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Dual Fixation in Complex Long Bone Fractures: A Case Series of 30 Patients

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Learning Point of the Article:

Dual fixation should be considered in long bone fractures where single-implant constructs are predicted to be biomechanically insufficient, including highly comminuted diaphyseal fractures, periarticular injuries, osteoporotic bone, and established non-union.

Abstract

Introduction: Complex long bone fractures characterized by comminution, segmental patterns, metaphyseal extension, or associated joint instability pose significant challenges to stable fixation. While intramedullary nailing remains the standard treatment for diaphyseal fractures, certain fracture configurations are prone to mechanical failure, delayed union, or non-union when treated with a single fixation modality. Dual fixation using a combination of intramedullary nailing and plate augmentation may provide superior biomechanical stability and improve healing outcomes.

Objectives: To evaluate the clinical and radiological outcomes of primary dual fixation in complex long bone fractures and to assess its role as a proactive strategy for preventing fixation failure and non-union.

Materials and Methods: A prospective case series was conducted at a tertiary care center over a 24-month period. Thirty adult patients (24 males, 6 females; mean age 36.9 years) with complex long bone fractures were treated using primary dual fixation consisting of a non-locking intramedullary nail supplemented with plate augmentation. Fracture locations included the femur (n = 14), humerus (n = 14), and ulna (n = 2). Patients were followed for a minimum of 12 months. Outcome measures included radiological union, functional scores using the Disabilities of the Arm, Shoulder, and Hand (DASH) and lower extremity functional scale (LEFS), time to mobilization, and complications.

Results: Union was achieved in all 30 patients (100%). Mean time to radiological union was 16.5 weeks (range 13–22 weeks). Delayed union occurred in 3 patients (10%) but resolved without additional intervention by 24 weeks. No cases of non-union or construct failure were observed. Mean DASH score for upper-limb fractures was 12.8, while the mean LEFS score for lower-limb fractures was 75.6. Excellent-to-good functional outcomes were achieved in 26 patients (86.7%). Partial weight-bearing commenced at a mean of 4.5 weeks, and full weight-bearing was achieved at a mean of 10.8 weeks in lower-limb fractures. Complications included superficial infection in 2 patients (6.7%), implant irritation in 3 patients (10%), and migration of a titanium elastic nail in 2 patients (6.7%). No deep infections occurred.

Conclusion: Primary dual fixation provides reliable union, excellent functional outcomes, and a low complication rate in complex long bone fractures. By combining the load-sharing advantages of intramedullary nailing with the rotational and axial stability of plate augmentation, this strategy may prevent the delayed union, non-union, and fixation failures traditionally associated with mechanically unstable fracture patterns. These findings support consideration of dual fixation as a definitive primary treatment option in selected complex fractures and warrant further evaluation through prospective comparative studies.

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Introduction

Complex long bone fractures, commonly resulting from high-energy trauma, such as road traffic accidents (RTA) and falls from height, present significant challenges in orthopedic practice. These injuries are often associated with comminution, segmental fracture patterns, and metaphyseal-diaphyseal extension, making stable fixation difficult to achieve with a single modality.

Intramedullary nailing is widely regarded as the gold standard for diaphyseal fractures due to its load-sharing properties and minimally invasive nature [1]. However, in complex fracture configurations, nailing alone may not provide adequate rotational or axial stability. Plate augmentation, when combined with intramedullary nailing, enhances construct rigidity and helps maintain alignment, especially in comminuted or segmental fractures [2].

Nail-plate combination fixation has been used traditionally as a revision strategy for long bone diaphyseal fractures in which primary fixation has failed. Whether the index procedure was an intramedullary nail or a plate, the resulting non-union or delayed union has historically been addressed by combining both implant types at the revision stage. A substantial body of published evidence supports this revisional nail-plate approach, confirming its efficacy in salvaging failed primary fixation and restoring the mechanical environment required for healing [3].

However, the clinical and economic burden of a second operative procedure with its attendant's anesthetic risk, prolonged rehabilitation, and increased cost is considerable. Humeral shaft fractures, for instance, carry a well-documented predisposition to non-union even after technically satisfactory primary fixation, with reported rates ranging from 5% to 15% [4]. Comminuted distal femoral fractures fixed by intramedullary nailing alone are prone to delayed union secondary to the so-called "windshield wiper" effect, that is, cyclical toggling of the distal nail within the widening medullary canal of the metaphysis generates interfragmentary motion that impedes callus consolidation [5]. Monteggia and Galeazzi fracture-dislocations with long segmental comminution similarly present biomechanical environments in which a single fixation modality struggles to maintain adequate stability throughout the healing period [6].

Recognizing these failure patterns, we propose a paradigm shift in the management of selected unstable long bone diaphyseal fractures. The proactive, primary application of dual fixation combining non-locking intramedullary nailing with supplemental plate fixation, or employing dual-plate constructs at the index procedure, before the patient has had the opportunity to develop non-union or delayed union. The target population for this approach comprises closed fractures, or Grade I open fractures amenable to debridement and primary internal fixation [7], that the operating surgeon judges to be mechanically unstable by virtue of comminution, displacement, segmental bone loss, or association with adjacent joint instability. These fractures, under physiological muscular loads, cannot maintain their reduction with a single implant alone.

By performing dual fixation as a primary procedure, we aim to provide simultaneous load sharing and load bearing, superior rotational stability, enhanced callus formation through micromotion control, and earlier safe mobilization, thereby pre-empting the complications that would otherwise necessitate a second surgery over the course of the 9-month healing window.

We present a series of 30 patients managed with primary dual fixation over a 3-year period, few of whom are described in detail as representative cases. We discuss the biomechanical rationale for implant selection, the operative technique principles, and clinical and radiological outcomes at a minimum follow-up of 12 months.

Materials and Methods

This prospective case series was conducted at a tertiary care

Figure 1: Intra op photo showing surgical technique of tens with plate augmentation in a distal femur fracture patient.

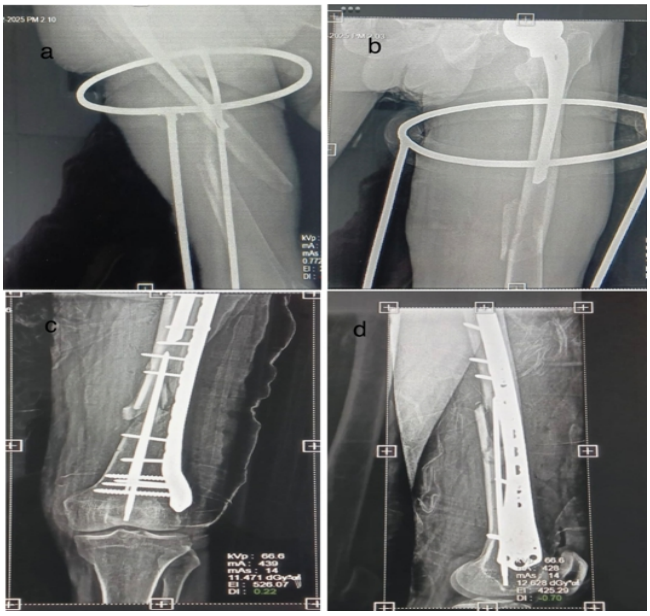

Figure 2: (a and b) pre-operative X-rays; (c and d) post-operative X-rays.

Figure 3: (a and b) pre-operative X-rays; (c and d) – post-operative X-rays.

center over a period of 24 months, including 30 patients with complex long bone fractures treated using a nail-and-plate combination technique.

Inclusion criteria

- Patients aged 18–65 years
- Complex long bone fractures (comminuted, segmental, or with metaphyseal extension)
- Closed fractures and open fractures up to Gustilo-Anderson Grade III B
- Patients treated with intramedullary nail combined with plate augmentation.

Exclusion criteria

- Gustilo-Anderson Grade III C fractures
- Patients medically unfit for surgery
- Loss to follow-up.

Patient demographics (Table 1)

Fracture distribution (Table 2).

Surgical technique

All patients were treated using a standardized dual fixation

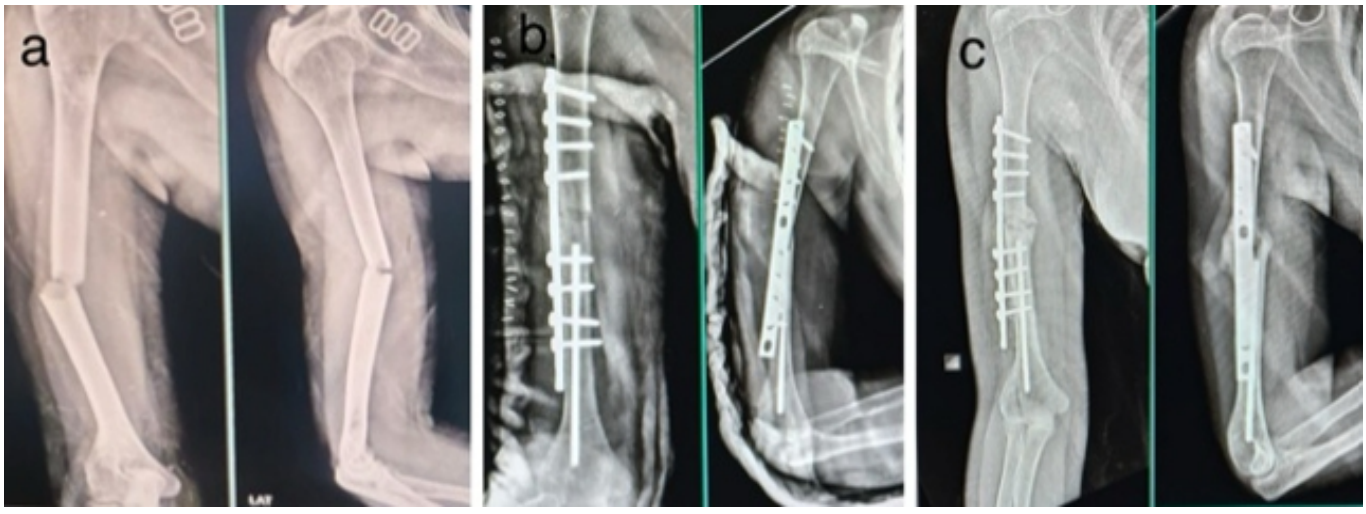

Figure 4: (a) pre-operative X-rays; (b) post-operative X-rays; (c) 3 month follow-up X-rays.

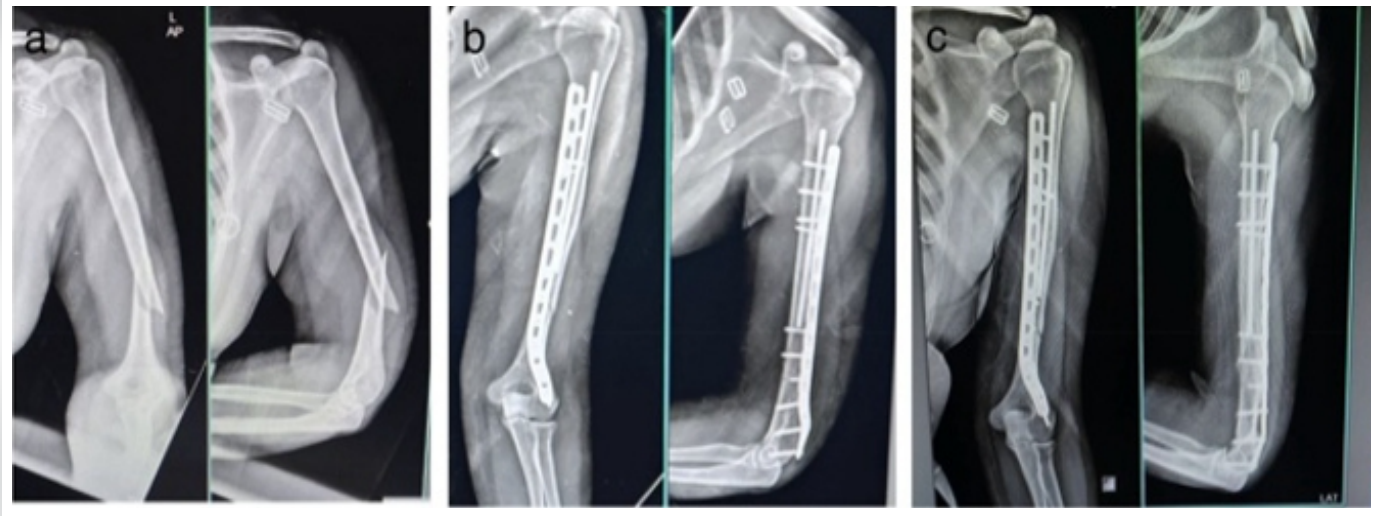

Figure 5: (a) pre-operative X-rays; (b) post-operative X-rays; (c) 2 month follow-up X-rays.

approach: Non-locking intramedullary nailing followed by supplementary plate augmentation.

- Closed or minimally invasive non-locking intramedullary nailing was performed first to restore length and alignment
- A locking compression plate was then applied to address residual instability, especially in comminuted or metaphyseal regions
- Care was taken to minimize soft tissue dissection and preserve periosteal blood supply (Fig. 1).

Post-operative protocol

- Early range of motion exercises were initiated within 48 h
- Partial weight-bearing was started between 4 and 6 weeks depending on fracture stability
- Full weight-bearing was allowed after evidence of radiological union.

Follow-up and outcome assessment

Patients were followed at regular intervals up to 12 months.

Outcome measures included:

- Time to radiological union

Functional outcome scores:

- Disabilities of the arm, shoulder and hand (DASH) (upper limb)
- Lower extremity functional scale (LEFS) (lower limb)
- Complications, including infection, implant failure, delayed union, and non-union.

Statistical analysis

Descriptive statistical analysis was performed, with mean and range calculated for continuous variables.

Illustrative cases

1. A 55-year-old male with a/h/o RTA with Vancouver type C peri-prosthetic femur fracture of the left side (Fig. 2)
2. 18-year-male with a/h/o self-fall from height with distal femur fracture managed by tens nail with fibular strut graft with distal femur plate (Fig. 3)
3. 42-year-old female with type 12-A3 shaft humerus fracture (Fig. 4)
4. A 19-year-old female with type 12-A1 shaft humerus fracture (Fig. 5).

Figure 6: (a) pre-operative X-ray; (b) post-operative X-ray showing tens nail inserted in anterograde fashion.

Figure 7: (a) pre-operative X-rays; (b) post-operative X-rays.

Table 1: Patient demographics (*n* =30)

Bone	*n*	Percentage
Femur	14	46.7
Humerus	14	46.7
Ulna	2	6.7
Total	30	100

In case number 3rd and 4th, tens nail was inserted through the fracture site to maintain alignment, which was augmented with a plate. In this approach, migration of the tens nail was seen in post-operative X-rays as the tens nail was not fixed in the canal, so we fixed this problem by inserting the tens nail in anterograde or retrograde fashion through the bony cortex so that it gets a fixation point in bone.

5. A 76-year-old male with type P2A shaft humerus fracture managed with anterograde tens nail and 4.5 dcp plate (Fig. 6)

6. 49-year-old male with non-union distal third humerus, plating done 6 months back, managed by long plate, retrograde tens nail, and vascularized pedicular fibular bone graft (Fig. 7)

7. A 46-year-old male presented with a/h/o RTA with a type 3 comminuted fracture of the olecranon managed with tens and olecranon hook plate (Fig. 8).

Discussion

The mechanical behavior of a fixation construct is determined by its bending stiffness, torsional rigidity, axial stability, and resistance to fatigue failure. In simple fracture patterns, a single well-positioned implant can adequately address all four parameters. However, in comminuted, segmental, or periarticular fractures, the loss of cortical continuity generates high bending moments at the implant-bone interface, and no single intramedullary or extramedullary device achieves sufficient stability across all loading planes simultaneously.

Laboratory biomechanical studies have consistently demonstrated that nail-plate constructs exhibit superior torsional rigidity compared to nailing alone, while orthogonal dual-plate configurations provide the highest resistance to varus-valgus loading and axial collapse in metaphyseal comminution [8, 9]. Previous studies have demonstrated a 34% reduction in implant strain and a 28% increase in construct

Table 2: Distribution of fractures by bone

Complication	*n* (%)	Management
Superficial infection	2 (6.7)	Conservative
Deep infection	0	–
Implant irritation	3 (10)	Implant removal after union
Tens nail migration	2 (6.7)	Anterograde/retrograde cortical fixation

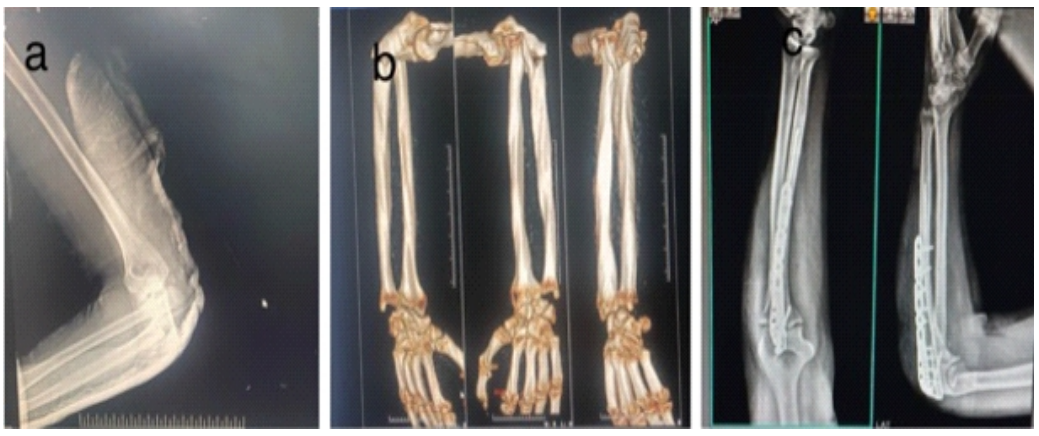

Figure 8: (a and b) pre-operative X-rays and 3D computed tomography; (c) post-operative X-rays.

Table 3: Functional and union outcomes (*n*=30)	
Outcome parameter	**Result**
Fracture union	
Union achieved, *n* (%)	30 (100)
Mean time to union, weeks (range)	16.5 (13–22)
Delayed union, *n* (%)	3 (10)
Non-union, *n*	0
Functional outcomes	
Mean DASH score (upper limb)	12.8
Mean LEFS score (lower limb)	75.6
Excellent/good outcome, *n* (%)	26 (86.7)
Fair outcome, *n* (%)	4 (13.3)
Mobilization	
Mean time to partial weight-bearing, weeks	4.5
Mean time to full weight-bearing (lower limb), weeks	10.8
DASH: Disabilities of the arm, shoulder and hand, LEFS: Lower extremity functional scale	

stiffness when a supplemental plate was added to a locked intramedullary nail (IMN) in a simulated segmental femoral fracture model [10]. These mechanical advantages translate clinically to lower rates of construct failure, malunion, and non-union [11].

Conventionally, nail-plate combinations were reserved for the revision setting and were deployed only after a primary fixation construct had demonstrably failed. Our series challenges this reactive approach. Based on our 3-year, 30-patient experience and a review of the published literature, we propose that the following fracture types warrant primary dual fixation at the index procedure, because the surgeon can predict with sufficient confidence from the initial radiographs and computed tomography (CT) that single-implant fixation will be mechanically inadequate:

- Humeral shaft fractures: Notorious for non-union even after technically satisfactory single-modality fixation. The combination of poor cortical contact at the fracture site, distraction by the weight of the limb, and unpredictable periosteal vascularity justifies primary dual fixation with IMN plus anterolateral plate in comminuted or displaced patterns.
- Distal femoral fractures with significant metaphyseal comminution: The diverging medullary canal of the distal femur allows a locked nail to toggle cyclically under physiological loading – the so-called windshield wiper effect – generating interfragmentary motion that impedes union. A supplemental medial or lateral plate neutralizes this rotational toggle and protects the healing callus.
- Monteggia fracture-dislocations and Galeazzi fracture-dislocations with long segmental or comminuted forearm fracture components: The combination of axial, rotational, and ligamentous instability in these injury patterns renders single-implant fixation prone to loss of reduction and radio-ulnar joint re-dislocation.
- Segmental long bone fractures (intercalary fragment >5 cm): The loss of a continuous cortical strut renders a single intramedullary nail unable to control torsion across both fracture levels simultaneously.
- Comminuted diaphyseal fractures under high muscular deforming forces (e.g., mid-shaft femur, proximal tibia), where physiological loads cannot be resisted by a single implant; dual fixation provides load sharing and reduces cyclic implant strain.

Results

All 30 patients completed a minimum follow-up of 12 months.

Fracture Union:

- Union was achieved in all 30 patients (100%)
- The mean time to union was 16.5 weeks (range: 13–22 weeks)
- Delayed union was observed in 3 cases (10%), which united by 24 weeks without additional intervention
- No cases of non-union were recorded.

Functional outcomes:

- Mean DASH score (upper limb cases): 12.8
- Mean LEFS score (lower limb cases): 75.6
- Excellent to good outcomes were observed in 26 patients (86.7%)

Table 4: Complications and their management	
Variable	**Value**
Total patients	30
Mean age, years (range)	36.9 (18–63)
Gender – Male, *n* (%)	24 (80)
Gender – Female, *n* (%)	6 (20)
Mode of injury	
Road traffic accident, *n* (%)	23 (76.7)
Fall from height, *n* (%)	5 (16.7)
Direct trauma, *n* (%)	2 (6.7)
***Exact number not specified; resolved by modified nail insertion technique**	

• Fair outcomes in 4 patients (13.3%), primarily due to joint stiffness.

Mobilization:

• Partial weight-bearing initiated at a mean of 4.5 weeks

• Full weight-bearing achieved at a mean of 10.8 weeks in lower limb fractures.

Complications:

• Superficial infection: 2 cases (6.7%), managed conservatively

• Deep infection: None

• Implant irritation: 3 cases (10%), managed with implant removal after union

• Migration of the tens nail was seen (Table 3 and 4).

Conclusion

Nail-plate combination fixation has long been validated as a salvage strategy for failed primary fixation of long bone diaphyseal fractures. This series advances that concept by demonstrating that the same dual fixation principle applied proactively at the index procedure can prevent the non-union and delayed union that would otherwise mandate a second surgery in mechanically unstable fractures.

When the treating surgeon assesses, on plain radiographs and CT, that a fracture is comminuted, displaced, or located in a biomechanically vulnerable zone, such as the humeral shaft, distal femoral metaphysis, or the forearm in the context of a Monteggia or Galeazzi dislocation, primary dual fixation with an intramedullary nail supplemented by a long plate at appropriate screw density should be considered as the definitive fixation strategy. This approach simultaneously provides load sharing, load bearing, and rotational stability; promotes robust callus formation; enables earlier mobilization; reduces joint stiffness; and eliminates the morbidity, cost, and psychological burden of a second operative procedure.

Over a 3-year period and 30 patients, this strategy produced no non-unions, no construct failures, and no second fixation procedures in a cohort of fractures where published single-implant revision rates of 5–12% would have been expected. These results, while preliminary, support the broader adoption of primary dual fixation in prospectively identified unstable long bone diaphyseal fractures and justify the design of prospective randomized trials to confirm these findings.

Clinical Message

1. Dual fixation should be considered in long bone fractures where single-implant constructs are predicted to be biomechanically insufficient, including highly comminuted diaphyseal fractures, periarticular injuries, osteoporotic bone, and established non-union

2. Patient selection, preoperative planning with CT imaging, and attention to implant positioning are critical determinants of outcome in dual fixation procedures

3. A high union rate and satisfactory functional outcomes can be expected with dual fixation when appropriate surgical principles are followed.

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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