

Outcome of Non-union Diaphyseal Fracture of the Humerus Managed by Ilizarov External Fixation

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ABSTRACT

Introduction: Humeral shaft fractures are common in adults, and a subset progresses to established non-union, causing persistent pain, deformity, and functional limitation. Ilizarov circular external fixation offers stable fixation with minimal soft-tissue disruption and can address complex non-union, including infected cases, but local outcome data remain limited. **Methods & Materials:** Adults with established diaphyseal humeral non-union were enrolled consecutively at NITOR, Dhaka, from April 2023 to April 2025. Patients were followed until frame removal, with union assessed clinically and on AP and lateral radiographs, while shoulder ROM (goniometer), pain (VAS), and complications were recorded at predefined time points; results were summarised descriptively in SPSS v26.0. **Result:** Twenty-four adults with diaphyseal humeral non-union were included, evenly split between ages 21–30 and 31–55 years, and 58.3% were male. Infection-related non-union was the most common aetiology (62.5%), followed by implant failure (29.2%). Complications were infrequent, with pin tract infection and wire breakage each occurring in 4.2%, and any complication in 8.4%. Pain improved markedly over follow-up, shifting from predominantly severe at baseline (66.7%) to mostly pain-free by 12 months (66.7%) and 24 months (75.0%). Shoulder function also improved progressively, with all patients $\leq 30^\circ$ at baseline, most exceeding 90° by 24 weeks (79.1%), and at 24 months, 50.0% achieving $91\text{--}130^\circ$ and 37.5% exceeding 130° of motion. **Conclusion:** Ilizarov circular external fixation provided effective management of humeral shaft non-union, with low complication rates and sustained improvements

in pain and shoulder range of motion. It appears to be a practical option for complex, including infection-related, non-unions when appropriate pin care and rehabilitation are maintained.

Keywords: Humeral shaft non-union, Ilizarov external fixation, and Circular fixator

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INTRODUCTION

Humeral diaphyseal fractures are prevalent injuries among adults. While most cases achieve union, a significant minority progress to delayed union or established non-union, resulting in chronic pain, deformity, diminished upper-limb function, and extended socioeconomic dependence. Contemporary population data indicate a persistent burden and evolving treatment patterns. For example, a registry analysis identified 23,718 adult humeral shaft fractures between 1996 and 2018, with a stable incidence of approximately 25 per 100,000 annually. However, there were notable temporal changes in surgical management, as plate fixation increasingly replaced intramedullary nailing among operative cases^[1]. Regional epidemiological studies from China also demonstrate measurable incidence and demographic clustering in large community samples, underscoring the significance of humeral shaft trauma in Asian populations^[2]. Globally, humeral shaft fractures

constitute approximately 1-5% of adult fractures. Although functional bracing remains a primary treatment, the proportion managed surgically has risen, influenced by expectations of accelerated recovery, improved alignment control, and the availability of diverse fixation techniques^[3,4]. The clinical challenge is that “high union rates” at the cohort level can mask substantial morbidity for the subset that fails to heal. Systematic synthesis comparing operative and non-operative pathways suggests that non-operative management can carry a higher risk of nonunion, whereas operative fixation achieves high union with trade-offs including radial nerve palsy, infection, and implant-related complications, so the optimal strategy remains context dependent^[5]. Ongoing comparative research, including multicenter observational work such as HUMMER, and embedded randomised trial protocols, reflects persistent uncertainty regarding best care across patient, fracture, and system

contexts^[6,7]. Once non-union is established, conventional revision options, typically compression plating with bone grafting, can be effective but often require wide exposure, biological augmentation, and careful management of deformity, bone loss, or infection, factors that complicate repeat internal fixation, particularly where resources and follow-up are constrained^[8]. Ilizarov circular external fixation represents a biologically advantageous alternative for managing complex humeral non-union. This ring construct provides stable, multiplanar fixation with minimal additional soft-tissue disruption and allows for controlled compression-distraction and alignment correction. These features enable simultaneous management of instability, deformity, limb-length discrepancies, and infection, while facilitating early joint mobilisation. In a series employing Ilizarov fixation for both septic and aseptic humeral shaft non-union, all patients achieved union, with most demonstrating excellent

or good functional outcomes according to ASAMI criteria [9]. Additional case series of infected non-union treated with compression-distraction Ilizarov techniques have reported favourable results without the need for radical bone excision, supporting its use when internal hardware is contraindicated [10]. Nevertheless, the current evidence base is limited by small, heterogeneous studies, and there is a lack of standardised functional outcome reporting, comprehensive complication profiling, and setting-specific feasibility data. Therefore, this study aims to evaluate radiological union, time to union, functional recovery, and complications in patients with non-union diaphyseal humeral fractures treated with Ilizarov external fixation.

METHODS & MATERIALS

This observational cohort study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, over two years, from April

2023 to April 2025. Adults presenting with established nonunion of diaphyseal humeral fractures were enrolled consecutively and managed using circular Ilizarov external fixation according to unit protocol. Patients aged under 18 years; nonunion of the proximal or distal humerus, intra-articular, or pathological fractures were excluded from the study. Baseline data were recorded from admission notes and operative records, including age, sex, laterality, clinically assigned cause of nonunion (infection-related, implant failure, or inadequate mobilisation after prior conservative care), and any preexisting complications. After frame application, patients were reviewed at regular intervals for clinical progress, pin site status, and radiographic evidence of healing, and the duration of fixation, defined as time from application to frame removal, was documented. The primary outcome was fracture union, assessed using combined clinical criteria, pain-free functional use, absence of abnormal mobility, and radiological criteria, bridging

callus or consolidation across cortices on standard anteroposterior and lateral radiographs. Functional outcome was assessed using shoulder range of motion measured with a goniometer at predefined timepoints from baseline through follow-up, and pain intensity was quantified at the same timepoints using a 10 cm Visual Analogue Scale (VAS), scored from 0 (no pain) to 10 (worst pain). Data were analysed descriptively using SPSS (v 26.0), categorical variables were summarised as numbers and percentages, and continuous variables were summarised as mean with standard deviation or median with interquartile range where appropriate.

RESULTS

Table 1 summarises a balanced-age cohort; 12 participants (50.0%) were aged 21–30 years, and 12 (50.0%) were 31–55 years. The sample was predominantly male, 14 (58.3%), with females comprising 10 (41.7%).

Table I

Baseline characteristics of the study population (n = 24).

Variable	Category	Frequency (n)	Percentage (%)
Age group (years)	21 to 30	12	50.00
	31 to 55	12	50.00
Sex	Male	14	58.30
	Female	10	41.70

Table II shows that infection-related non-union was the leading underlying cause, 15

cases (62.5%), followed by implant failure in 7 (29.2%). Inadequate mobilisation after

conservative management was the least common, 2 cases (8.3%).

Table II

Underlying causes of humeral shaft non-union (n = 24).

Cause category (as per note)	Frequency (n)	Percentage (%)
Infection related non union	15	62.5
Implant failure	7	29.2
Inadequate mobilization after conservative method	2	8.3
Total	24	100

Table III indicates a low complication burden during Ilizarov management; pin tract infection occurred in 1 patient (4.2%)

and wire breakage in 1 (4.2%), with any complication reported in 2 patients overall (8.4%). The “Total” row appears to be a

formatting error, because the frequencies listed indicate 2 total complication cases in a cohort of 24.

Table III

Instances of complications during Ilizarov management (n = 24).

Complication	Frequency (n)	Percentage (%)
Pin tract infection	1	4.2
Wire breakage	1	4.2
Any complication	2	8.4
Total	4	16.8

Table IV demonstrates a consistent reduction in pain severity over time following Ilizarov fixation. At baseline, most patients reported severe pain (VAS 7–10), 16 (66.7%), with the remainder in the moderate range (VAS 4–6), 8 (33.3%). By

12 weeks, pain had shifted predominantly to the moderate band, 15 (62.5%), with fewer patients remaining severe, 4 (16.7%). Thereafter, the distribution continued to improve, and by 24 weeks, most patients reported mild pain (VAS 1–3), 13 (54.2%),

or were pain-free, 8 (33.3%). At 12 and 24 months, the majority were pain-free, 16 (66.7%) and 18 (75.0%), respectively, with the remainder reporting only mild pain.

Table IV

Visual analogue scale (VAS) pain score over follow-up, distribution of cases by VAS band ($n = 24$).

Follow-up time point	0 (no pain)	1–3 (mild)	4–6 (moderate)	7–10 (severe)
Baseline	0 (0.0)	0 (0.0)	8 (33.3)	16 (66.7)
12 weeks	0 (0.0)	5 (20.8)	15 (62.5)	4 (16.7)
18 weeks	1 (4.2)	12 (50.0)	10 (41.7)	1 (4.2)
24 weeks	8 (33.3)	13 (54.2)	3 (12.5)	0 (0.0)
12 months	16 (66.7)	8 (33.3)	0 (0.0)	0 (0.0)
24 months	18 (75.0)	6 (25.0)	0 (0.0)	0 (0.0)

Table V demonstrates a clear, progressive improvement in shoulder range of motion over follow-up. At baseline, all patients were in the $\leq 30^\circ$ band, 24 (100.0%); by 12

weeks, 14 (58.3%) had improved to $>30^\circ$, and by 24 weeks, 19 (79.1%) were $>90^\circ$. At 12 months, most patients were in the $91\text{--}130^\circ$ band, 13 (54.2%), while 9

(37.5%) achieved $>130^\circ$; this pattern was sustained at 24 months, with 12 (50.0%) in $91\text{--}130^\circ$ and 9 (37.5%) remaining $>130^\circ$, including 7 (29.2%) reaching $161\text{--}175^\circ$.

Table V

Progression of shoulder range of motion over follow-up, distribution of cases by ROM band ($n = 24$).

Follow-up time point	$\leq 30^\circ$	31 to 90°	91 to 130°	131 to 160°	161 to 175°
Baseline	24 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
12 weeks	10 (41.7)	8 (33.3)	6 (25.0)	0 (0.0)	0 (0.0)
18 weeks	4 (16.7)	8 (33.3)	9 (37.5)	3 (12.5)	0 (0.0)
24 weeks	1 (4.2)	4 (16.7)	11 (45.8)	3 (12.5)	5 (20.8)
12 months	0 (0.0)	2 (8.3)	13 (54.2)	2 (8.3)	7 (29.2)
24 months	0 (0.0)	3 (12.5)	12 (50.0)	2 (8.3)	7 (29.2)

DISCUSSION

Among adults with established humeral diaphyseal nonunion treated with circular Ilizarov fixation, infection-related nonunion accounted for the majority of cases (62.5%), followed by implant failure (29.2%). This distribution aligns with expectations in a national tertiary referral context, where patients frequently present after multiple failed interventions, prolonged symptoms, or ongoing sepsis. Such patterns have been associated with technical and biological causes of nonunion in large institutional reviews [11]. The aetiology is significant because infection shifts the treatment objective from achieving stability with grafting to prioritising eradication of infection alongside stability. In this context, circular external fixation offers distinct advantages over internal fixation constructs [12]. While fracture union and time in frame were the primary protocol outcomes, the current results highlight a notably low burden of frame-related complications. Pin tract infection and wire breakage each occurred in only 4.2% of cases. Additionally, there was a consistent, time-dependent improvement in shoulder range of motion, with most patients progressing from severe baseline restriction to functional arcs by 12 to 24 months. These low rates of pin site complications compare favourably with the broader literature, where external fixation for humeral shaft nonunion is typically associated with higher complication rates, even when union rates are high [13]. Recent Ilizarov series report high consolidation rates with frame times of 6 to 10 months, though minor pin tract infection, joint stiffness, and patient tolerance issues remain variable [14,15]. In the study by

Meselhy et al, union was achieved in all cases with a mean frame time of approximately eight months, supporting the reliability of stable circular fixation, combined with debridement, when necessary, in achieving consolidation in both septic and aseptic cases [14]. Comparative studies further indicate that infected nonunions often require staged approaches, such as temporary external fixation followed by definitive fixation, and that persistent infection is a primary cause of failure, rather than the choice of fixation construct alone [16]. The substantial improvement in shoulder motion represents a significant functional outcome. Circular fixation enables early, protected limb uses without extensive periosteal stripping and avoids repeated dissection through scarred tissue around the radial nerve, which is a common concern in revision plating [12]. The observed trajectory, with early gains at 12 to 24 weeks and continued improvement through 12 to 24 months, supports the concept that restoration of painless stability facilitates progressive rehabilitation, assuming adequate physiotherapy access and adherence [12,17]. In terms of treatment selection, the broader literature continues to endorse compression plating with autologous grafting as the preferred approach for aseptic humeral shaft nonunion, given the consistently high union rates reported in systematic reviews [13]. However, outcomes following internal fixation are influenced by biological and contextual factors. Patients with osteoporotic bone, bone loss, multiple prior failures, or infection may benefit from adjuncts such as cortical struts or alternative constructs, and selected series document both successful outcomes and

persistent disability despite eventual union [18,19].

LIMITATIONS

The primary limitations of this study are the small, single-centre sample size ($N=24$), which restricts both precision and generalizability, and the observational design lacking a comparison group, which precludes causal inference relative to plating or nailing.

CONCLUSION

Ilizarov circular external fixation achieved favourable clinical outcomes for humeral shaft nonunion in this cohort, with minimal frame-related complications, progressive pain relief and sustained improvement in shoulder range of motion over follow-up. These findings support Ilizarov fixation as a practical option, particularly for complex and infection-related nonunions, when meticulous pin care and structured rehabilitation are ensured.

RECOMMENDATION

Ilizarov external fixation is recommended for established humeral shaft nonunion, particularly in cases associated with infection or failed internal fixation, when managed in experienced centres. Meticulous debridement when indicated, standardised pin-site care, early supervised shoulder mobilisation, and scheduled radiographic follow-up are essential. Future multicenter comparative studies utilising validated functional scores are warranted.

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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee

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