

# Functional Outcomes of Gap Non-Union Humerus Fractures Treated with Fibular Strut Graft, Iliac Crest Graft, and Locking Compression Plate

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## Learning Point of the Article:

Learning point- For treating a gap nonunion of the humerus with failed osteosynthesis, using a locking compression plate (LCP) combined with a fibula strut graft and an iliac crest bone graft is considered a highly effective method. This approach is often regarded as a gold standard due to its ability to provide both structural support and biological enhancement for bone healing.

## Abstract

**Introduction:** The humeral shaft gap non-union treatment surgically after unsuccessful fixation is difficult. In this study, the functional outcome of unsuccessful fixation of humeral shaft gap non-unions using a locking compression plate (LCP), fibular strut graft, and iliac bone graft was evaluated.

**Case Report:** After taking ethical approval, we studied 10 patients with humeral shaft gap non-unions with unsuccessful surgical fixation treated with open reduction and internal fixation using LCP with fibular strut graft and iliac cancellous bone graft. The study duration was from January 2022–January 2024. The mean time from non-union was 7 months. Disabilities of the arm, shoulder, and hand (DASH) scores improved significantly from a pre-operative average of  $59.2 \pm 7.3$  to a mean final score of  $24.6 \pm 4.8$  reflecting a mean improvement of 34.6 with no complications.

**Conclusion:** This study shows that LCP with fibular strut graft and iliac bone grafts is a good alternative for diaphyseal humerus gap non-union along with statistically significant improvement in functional outcome, with union seen in all cases. This construct augments biomechanical stability and good biological healing in these gap non-unions.

**Keywords:** Humeral fracture, non-union, locking compression plating, humerus, fibular strut graft.

## Introduction

Gap non-union of the shaft of the humerus fractures can be difficult to treat, particularly when standard bone healing techniques fail. Complicating variables such as implant loosening caused by disuse osteoporosis, osteolysis, comminution, or severe bone depletion make therapy even more challenging [1].

Several treatment options have been documented, including

open reduction and internal fixation using dynamic compression plate, locking compression plate (LCP), intramedullary interlocking nail, and external fixation. However, getting successful results remains difficult, especially when stability is impaired due to implant loosening or bone quality concerns [1].

Fibular strut grafting, when paired with plating, appears to be a promising treatment for humerus gap non-union. This treatment improves stability and biological support for gap non-unions in

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**Figure 1:** Pre-operative status - X-ray and clinical photograph.



**Figure 2:** X-ray after plate removal.

long bone fractures when compared to traditional procedures [2,3].

Furthermore, autologous bone grafts remain the “gold standard,” with the iliac crest being the most often harvested region [4].

Our study aims to investigate the efficacy of using a non-vascularized fibular strut graft in conjunction with autologous iliac crest bone graft and locking compression plating to treat humerus shaft gap non-unions caused by failed previous fixations.

### Case Report

Approval from the ethics committee was taken from D.Y. Patil Hospital (Number-265), Nerul, Navi Mumbai for our study. Informed consent was taken from all patients. Data were collected retrospectively from the institute for a period of 2

years from January 2022 to January 2024 for operated cases of gap non-union of humerus fracture with failed primary osteosynthesis. Inclusion criteria were non-union humerus with a significant gap (>4 mm), age >18 years, and non-union duration of >1 year (Fig. 1). Exclusion criteria were cases with infection, congenital abnormalities, compound fractures, and patients with neuropathic diseases.

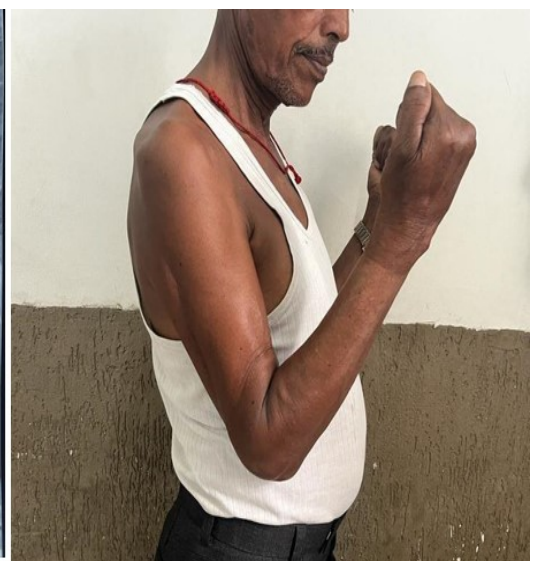
As there was a gap non-union and instability at the fracture site, intramedullary stability was given by autologous fibular strut graft along with iliac crest cancellous graft in addition to LCP. We selected the same side fibula for cortical strut graft to provide added stability and iliac crest graft for osteo-induction at the site of fracture with LCP. Clinical and radiological follow-up was done for all 10 patients regularly with no loss of follow-up.



**Figure 3:** Fibular strut graft harvested intraoperatively.



**Figure 4:** Post-operative status X-ray showing union and function assessment.







**Figure 5:** Post-operative range of motion.

### Surgical techniques

All cases were operated on under supra-clavicular block and general anesthesia. Regional anesthesia was given for post-operative pain analgesia. There were two teams operating simultaneously to save time. One team harvested the ipsilateral fibula as the patient was in a lateral position and the other team was operating on the humerus non-union site. The standard procedure for ipsilateral fibula removal was done under a tourniquet. The graft taken was from the central 1/3rd of the fibula making sure to preserve knee and ankle instability and avoiding peroneal nerve injury. The graft harvested was approximately 8–14 cm (Fig. 2 and 3). We did multiple drill holes proximally and distally before doing an osteotomy.

The incision of the humerus was taken over the old healed surgical scar. Old implants were removed from the fracture site and an X-ray was taken to assess the non-union (Fig. 2). The scarred and fibrous tissue were removed along with bone debridement till bleeding bone edges were seen. Mobilization of the radial nerve was performed. Shingling was done at the fracture ends. Sequential reaming with rigid reamers was done in the proximal and distal fragment to recanalize the medullary canal so that the fibular strut graft snugly fits. The fibular strut graft was placed at the fracture site making sure that the center of the graft is at the fracture site. Cancellous bone grafting taken from the iliac crest was put at the graft-humerus interface in all patients to improve the chances for the bony union. Fixation was done with a 12–15 holed 4.5 mm LCP. In all patients, both the proximal and distal humerus fragments had four screws each.

### Post-operative follow-up

Postoperatively, the patients were given a universal shoulder

immobilizer for 4 weeks and active shoulder and elbow range of motion exercises were done. Follow-up of patients was done every 2 weeks till 1 month. Then, monthly follow-up was done till union was seen radiologically. Later, follow-up was done every 2 months. All 10 patients were followed up for a minimum of 2 years, that is, 24 months. Functional assessment was examined by disabilities of the arm, shoulder, and hand (DASH) score both before and after the operation.

### Results

Ten patients were screened with humeral non-union following failed primary osteosynthesis with male:female ratio of 7:3. The average age of the patients was 46.9 years ( $\pm 6.52$ ). The average duration of non-union since the initial surgery was around 1.2 years, with average bone gaps of 4.59 mm ( $\pm 0.53$ ). Five patients on the left and right side each were studied. Each patient had undergone 1–2 previous procedures. The sites were predominantly in the middle third of the humerus. Patients with signs of infection were excluded, and erythrocyte sedimentation rate and C-reactive protein values were checked to rule out infections.

Follow-up was for a minimum of 24 months, during which all cases achieved union at an average time of 7.2 months ( $\pm 0.97$ ), seen by the union in at least three of the four cortices on X-rays (Fig. 4). No pain was reported at the site, with the average time to the radiological union being 7 months (Table 1).

Clinically, the mean shortening of the arm was around 8.2 mm ( $\pm 0.47$ ) compared to the other side. Post-operative abduction and flexion of the shoulder were seen to be reduced by a mean of 15° each, though pre-operative elbow flexion stiffness resolved partially in all patients.

Patients' activity levels returned to near pre-injury status, with

S. no	Sex	Age	Date of injury	Mechanism of injury	Mode of index treatment	Side of injury	Gap non-union	Neurological status	Date of surgery	Time of union (months)	DASH score pre-operative	DASH score post-operative	Shortening (mm)
1	M	51	22.02.22	RTA	ORIF with plating	Right	4	Normal	04.12.23	8	56	19	8.2
2	M	43	01.04.23	RTA	ORIF with plating	Left	5	Normal	11.09.23	6	48	20	8.4
3	F	48	14.11.22	RTA	ORIF with plating	Left	4.2	Normal	23.06.23	6	62	28	9
4	M	54	17.05.22	RTA	ORIF with plating	Right	5.6	Normal	02.01.23	8	67	25	8.3
5	F	56	18.04.22	RTA	CRIF with nailing	Left	4.4	Normal	01.12.22	8	64	21	8.6
6	M	55	24.06.22	RTA	ORIF with plating	Right	4	Normal	05.02.23	8	58	22	8.1
7	M	39	20.01.23	RTA	Conservative	Right	5.2	Normal	08.11.22	6	68	32	7.4
8	F	40	28.07.22	RTA	CRIF with nailing	Left	4.7	Normal	02.02.23	6	67	31	7.5
9	M	45	21.10.22	RTA	ORIF with plating	Right	4	Normal	30.08.23	8	55	29	8.1
10	M	38	26.12.22	RTA	CRIF with nailing	Left	4.8	Normal	18.10.23	8	47	19	8.4

**Table 1: Patient data of case series of our study.**

the DASH scores improving significantly from a pre-operative average of  $59.2 \pm 7.3$  to a mean final score of  $24.6 \pm 4.8$  reflecting a mean improvement of 34.6. Results of the paired t-test indicated that there is a significant large difference between before ( $M = 59.2$ ,  $SD = 7.7$ ) and after ( $M = 24.6$ ,  $SD = 5.1$ ),  $t(9) = 19$ ,  $P < 0.001$ . Satisfaction with the treatment was high among all patients, and no graft site complications is seen (Fig. 5).

### Discussion

Non-union of the shaft of the humerus, particularly in complex cases, is an issue influenced by many factors such as pattern of fracture, interposition of soft tissue, quality of primary fixation [4], and factors such as smoking, obesity, alcoholism, and diabetes [5]. After failed treatment, complications such as poor fracture end contact, inadequate stabilisation, bone devitalization, osteopenia, and bone defects are seen. These patients generally present with gap non-union, local osteoporosis due to disuse, and various implant-related issues such as breakage and metallosis, making surgical reconstruction tough.

Several options are there for fixing gap non-union of the humerus with bone defects, including plating, nailing, and external fixators. Our preferred method is LCP due to its rigidity and suitability for osteopenic bones [6, 7, 8]. LCP offers stable fracture stability and solves issues related to poor bone quality and screw purchase [9, 10].

In our approach, we used fibular strut grafts for their structural integrity and minimal harvest site morbidity, along with iliac crest grafts for added strength at the site. This method avoids shortening and provides immediate stability post-surgery. Despite concerns about graft resorption due to inadequate vascularity, our results did not show any failures.

Compared to other options such as bone transport or the use of bone morphogenetic proteins, autologous fibular grafts are cost-effective and suitable in settings with limited resources. While fibular strut grafts may theoretically disrupt blood supply, immediate fixation mitigates this risk, ensuring graft survival [11].

Wright et al. [12] used an intramedullary fibular bone graft and a compression plate in nine humeral non-unions. Morsi (union in 6 out of 7, 86%), Steinlechner and Mkandawire (union in 7 out of 8, 88%), and Lawal et al. (union in 8 out of 10, 80%) all reported excellent results in their respective studies on non-vascularized fibular grafting concluding separately that it is a comparatively simple procedure with excellent results [13, 14]. Lawal et al. succeeded in achieving graft incorporation in eight out of the ten patients they included in three series. The average defect was 6.5 cm. They concluded that free fibular grafting is a good option for bone defects in developing countries [15].

Our series, though limited to 10 patients, demonstrated less complication and supports the reliability and cost-effectiveness of using fibular strut grafts for complex humerus gap non-unions. Complications were negligible, showing the viability of this technique in limited resource settings.



## Conclusion

We conclude that the combination of iliac crest graft with fibular strut graft and fixation using LCP is a good option for complex humerus non-union in the diaphysis where bone loss and osteopenia are seen. Using a fibular strut graft added biomechanical stability in osteoporosis, while an iliac crest bone graft enhanced the biological environment of the site of fixation. This approach showed an average improvement of the DASH score by 34.6 points, with all cases returning to their previous activity levels with achieving full union radiologically even when there were multiple failed surgeries previously. The procedure can be performed with less complications and

serves as a feasible option in less resourceful settings where bone banks, allografts, or bone morphogenetic proteins are not available.

## Clinical Message

For treating a gap non-union of the humerus with failed osteosynthesis, using a locking compression plate (LCP) combined with a fibular strut graft and an iliac crest bone graft is considered a highly effective method. This approach is often regarded as a gold standard due to its ability to provide both structural support and biological enhancement for bone healing.

**Declaration of patient consent:** The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Conflict of interest:** Nil **Source of support:** None

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