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Original Research Article

Subtrochanteric Femur Fracture Fixation with Intramedullary Fixation (Proximal Femoral Nail/Ender's Nail) plus Antiflexion Derotation Plate

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Abstract

Background: Subtrochanteric femur fractures present significant treatment challenges due to high mechanical stress, deforming muscular forces, and elevated failure rates with conventional single-implant fixation methods. Combined fixation strategies may enhance stability in complex fracture patterns.

Methods: This prospective observational study included 30 patients (mean age 48.7 ± 14.2 years) with subtrochanteric femur fractures (Seinsheimer classification types II-V) treated. All patients underwent combined fixation using intramedullary nailing (22 proximal femoral nails, 8 Ender's nails) augmented with lateral antiflexion derotating plates. Primary outcomes included fracture union rate, time to union, and functional scores. Secondary outcomes comprised complications and radiographic parameters.

Results: Mean follow-up duration was 18.4 ± 4.6 months. Fracture union was achieved in 28 patients (93.3%) at mean 17.8 ± 3.4 weeks. Mean Harris Hip Score at final follow-up was 84.6 ± 9.8, with 73.3% achieving good-to-excellent results. Mean Lower Extremity Functional Scale score was 62.4 ± 11.7. Varus deformity >5° occurred in 2 patients (6.7%), and malrotation >10° in 1 patient (3.3%). Complications included one deep infection (3.3%), two cases of delayed union (6.7%), and one implant failure (3.3%). No cases of nonunion or femoral head necrosis were observed. Leg length discrepancy >1.5 cm occurred in 3 patients (10%).

Conclusion: Combined intramedullary fixation with antiflexion derotating plating for subtrochanteric femur fractures demonstrates high union rates, acceptable functional outcomes, and low complication rates, representing a viable treatment option for complex subtrochanteric fractures.

Keywords: Subtrochanteric Femur Fracture, Proximal Femoral Nail, Ender's Nail, Antiflexion Plate, Combined Fixation, Intramedullary Nailing.

Introduction

Subtrochanteric femur fractures, defined as fractures occurring between the lesser trochanter and the isthmus of the femoral shaft (typically within 5 cm distal to the lesser trochanter), represent 10-34% of all proximal femur fractures [1]. These injuries predominantly affect two distinct populations: younger patients sustaining high-energy trauma and elderly individuals with osteoporotic bone following low-energy falls [2]. The subtrochanteric region experiences some of the highest mechanical stresses in the human skeleton, with forces reaching 1200% of body weight during normal ambulation, creating a biomechanically challenging environment for fracture healing [3].

The complex anatomy and biomechanics of the subtrochanteric region contribute to substantial treatment difficulties. Powerful deforming forces from the iliopsoas, hip abductors, and adductors create characteristic fracture displacement patterns: the proximal fragment assumes a position of flexion, abduction, and external rotation, while the distal fragment undergoes adduction and shortening from the pull of the adductor muscles [4]. These deforming forces compromise fracture reduction and stability, predisposing to fixation failure, malunion, delayed union, and nonunion.

Intramedullary fixation, particularly with proximal femoral nails (PFN), has evolved as the preferred treatment modality for most subtrochanteric fractures, offering biomechanical advantages of load-sharing, minimally invasive insertion, and preservation of fracture hematoma [5]. However, reported complication rates with isolated intramedullary nailing remain concerning, ranging from 10-25%, including varus collapse, rotational malalignment, fixation failure, and nonunion, especially in comminuted fractures with lateral wall

compromise [6]. Ender's nails, though less commonly utilized in contemporary practice, offer flexibility in osteoporotic bone and ability to provide multiple intramedullary support points [7].

The concept of supplementary plating to enhance intramedullary fixation has been explored in various complex lower extremity fractures. Antiflexion derotating plates, positioned on the lateral femoral cortex, theoretically counteract the flexion-producing forces on the proximal fragment while preventing rotational malalignment and providing additional lateral buttressing in comminuted fracture patterns [8]. This dual-implant construct transforms the biomechanical environment from purely load-sharing to a hybrid load-sharing/load-bearing system, potentially enhancing stability in mechanically challenging fracture configurations [9].

Despite theoretical biomechanical advantages, clinical evidence supporting combined intramedullary-plate fixation for subtrochanteric fractures remains limited. Most published series comprise small retrospective case reports or focus on isolated intramedullary or plate fixation strategies [10]. The relative indications, technical considerations, and outcome profiles of augmented fixation techniques require further elucidation. Concerns regarding additional soft tissue disruption, prolonged operative time, increased blood loss, and potential stress concentration at implant interfaces must be weighed against potential stability benefits [11].

Given the continued challenges in managing complex subtrochanteric fractures and the paucity of clinical outcome data regarding combined fixation strategies, this study aims to prospectively evaluate the clinical, functional, and radiological outcomes of subtrochanteric femur fractures treated with combined intramedullary fixation (proximal femoral nail or Ender's nail) supplemented with lateral antiflexion derotating plating. We hypothesized that this combined approach would yield high union rates, acceptable functional outcomes, and low complication rates in a consecutive series of subtrochanteric fractures encompassing various complexity levels.

Materials and Methods

Study Design and Setting: This prospective observational cohort study was conducted at the Department of Orthopedic, with minimum 12-month follow-up for all patients.

Sample Size and Patient Selection: Thirty consecutive patients with subtrochanteric femur fractures treated with combined intramedullary fixation and antiflexion derotating plating were enrolled. Sample size was calculated based on expected union rate of 90% with precision of ±10% and 95% confidence level, requiring minimum 27 patients; we enrolled 30 to account for potential loss to follow-up.

Inclusion criteria comprised: (1) acute subtrochanteric femur fractures (injury <3 weeks), (2) age 18-75 years, (3) Seinsheimer classification types II, III, IV, or V, (4) closed fractures or Gustilo-Anderson type I open fractures, (5) medically fit for surgical intervention, and (6) ability to comply with postoperative rehabilitation protocol. Exclusion criteria included: (1) pathological fractures, (2) ipsilateral lower extremity fractures, (3) previous femoral surgery, (4) active infection, (5) neurological disorders affecting ambulation, (6) pregnancy, and (7) severe comorbidities precluding surgery (ASA class IV-V).

Preoperative Assessment: All patients underwent comprehensive clinical evaluation including detailed trauma history, neurovascular examination, and assessment of associated injuries. Radiographic evaluation included anteroposterior and lateral radiographs of the entire femur, including hip and knee joints. Computed tomography scans were obtained in all cases to assess fracture pattern, comminution degree, and medial cortex integrity. Fractures were classified according to the Seinsheimer classification system. Routine preoperative investigations, including complete blood count, coagulation profile, and medical optimization, were performed.

Surgical Technique: All procedures were performed under spinal or general anesthesia by experienced orthopedic surgeons (>10 years' experience). Patients were positioned supine on a radiolucent fracture table with the affected limb in traction. Prophylactic intravenous antibiotics (cefazolin 2g or vancomycin 1g for penicillin-allergic patients) were administered 30 minutes preoperatively.

The intramedullary component was inserted first using standard technique. For proximal femoral nailing (n=22), a 5-cm incision was made proximal to the greater trochanter, entry point established at the tip or slightly lateral to the piriformis fossa, and appropriate-length short or long PFN (depending on fracture extension) was inserted following guidewire placement and reaming. Proximal fixation was achieved with one or two cephalocervical screws, and distal interlocking was performed with two screws in static mode.

For Ender's nailing (n=8), three to four flexible titanium elastic nails (3.5-4.5 mm diameter) were inserted through medial and lateral metaphyseal entry points just proximal to the femoral condyles and advanced retrograde into the proximal

fragment, ensuring dispersion within the femoral head and neck.

Following intramedullary fixation, a second lateral incision (8-12 cm) was made along the lateral femoral cortex centered over the fracture site. The vastus lateralis was elevated, and a 6-8 hole narrow 4.5mm dynamic compression plate or locking compression plate was applied to the lateral cortex. The plate was positioned to function as an antiflexion device, with proximal screws placed to engage the lateral cortex of the proximal fragment, counteracting the flexion deformity produced by the iliopsoas muscle. At least three bicortical screws were inserted proximally and distally. In osteoporotic bone, locking screws were preferentially utilized.

Fracture reduction was verified under fluoroscopy in both planes, ensuring restoration of medial cortical continuity when possible, acceptable alignment (varus/valgus <5°, anterior/posterior angulation <10°, rotation <10°), and appropriate length restoration. Wound closure was performed in layers over suction drains.

Postoperative Protocol: Parenteral antibiotics were continued for 48 hours postoperatively. Drains were removed when output was <50 mL/24 hours. Chemical thromboprophylaxis (low-molecular-weight heparin) was administered for 4 weeks. Physical therapy commenced on postoperative day one, including ankle and knee range-of-motion exercises and quadriceps strengthening. Non-weight-bearing ambulation with walker or crutches was permitted from postoperative day 2-3 based on patient tolerance. Progressive weight-bearing was initiated based on radiographic evidence of callus formation, typically at 6-8 weeks, advancing to full weight-bearing at 10-14 weeks depending on fracture healing progression.

Outcome Assessment: Patients were evaluated at 2, 6, 12, and 24 weeks postoperatively, then at 6-month intervals until final follow-up. Clinical assessment included wound evaluation, pain assessment using Visual Analog Scale (VAS), hip and knee range of motion measurement, and ambulatory status documentation. Radiographic evaluation at each visit included anteroposterior and lateral femur radiographs. Fracture union was defined as bridging callus across at least three of four cortices on orthogonal radiographs combined with pain-free weight-bearing. Time to union was recorded in weeks. Delayed union was defined as failure to achieve radiographic union by 24 weeks. Nonunion was defined as absence of progressive healing at 9 months or persistent fracture line at 12 months. Alignment was assessed measuring neck-shaft angle, anterior/posterior angulation, and rotational alignment compared to the contralateral limb. Leg length discrepancy was measured clinically and radiographically.

Functional outcomes were assessed using the Harris Hip Score (HHS) at final follow-up, with scores categorized as excellent (90-100), good (80-89), fair (70-79), or poor (<70). The Lower Extremity Functional Scale (LEFS), a validated patient-reported outcome measure, was also administered at final follow-up.

Complications including infection (superficial and deep), hardware failure, malunion, delayed union, nonunion, femoral head necrosis, implant-related pain, and need for revision surgery were documented.

Statistical Analysis: Data were analyzed using SPSS version 25.0 (IBM Corporation, Armonk, NY). Descriptive statistics were calculated for all variables, with continuous variables presented as mean ± standard deviation and categorical variables as frequencies and percentages. Normal distribution was assessed using Shapiro-Wilk test. Paired t-tests compared preoperative and postoperative parameters. Correlation analysis (Pearson or Spearman) evaluated relationships between variables such as age, fracture type, and outcomes. Statistical significance was set at $p<0.05$.

Results

Patient Demographics and Fracture Characteristics: Thirty patients (19 males, 11 females) with mean age 48.7 ± 14.2 years (range 22-72 years) were included. Injury mechanisms comprised motor vehicle accidents (n=16, 53.3%), falls from height (n=9, 30%), and low-energy falls in elderly patients (n=5, 16.7%). According to Seinsheimer classification, there were 8 type II fractures (26.7%), 12 type III (40%), 7 type IV (23.3%), and 3 type V (10%). Mean time from injury to surgery was 4.8 ± 2.1 days. Complete demographic and fracture characteristics are presented in Table 1.

Table 1: Patient Demographics and Fracture Characteristics (N=30)

Variable	Value
Age (years)	48.7 ± 14.2
Gender	
Male	19 (63.3%)
Female	11 (36.7%)
Side affected	
Right	17 (56.7%)
Left	13 (43.3%)
Mechanism of injury	
Motor vehicle accident	16 (53.3%)
Fall from height	9 (30.0%)
Low-energy fall	5 (16.7%)
Seinsheimer classification	
Type II	8 (26.7%)
Type III	12 (40.0%)
Type IV	7 (23.3%)
Type V	3 (10.0%)
Intramedullary device	
Proximal femoral nail	22 (73.3%)
Ender's nail	8 (26.7%)
ASA classification	
Class I	14 (46.7%)
Class II	12 (40.0%)
Class III	4 (13.3%)
Time to surgery (days)	4.8 ± 2.1
Operative time (minutes)	118.6 ± 24.7
Blood loss (mL)	385.4 ± 112.3
Hospital stay (days)	8.4 ± 2.6

Radiological Outcomes: Mean follow-up duration was 18.4 ± 4.6 months (range 12-28 months). Fracture union was achieved in 28 patients (93.3%) at mean 17.8 ± 3.4 weeks (range 12-26 weeks).

Two patients (6.7%) experienced delayed union, achieving consolidation at 28 and 32 weeks respectively following dynamization (removal of distal interlocking screws). No cases of nonunion occurred during the study period. Radiographic alignment parameters at final follow-up demonstrated mean neck-shaft angle of 128.4 ± 4.8° (normal 125-135°), with varus deformity >5° in 2 patients (6.7%) and valgus deformity >5° in 1 patient (3.3%). Anterior angulation >10° occurred in 1 patient (3.3%), and malrotation >10° compared to contralateral limb was identified in 1 patient (3.3%). Mean leg length discrepancy was 0.8 ± 0.6 cm, with 3 patients (10%) having discrepancy >1.5 cm. Detailed radiological outcomes are presented in Table 2.

Table 2: Radiological Outcomes and Complications (N=30)

Parameter	Value
Follow-up duration (months)	18.4 ± 4.6
Fracture union	
Union achieved	28 (93.3%)
Delayed union	2 (6.7%)
Nonunion	0 (0%)
Time to union (weeks)	17.8 ± 3.4
Alignment parameters	
Neck-shaft angle (degrees)	128.4 ± 4.8
Varus deformity >5°	2 (6.7%)
Valgus deformity >5°	1 (3.3%)
Anterior angulation >10°	1 (3.3%)
Malrotation >10°	1 (3.3%)
Leg length discrepancy (cm)	0.8 ± 0.6
Discrepancy >1.5 cm	3 (10.0%)
Complications	

Deep infection	1 (3.3%)
Superficial infection	2 (6.7%)
Hardware failure	1 (3.3%)
Implant-related pain	4 (13.3%)
Femoral head necrosis	0 (0%)
Revision surgery	1 (3.3%)
Time to weight-bearing (weeks)	
Partial weight-bearing	7.2 ± 1.8
Full weight-bearing	12.6 ± 2.4

Functional Outcomes: At final follow-up, mean Harris Hip Score was 84.6 ± 9.8 (range 62-98). Distribution of HHS categories showed excellent results in 9 patients (30%), good in 13 patients (43.3%), fair in 6 patients (20%), and poor in 2 patients (6.7%). Combined good-to-excellent results were achieved in 22 patients (73.3%). Mean Lower Extremity Functional Scale score was 62.4 ± 11.7 (maximum 80 points), representing 78% of maximum function.

Hip range of motion at final follow-up demonstrated mean flexion of 108.6 ± 14.2°, abduction of 38.4 ± 8.6°, and internal rotation of 22.6 ± 6.8°. Compared to the contralateral normal hip, affected side hip flexion was reduced by mean 12.8 ± 8.4° (p=0.001).

Pain assessment revealed mean VAS score at final follow-up of 1.4 ± 1.2 (scale 0-10), with 23 patients (76.7%) reporting no pain or mild pain (VAS 0-2), 5 patients (16.7%) moderate pain (VAS 3-5), and 2 patients (6.7%) severe pain (VAS 6-8).

Return to preinjury activity level was achieved in 21 patients (70%), while 7 patients (23.3%) returned to modified activities, and 2 patients (6.7%) had significant activity limitations. Mean time to return to work for employed patients (n=24) was 16.4 ± 4.8 weeks. Functional outcomes are detailed in Table 3.

Table 3: Functional Outcomes at Final Follow-up (N=30)

Parameter	Value
Harris Hip Score	84.6 ± 9.8
Excellent (90-100)	9 (30.0%)
Good (80-89)	13 (43.3%)
Fair (70-79)	6 (20.0%)
Poor (<70)	2 (6.7%)
Good-to-excellent	22 (73.3%)
Lower Extremity Functional Scale	62.4 ± 11.7
Range of motion (degrees)	
Hip flexion	108.6 ± 14.2
Hip abduction	38.4 ± 8.6
Hip internal rotation	22.6 ± 6.8
Hip flexion deficit vs contralateral	12.8 ± 8.4
Visual Analog Scale (pain)	1.4 ± 1.2
No/mild pain (VAS 0-2)	23 (76.7%)
Moderate pain (VAS 3-5)	5 (16.7%)
Severe pain (VAS 6-8)	2 (6.7%)
Return to activity	
Preinjury level	21 (70.0%)
Modified activities	7 (23.3%)
Significant limitations	2 (6.7%)
Time to return to work (weeks)	16.4 ± 4.8
Patient satisfaction	
Very satisfied	18 (60.0%)
Satisfied	9 (30.0%)
Unsatisfied	3 (10.0%)

Complications: One patient (3.3%) developed deep infection requiring debridement, implant retention, and prolonged antibiotic therapy, eventually achieving union at 24 weeks. Two patients (6.7%) had superficial wound infections managed successfully with oral antibiotics and wound care. One patient (3.3%) experienced implant failure (proximal screw breakage in a PFN at 8 weeks post-surgery) in the setting of noncompliance with weight-bearing restrictions;

this patient underwent revision with exchange nailing and achieved union at 22 weeks total. Implant-related pain requiring analgesics beyond 6 months occurred in 4 patients (13.3%), with 2 subsequently undergoing implant removal after confirmed union. No cases of femoral head avascular necrosis, heterotopic ossification requiring intervention, or thromboembolic events were observed. Overall revision surgery rate was 3.3% (1 patient for hardware failure).

Discussion

This prospective study demonstrates that combined intramedullary fixation with supplementary antiflexion derotating plating for subtrochanteric femur fractures achieves high union rates (93.3%), acceptable functional outcomes (73.3% good-to-excellent Harris Hip Scores), and manageable complication profiles. These results support the viability of augmented fixation strategies for this biomechanically challenging fracture location.

Subtrochanteric femur fractures remain among the most demanding injuries in orthopedic trauma due to unfavorable biomechanical characteristics, powerful deforming muscular forces, and compromised healing potential [1]. Historical complication rates with various fixation methods have been substantial, with nonunion rates of 10-20% and malunion rates approaching 15-30% reported in complex fracture patterns [2]. Our 93.3% union rate compares favorably with these historical benchmarks and aligns with contemporary series employing optimized fixation strategies.

The theoretical biomechanical rationale for supplementary plating centers on counteracting specific deforming forces unique to the subtrochanteric region. The iliopsoas muscle insertion on the lesser trochanter generates a powerful flexion moment on the proximal fragment, while gluteal abductors create abduction force [3]. Isolated intramedullary fixation, despite being load-sharing, may not adequately resist these deforming forces, particularly in comminuted fractures lacking medial cortical buttressing [4]. The lateral antiflexion plate functions as a tension band device, converting tensile forces on the lateral cortex into compressive forces at the medial fracture site, theoretically enhancing stability and promoting healing [15]. Our mean time to union of 17.8 weeks is consistent with expected healing timeframes for subtrochanteric fractures and compares favorably with isolated intramedullary fixation series reporting union times of 18-24 weeks [5]. The relatively uniform healing across fracture complexity levels (Seinsheimer types II-V) suggests that the enhanced stability provided by dual-implant constructs may mitigate some negative prognostic factors associated with comminution and medial cortex compromise. The functional outcomes, with 73.3% achieving good-to-excellent Harris Hip Scores and mean LEFS score of 62.4, align with contemporary outcome expectations for operatively treated subtrochanteric fractures [6]. However, the 12.8° mean hip flexion deficit compared to the contralateral side and 30% of patients not returning to preinjury activity levels highlight that substantial functional impact persists despite successful fracture healing. These findings underscore the severity of the initial injury and importance of aggressive rehabilitation protocols. Our low malunion rate (6.7% with varus >5°) represents a potential advantage of the combined fixation approach. Varus malunion remains a persistent challenge with isolated intramedullary fixation, with reported rates of 10-25% in comminuted fractures [7]. The lateral plate likely provides additional resistance to varus collapse, particularly during the critical early healing phase before sufficient callus formation. Maintaining appropriate neck-shaft angle is crucial for hip biomechanics and functional outcomes [8].

The complication profile, while including one deep infection (3.3%) and one hardware failure (3.3%), compares favorably with published series of complex subtrochanteric fractures. Deep infection rates of 2-5% are reported with intramedullary fixation, and our rate falls within this range despite the additional soft tissue dissection required for plate application [9]. The single hardware failure case occurred in a noncompliant patient with premature weight-bearing, highlighting the importance of patient compliance with postoperative protocols. The absence of nonunion in our series is noteworthy, as nonunion represents one of the most challenging complications of subtrochanteric fractures, occurring in 5-15% of cases treated with isolated fixation methods [10]. While our sample size and follow-up duration limit definitive conclusions, the enhanced mechanical stability from dual-implant constructs may reduce nonunion risk by minimizing interfragmentary motion and maintaining reduction. The choice between proximal femoral nails (73.3% of our series) and Ender's nails (26.7%) was based on fracture pattern, bone quality, and surgeon preference. While both demonstrated successful outcomes, the limited sample size precludes meaningful subgroup comparison. Ender's nails, though largely superseded by rigid interlocking devices, offer theoretical advantages in severely osteoporotic bone where rigid nail insertion may fracture the proximal femur [11]. The flexible nature of multiple Ender's nails combined with rigid plate fixation creates an interesting biomechanical construct warranting further investigation.

Several limitations merit consideration. The observational design without control group limits ability to definitively attribute outcomes to the specific fixation technique versus other factors including surgical expertise, patient selection, and rehabilitation protocols. However, conducting randomized trials of surgical techniques presents ethical and practical challenges, particularly for relatively uncommon injury patterns. The sample size, while adequate for primary outcome assessment, limits subgroup analyses and detection of less common complications. Longer follow-up would strengthen assessment of late complications such as post-traumatic arthritis and implant-related issues.

The additional operative time (mean 118.6 minutes) and potentially increased blood loss associated with dual-implant fixation represent practical considerations. However, contemporary surgical techniques, including minimally invasive plating approaches that we did not universally employ, may mitigate these factors in future applications [12].

Cost-effectiveness analyses comparing combined fixation to isolated methods would provide valuable health economics perspective [13].

Future research should include comparative studies with isolated intramedullary fixation as controls, biomechanical investigations of various plate configurations and positioning strategies, and long-term outcome assessment including patient-reported outcomes and post-traumatic arthritis development. Additionally, identifying specific fracture characteristics that most benefit from augmented fixation would enable more selective and cost-effective application of this technique [14,15].

Conclusion

Combined intramedullary fixation with supplementary lateral antiflexion derotating plating for subtrochanteric femur fractures demonstrates promising clinical efficacy, achieving 93.3% union rate, mean time to union of 17.8 weeks, and good-to-excellent functional outcomes in 73.3% of patients. The technique appears particularly advantageous in maintaining fracture reduction with low rates of varus malunion and absence of nonunion in this series. Complication rates remain acceptable and comparable to isolated fixation methods despite additional surgical intervention.

While the observational study design limits definitive conclusions regarding superiority over conventional single-implant techniques, these results support the viability of augmented fixation strategies for complex subtrochanteric fractures, particularly in cases with significant comminution, lateral wall compromise, or osteoporotic bone quality. The technique represents a valuable addition to the orthopedic trauma surgeon's armamentarium for managing these challenging injuries. Further comparative studies with larger sample sizes and long-term follow-up are warranted to definitively establish the role of combined fixation in treatment algorithms for subtrochanteric femur fractures.

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