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CASE REPORT

Hybrid Illizarov Fixation for Atrophic Nonunion Following Failed AO External Fixation of Open Humerus Fracture – A Case Report

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Abstract

Background: Atrophic nonunion of the humerus is a challenging condition, especially following failure of conventional fixation methods such as the AO external fixator for open fractures. The Ilizarov technique provides a biologically favourable mechanical environment for bone healing in such complex cases[1,2]. **Case Presentation**: A 35-year-old male presented with atrophic nonunion of the midshaft humerus, six months after a failed AO external fixator application for an open humerus fracture. The patient had a restricted range of motion, pain, and functional disability. Radiographs revealed hypertrophic callus absence and a significant bone gap. The patient was managed with a hybrid Ilizarov external fixator incorporating both Schantz pins and half rings for optimal stability. Union was achieved at 4 months. **Conclusion**: This case highlights the utility of hybrid Ilizarov fixation in complex nonunions, the critical role of accurate classification using Weber-Cech and Paley systems, and the importance of restoring both mechanical and biological environments for bone healing. Hybrid Ilizarov fixation offers a viable salvage treatment for atrophic nonunion of the humerus, especially after failure of previous fixation. It provides stable fixation, stimulates osteogenesis, and allows early rehabilitation[3].

Keywords: Atrophic Nonunion, Bone Grafting, External Fixator Failure, Humerus Fracture, Ilizarov Fixator

1. Introduction

Nonunion of fractures is a common complication in orthopaedic trauma, with reported rates of 2–10% in long bone fractures[1]. The humerus, although not a weight-bearing bone, can present unique challenges in nonunion due to its mobility and proximity to neurovascular structures. Atrophic nonunions, in particular, are biologically inactive and often require both mechanical stability and biological stimulation to heal[2].

The AO external fixator has been a traditional method for managing open fractures and infected nonunions; however, it may fall short in providing long-term stable fixation and promoting biological healing in certain cases[3]. Failed external fixation often leads to further bone loss, scarring, and reduced healing potential.

The Ilizarov method, originally described by Gavriil Ilizarov, provides a biomechanically stable and biologically favourable environment through circular external fixation[4]. The hybrid Ilizarov system, which combines the rigidity of Schanz pins with the Ilizarov half-rings, adapts well to anatomically complex regions like the humerus and is ideal for managing nonunions, especially when previous surgical interventions have failed[5].

This case report presents a patient with an atrophic nonunion after failed AO external fixator treatment for an open fracture of the humerus, managed successfully with a hybrid Ilizarov fixator.

2. Aim and Objectives

To present a case of atrophic humeral nonunion previously managed with an AO external fixator for

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an open fracture of the humerus and later treated successfully using a hybrid Ilizarov fixator. The report emphasises classification-based evaluation, biological principles, and surgical strategy.

3. Review of Literature

Nonunion remains a significant complication in fracture management, with reported incidence ranging from 2% to 10% depending on fracture type, location, patient comorbidities, and the method of fixation[1,2]. Among these, atrophic nonunion represents a biologically inactive state where the fracture ends show no signs of callus formation due to impaired vascularity and cellular activity.

Ilizarov's method, introduced by Gavriil Ilizarov in the 1950s, revolutionised nonunion treatment. It relies on the principles of tension-stress effect and mechanical stimulation to promote bone regeneration[4,5]. The technique is particularly beneficial in cases where traditional internal fixation fails or where the biological environment is compromised, as in atrophic nonunions. The method allows for early mobilisation, multiplanar stability, and adjustable compression or distraction based on clinical and radiological progress.

Hybrid Ilizarov systems combine ring fixation with monolateral components such as half pins to adapt to anatomical regions with soft tissue limitations like the humerus[6,7]. This configuration offers better patient compliance and easier application while preserving the benefits of circular fixation.

The Weber and Cech classification remains foundational in diagnosing the type of nonunion and guiding treatment strategies[8]. Hypertrophic nonunions, typically caused by instability, may respond well to rigid fixation alone. In contrast, atrophic nonunions, such as in this case, require biological enhancement in addition to mechanical stability. AO/ASIF classification further stratifies nonunions based on viability, helping surgeons determine the need for biological adjuncts[7].

Paley's classification, originally formulated to categorise limb length discrepancies and deformities, has been adapted to address nonunions as well. It offers a structural and biomechanical understanding of bone loss, defect size, and complexity in long bone nonunions. Specifically, it helps guide treatment approaches such as the need for distraction osteogenesis, acute shortening-lengthening procedures, or bridging constructs based on whether the defect is segmental (Type B1), with shortening (Type B2), or involves angular deformities and rotational malalignment. In our case, the presence of shortening without bone loss (Type B2) informed the strategy of gradual distraction followed by compression using the hybrid Ilizarov system[4,6].

Recent studies by Ring *et al.*[9] and Green *et al.*[10] have shown high success rates of union using circular external fixators in complex humeral nonunions. Furthermore, the diamond concept proposed by Giannoudis emphasises that bone healing is dependent on the interplay of osteogenic cells, osteoconductive scaffolds, growth factors, mechanical environment, and vascularity—many of which are positively influenced by the Ilizarov method[11].

Classification of Nonunion

(i) Weber and Cech Classification (1976)

This classification system is based on the biological activity and radiological appearance of the nonunion:
Hypertrophic Nonunion: Characterised by abundant callus formation, indicating good biological activity. Usually caused by inadequate mechanical stability.
Atrophic Nonunion: No visible callus formation. Bone ends appear sclerosed, narrowed, and tapered—indicative of poor vascularity and biological inactivity.
Our Case: Atrophic Nonunion.

(ii) AO/ASIF Classification

The AO/ASIF system broadly classifies nonunion into:
Viable Nonunion: Includes hypertrophic and oligotrophic types.
Nonviable Nonunion: Includes atrophic, necrotic, and defect types.
Case Context: Nonviable atrophic nonunion.

(iii) Paley Classification Type A (Bone loss <2 cm)

A1. Mobile deformity
A2. Fixed Nonunion

Type B (Bone loss >2 cm)

B1. Bone defect with no shortening
B2. Shortening with no bone defect B3. Both bone defect and shortening. *Our Case*: Type A1.

4. Materials and Methods

A single case of a non-randomised retrospective study with short-term follow-up of 5 months

(i) *Diagnostic workup included:*
X-ray: showing a gap and the absence of callus
Blood tests: ESR, CRP normal
Cultures: negative for infection
(ii) *Surgical intervention included:*
Removal of a broken Schantz pin
Debridement of fibrous tissue
Application of a hybrid Ilizarov construct with Schantz screw, half rings and connecting rod
(iii) *Post-operative care included:*
Pin site care
Early physiotherapy
Monthly radiographs
Frame removal after radiographic union.

5. Case Report

A 45-year-old male was admitted to our emergency department with a history of accidental cut injury with a fall on an outstretched arm on 12/04/23. Upon physical examination, there was abnormal mobility and crepitus in the left arm with a lacerated wound of size 7*5*2 cm over the anteromedial aspect of the distal arm. Neurovascular examination was normal, and there were no other associated injuries. Plain radiographs revealed a fracture of the middle 3rd of the humerus (Figure 1).

The patient underwent wound debridement and external fixation of the humerus. Acceptable humerus reduction was obtained, and the postoperative period was uneventful (Figure 2).

The patient presented after 4 months with pin loosening and serous discharge from the pin tract site. Plain radiograph revealed a broken Schantz pin with no signs of union at the fracture site. External fixator removal was done (Figure 3).

Surgery for internal fixation was deferred due to infection, and the patient was put on a functional cast and was lost to follow-up.

Patient presented at 10 months post-injury with complaints of inability to use the left arm. On physical examination, there was painless abnormal mobility and shortening of the left arm. Plain radiograph showed a bone gap with absent callus at the fracture site (Figure 4). A diagnosis of atrophic nonunion was made, and the patient was planned for Hybrid Ilizarov fixation of the left humerus to promote shoulder mobility.

Surgical Procedure

Through the posterior approach for the humerus.

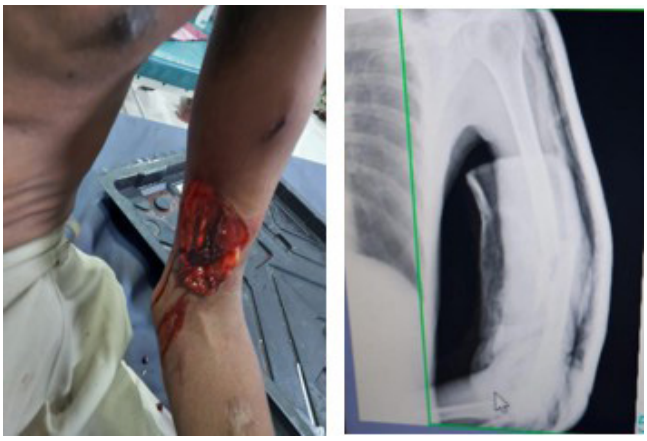

Figure 1. Preop wound and X-ray.

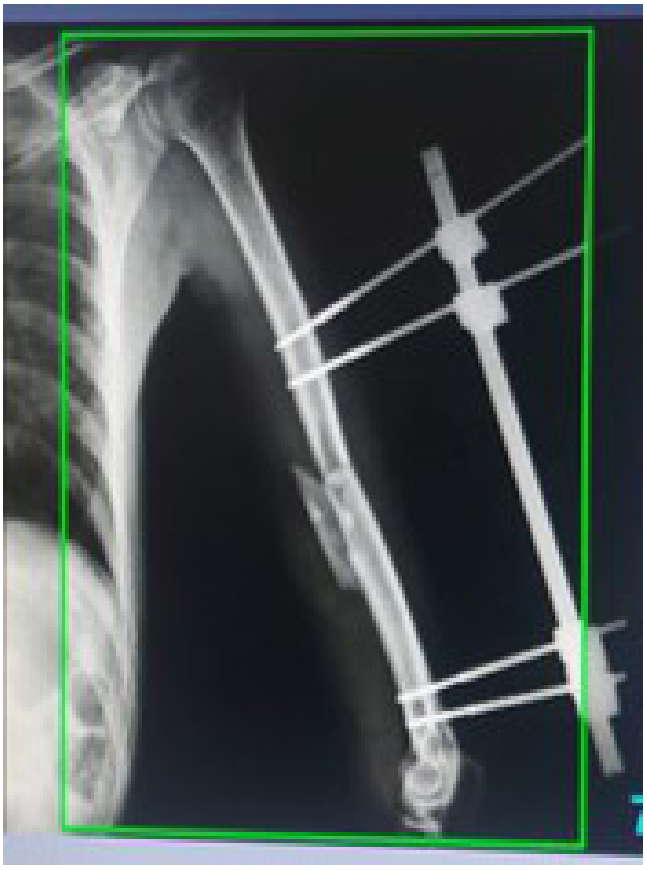

Figure 2. Immediate post-op X-ray after AO fixation.

Figure 3. Showing retained broken Schantz pin after AO external fixator removal.

- Identification and isolation of the radial nerve (Figure 5).
- Resection of fibrous tissue.
- Removal of broken Schantz pin.
- Sclerotic bone was excised until healthy bleeding bone ends were visualised (Paprika sign) and fracture provisionally fixed using a 5-holed 1/3rd tubular plate.
- The fracture site was compressed with a hybrid construct: distal Ilizarov rings and proximal Schanz pins connected with rods. The frame was tensioned and adjusted to achieve axial compression. The plate was removed.
- Construct was found to be stable. Wound wash and wound closure done.
- Postoperative period was uneventful with no neurovascular deficit or infection (Figure 6).

6. Results (Including Observations)

Follow-up:

Weekly for 4 weeks, then monthly.

Full union at 5 months (Figure 7).

The hybrid Illizarov fixator was removed at 5 months of follow-up after confirming fracture union in plain radiographs (Figure 8).

Figure 4. Showing humerus non-union with retained broken Schantz pin.

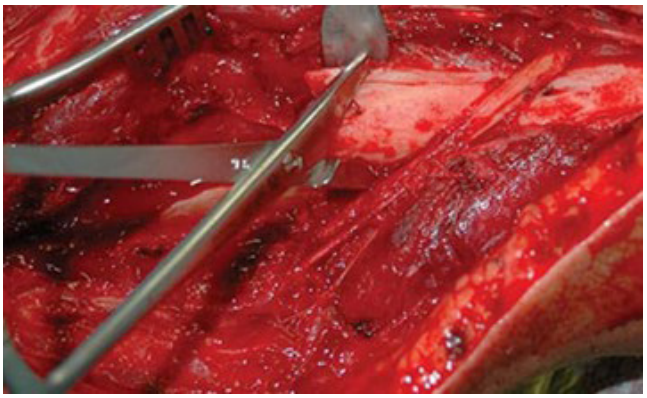

Figure 5. Intraoperative image showing isolation of the radial nerve.

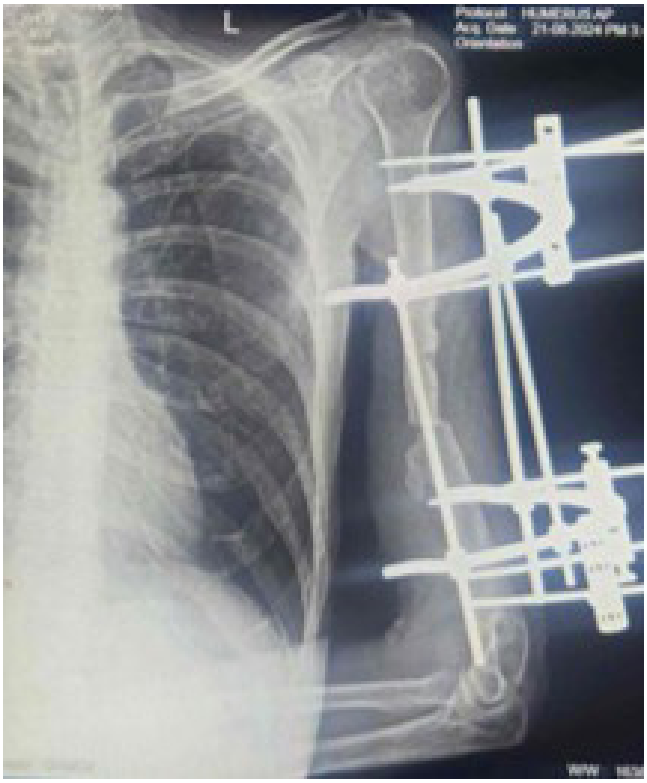

Figure 6. Immediate postoperative X-ray.

Figure 7. At the 3-month follow-up.

Figures 8. At 5 months follow-up after removal of the hybrid fixator. The fracture shows signs of complete union.

DASH score improved from 65 to 12.
Postoperative Functional Elbow Arc at 3 months follow-up (Ranges from 5°-120°) (Figure 9).

Outcome: Radiological union, pain-free range of motion at the shoulder and elbow.

7. Discussion

Atrophic nonunion is a biologically inactive form of nonunion, often resulting from compromised blood supply, excessive periosteal stripping, infection, or repeated failed surgical interventions[2,3]. In this case, the initial treatment with an AO external fixator for an open fracture of the humerus failed to achieve union, likely due to inadequate mechanical stability and absence of mechanical stimulation at the fracture site.

The humerus presents unique challenges in the treatment of nonunions. As a non-weight-bearing bone, it experiences reduced axial loading, limiting the natural biomechanical stimuli that encourage fracture healing[1]. Additionally, its mobility and proximity to

Figure 9. Functional outcome at 6 months follow-up.

neurovascular structures make surgical interventions more complex.

The hybrid Ilizarov fixator offers significant advantages in such settings. It provides multiplanar, circumferential stability and allows for controlled micromotion at the fracture interface—an important factor in promoting osteogenesis, particularly in biologically inactive nonunions[4,5]. The application of gradual compression across the fracture site helps re-establish contact between bone ends and initiates the bone healing cascade through the principle of mechanical osteosynthesis[6].

This case highlights the importance of using appropriate classification systems to guide treatment. According to the Weber and Cech classification, the nonunion was atrophic, indicating poor biological activity[8]. The AO/ASIF classification further characterised it as a nonviable type, supporting the use of advanced mechanical strategies. Based on Paley's classification, the presence of shortening without a bone defect (Type B2) indicated that a distraction-compression strategy was appropriate—well-executed through the Ilizarov system[4,6].

Literature supports the use of circular external fixators, especially the Ilizarov technique, in managing complex and revision nonunions[9,10]. Studies by Green SA and Ring et al. have documented high union rates and functional recovery using this method, even in challenging scenarios such as infection or multiple prior surgeries.

In our patient, hybrid Ilizarov fixation alone—without bone grafting—provided adequate mechanical stimulation and alignment, resulting in successful fracture union within six months. Functional recovery was marked, and no major complications were observed, underscoring the method's efficacy and safety.

8. Summary and Conclusion

This case highlights the utility of hybrid Ilizarov fixation in complex nonunions, the critical role of accurate classification using Weber-Cech and Paley systems, and the importance of restoring both mechanical and biological environments for bone healing. Hybrid Ilizarov fixation offers a viable salvage treatment for atrophic nonunion of the humerus, especially after failure of previous fixation. It provides stable fixation, stimulates osteogenesis, and allows early rehabilitation.

9. References

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