badman BL, Gaines RJ, Mighell MA, Sanders RW. Treatment of atrophic diaphyseal humeral nonunions with compressive locked plating and augmented with an intramedullary strut allograft. Journal of orthopaedic trauma. 2013 Feb 1;27(2):77-81.
21. Kashayi-Chowdojirao S, Vallurupalli A, Chilakamarri VK, Patnala C, Chodavarapu LM, Kancherla NR, Syed AH. Role of autologous non-vascularised intramedullary fibular strut graft in humeral shaft nonunions following failed plating. Journal of clinical orthopaedics and trauma. 2017 Nov 1;8:S21-30.

22. Gaillard J, Masquelet AC, Boutroux P, Cambon-Binder A. Induced-membrane treatment of refractory humeral non-union with or without bone defect. Orthopaedics & Traumatology: Surgery & Research. 2020 Sep 1;106(5):803-11.
23. Pierreux PA, Moungondo F, Schuind FA. Treatment of supracondylar humeral non-union by bone autograft and Hoffmann II external fixation. Orthopaedics & Traumatology: Surgery & Research. 2020 Apr 1;106(2):371-6.
24. Lawal YZ, Garba ES, Ogirima MO, Dahiru IL, Maitama MI, Abubakar K, Ejagwulu FS. Use of non-vascularized autologous fibula strut graft in the treatment of segmental bone loss. Annals of African medicine. 2011;10(1):25-8.
25. Steinlechner CW, Mkandawire NC. Non-vascularised fibular transfer in the management of defects of long bones after sequestrectomy in children. The Journal of Bone & Joint Surgery British Volume. 2005 Sep 1;87(9):1259-63.
26. Bharadwaj V. Functional Outcomes Of Locking Compression Plate (Lcp) In Surgical Management Of Humerus Shaft Fractures. International Journal. 2022 Jan;5(1):804.
27. Farouk O, El-Sherif E, Mostafa K, Khalil A. Intramedullary fibular graft and quadricortical plate fixation in atrophic non-union of the osteoporotic humerus. Injury Extra. 2008 Apr 1;39(4):152-4.

How to cite this article:

Rituj Agarwal and Prajwal M C. (2025). Restoring Union in Humeral Shaft Non union using Fibular grafts and Locking plates : A Prospective study. *Int J Recent Sci Res*.16(06), pp.331-336.

****