BIOMEDICINE AND CHEMICAL SCIENCES
AN INTERNATIONAL PEER-REVIEWED JOURNAL

BIOMEDICINE AND CHEMICAL SCIENCES
Website: https://journals.irapa.org/index.php/BCS
e-ISSN: 2790-296X | p-ISSN:2957-5826

Original Article

Outcomes of Proximal Femoral Nail Antirotation (PFN-A) in the Management of Unstable Intertrochanteric Femoral Fractures: A Prospective Study of 94 cases.

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Article History:
Received on: Aug 05, 2026
Revised on: Aug 15, 2026
Accepted on: Aug 25, 2026
Published on: Sep 06, 2026

Citation: Dr. B.L Khajotia *et al.* Outcomes of Proximal Femoral Nail Antirotation (PFN-A) in the Management of Unstable Intertrochanteric Femoral Fractures: A Prospective Study of 94 cases. *Biomedicine and Chemical Sciences, 5 (3): 92-99, 2026*

ABSTRACT

Background- Unstable intertrochanteric fractures are associated with substantial morbidity in elderly patients. Proximal Femoral Nail Antirotation (PFN-A) provides biomechanical advantages that permit stable fixation, early mobilization and improved functional recovery. This study evaluated the functional and radiological outcomes of PFN-A in unstable intertrochanteric fractures.

Methodology- A hospital-based prospective study was conducted on 94 patients with unstable intertrochanteric fractures treated with PFN-A at the Department of Orthopaedics, S.P. Medical College, Bikaner. Functional outcome was assessed using the Harris Hip Score (HHS), while radiological union was evaluated using serial radiographs and the Radiographic Union Score for Hip (RUSH). Operative variables, reduction quality, fracture union and postoperative complications were analysed.

Results- The mean age was 71.2±8.4 years, and 58.5% of patients were female. Trivial fall was the commonest mechanism of injury (84.0%). Anatomical reduction was achieved in 69.1% of cases, while 88.3% had a tip-apex distance below 25 mm. Radiological union was achieved in 97.9% of patients, with a mean union time of 14.6±3.2 weeks. According to the Harris Hip Score, 59.6% had excellent, 30.9% good and 9.6% fair functional outcomes, with no poor results. Most patients (78.7%) had no postoperative complications. AO fracture type was significantly associated with union time ($p<0.001$), tip-apex distance <25 mm predicted better functional outcome ($p=0.049$), osteoporosis increased postoperative complications ($p=0.005$), and increasing age was associated with poorer functional recovery ($p=0.009$).

Conclusion- PFN-A is a safe, reliable and effective implant for unstable intertrochanteric fractures, providing excellent fracture union, favourable functional outcomes and a low complication rate. Accurate reduction, optimal implant positioning and meticulous surgical technique are essential for achieving optimal results, particularly in elderly osteoporotic patients.

Keywords: Unstable intertrochanteric fracture; Proximal Femoral Nail Antirotation; PFN-A; Harris Hip Score; Radiographic Union Score for Hip; Functional outcome; Radiological union

INTRODUCTION

Intertrochanteric femur fractures are among the most common fragility fractures encountered in orthopaedic practice and represent a major cause of morbidity, mortality, and healthcare burden worldwide.[1,2] Their incidence continues to rise owing to increasing life expectancy, population ageing, and the growing prevalence of osteoporosis.[3] While most fractures in elderly individuals result from low-energy falls, younger patients typically sustain these injuries following high-energy trauma.[4]

Unstable intertrochanteric fractures, characterized by posteromedial comminution, reverse obliquity, disruption of the lateral femoral wall, or subtrochanteric extension, present a significant therapeutic challenge because of their inherent biomechanical instability and high risk of varus collapse, implant failure, and delayed functional recovery.[5,6] Early surgical stabilization has become the standard of care, aiming to restore anatomical alignment, facilitate early mobilization, reduce complications associated with prolonged immobilization, and improve functional outcomes.[7]

Although the dynamic hip screw remains an effective implant for stable fracture patterns, its performance in unstable fractures is limited by excessive fracture collapse, medialization of the shaft, and higher rates of mechanical failure.[8] Intramedullary fixation offers important biomechanical advantages, including a shorter lever arm, improved load sharing, and enhanced stability in unstable fracture configurations.[9,10] Among these devices, the Proximal Femoral Nail Antirotation (PFN-A) has gained widespread acceptance because its helical blade compacts cancellous bone, improves rotational stability, reduces the risk of cut-out, and preserves bone stock, particularly in osteoporotic bone.[11]

Despite encouraging clinical outcomes, implant-related complications and variability in fracture union and functional recovery continue to be reported, emphasizing the importance of meticulous surgical technique and objective postoperative assessment.[12] Functional recovery is commonly evaluated using the Harris Hip Score (HHS), whereas radiological healing can be objectively assessed using the Radiographic Union Score for Hip (RUSH).[13]

Therefore, the present prospective study was undertaken to evaluate the functional and radiological outcomes of unstable intertrochanteric femur fractures treated with Proximal Femoral Nail Antirotation (PFN-A), with particular emphasis on fracture union, functional recovery, and procedure-related complications.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based prospective observational study was conducted in the Department of Orthopaedics, S.P. Medical College and Associated Group of Hospitals, Bikaner, Rajasthan, over a period of 12 months following approval from the Institutional Ethics Committee.

Study Population

The study included consecutive patients aged >60 years presenting with closed unstable intertrochanteric femur fractures (AO/OTA 31-A2 and 31-A3; Evans type III–V and reverse obliquity) who were ambulatory before injury and were medically fit for surgery. Patients with polytrauma, pathological fractures, open fractures, subtrochanteric or intracapsular neck femur fractures, neglected fractures, or those who were non-ambulatory prior to injury were excluded. Written informed consent was obtained from all participants.

Sample Size

Sample size was calculated assuming an expected good-to-excellent functional outcome rate of 82.9%, with a 95% confidence level, 5% alpha error, and an absolute precision of 8%, yielding a minimum sample size of 85 patients. After allowing for a 10% dropout rate, the final sample size was 94 patients. Consecutive sampling was employed throughout the study.

Preoperative Assessment

All patients underwent detailed clinical evaluation, including demographic characteristics, mechanism of injury, pre-injury ambulatory status, associated comorbidities, and thorough local and neurovascular examination. Routine hematological and biochemical investigations, electrocardiography, chest radiography, and pre-anaesthetic evaluation were performed before surgery. Fractures were classified according to the AO/OTA classification, and osteoporosis was assessed radiographically using Singh's Index. Standard anteroposterior and lateral radiographs of the affected hip were obtained for fracture assessment and preoperative planning.

Surgical Procedure

All patients underwent fixation with Proximal Femoral Nail Antirotation (PFN-A) under spinal anaesthesia, with general anaesthesia reserved when indicated. Patients were positioned supine on a fracture table, and closed reduction under fluoroscopic guidance was attempted in all cases; limited open reduction was performed when satisfactory reduction could not be achieved. Appropriate nail length and diameter were selected based on preoperative planning and intraoperative assessment. The PFN-A was inserted through the tip of the greater trochanter, followed by placement of the helical blade into the femoral head under fluoroscopic guidance. Distal locking was performed using either static or dynamic locking according to fracture configuration. Intraoperative parameters including reduction quality, operative time, blood loss, implant position, neck-shaft angle, tip-apex distance, and fluoroscopy time were recorded. (Fig 1)

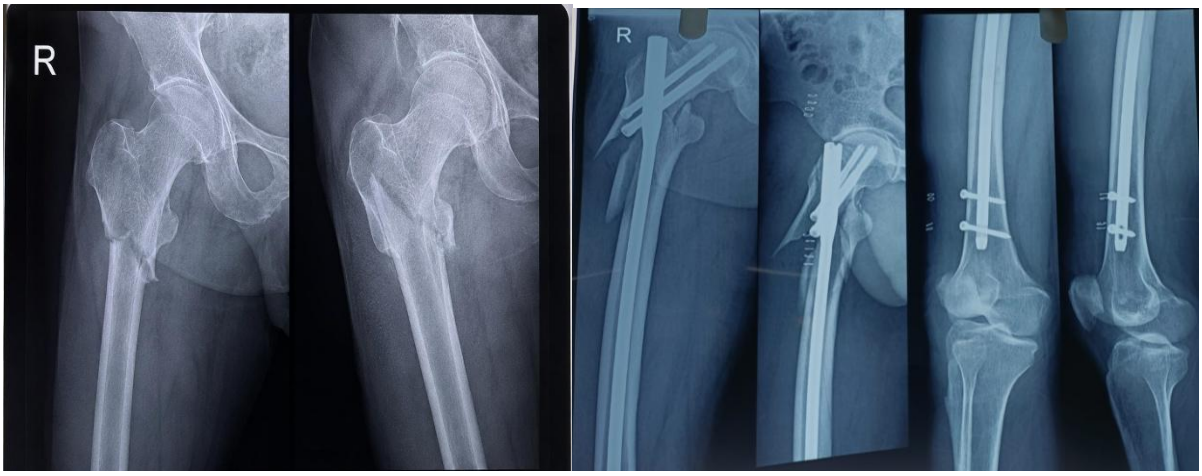

Fig 1 Unstable right intertrochanteric femur fracture managed with open reduction and fixation with Proximal Femoral Nail Antirotation (PFN-A).

Postoperative Rehabilitation and Follow-up

Standard postoperative antibiotic prophylaxis, thromboprophylaxis, analgesia, and physiotherapy protocols were followed. Quadriceps strengthening and ankle pump exercises were initiated on the first postoperative day, followed by assisted mobilization with walker support. Weight-bearing was progressively advanced according to fracture stability, implant fixation, and radiological evidence of healing. Patients were reviewed at 6 weeks, 3 months, and 6 months, with additional follow-up at 12 months where applicable. At each visit, clinical examination and radiographic assessment were performed to evaluate fracture healing, implant position, maintenance of reduction, and postoperative complications.

Outcome Measures

The primary functional outcome was assessed using the Harris Hip Score (HHS), categorized as excellent (90–100), good (80–89), fair (70–79), or poor (<70). Radiological union was evaluated using the Radiographic Union Score for Hip (RUSH) on serial anteroposterior and lateral radiographs. Additional parameters included fracture reduction quality, neck-shaft angle, tip-apex distance, time to union, intraoperative blood loss, and implant-related complications such as cut-out, cut-through, varus collapse, implant migration, delayed union, non-union, infection, and reoperation.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 21. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequency and percentage. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 94 patients with unstable intertrochanteric femur fractures treated with Proximal Femoral Nail Antirotation (PFN-A) were included in the study.

The mean age of the study population was 73.2 ± 7.8 years. The majority of patients belonged to the 61–70 years age group (51.1%), followed by 71–80 years (31.9%), while 17.0% were aged more than 80 years. Female patients constituted 58.5% of the study population, whereas males accounted for 41.5%. Right-sided fractures were slightly more common (52.1%) than left-sided fractures (47.9%). Trivial fall was the predominant mechanism of injury (84.0%), followed by road traffic accidents (11.7%) and falls from height (4.3%). Osteoporosis was the most frequent associated comorbidity (64.9%), followed by hypertension (45.7%) and diabetes mellitus (30.9%). Before injury, 61.7% of patients were ambulatory without support, while 29.8% used a walking stick and 8.5% required a walker.

Table 1 Baseline Demographic and Clinical Characteristics

Variable	Category	n (%)
Age group (years)	61–70	48 (51.1)
	71–80	30 (31.9)
	>80	16 (17.0)
Mean age	73.2 ± 7.8 years	
Sex	Male	39 (41.5)
	Female	55 (58.5)
Side involved	Right	49 (52.1)
	Left	45 (47.9)
Mode of injury	Trivial fall	79 (84.0)
	RTA	11 (11.7)
	Fall from height	4 (4.3)
Pre-injury mobility	Walking without aid	58 (61.7)
	Walking stick	28 (29.8)
	Walker	8 (8.5)
Comorbidities	Osteoporosis	61 (64.9)
	Hypertension	43 (45.7)
	Diabetes mellitus	29 (30.9)

According to the AO/OTA classification, 31A2.3 fractures were the most common (29.8%), followed by 31A2.2 (23.4%), 31A3.1 (20.2%), 31A3.2 (17.0%), and 31A3.3 (9.6%). Based on the Boyd and Griffin classification, Type III fractures predominated (48.9%), followed by Type IV (31.9%) and Type II (19.1%).

The mean interval from injury to surgery was 5.8 ± 3.4 days, with the majority of patients (59.6%) undergoing surgery within 4–7 days of injury. The mean operative duration was 74.8 ± 12.4 minutes, and 59.6% of procedures were completed within 60–75 minutes. Estimated intraoperative blood loss ranged from 60–75 mL in 60.6% of patients, 76–90 mL in 36.2%, and exceeded 90 mL in 3.2%. Anatomical reduction was achieved in 69.1% of patients, acceptable reduction in 27.7%, and poor reduction in 3.2%. A tip-apex distance (TAD) <25 mm was achieved in 88.3% of cases. A 10-mm PFN-A was used in 73.4% of patients, while a 170-mm nail was implanted in 78.7% of cases.

Table 2. Fracture Characteristics and Operative Details

Variable	Category	n (%)
AO/OTA classification	31A2.2	22 (23.4)
	31A2.3	28 (29.8)

	31A3.1	19 (20.2)
	31A3.2	16 (17.0)
	31A3.3	9 (9.6)
Boyd & Griffin	Type II	18 (19.1)
	Type III	46 (48.9)
	Type IV	30 (31.9)
Mean injury-surgery interval	**5.8 ± 3.4 days**	
Mean operative duration	**74.8 ± 12.4 min**	
Mean blood loss	**76.3 ± 11.8 mL**	
Anatomical reduction	65 (69.1)	
Acceptable reduction	26 (27.7)	
Poor reduction	3 (3.2)	
TAD <25 mm	83 (88.3)	
TAD ≥25 mm	11 (11.7)	
PFN-A diameter 10 mm	69 (73.4)	
PFN-A length 170 mm	74 (78.7)	

Radiological union was achieved in 92 (97.9%) patients. Most fractures (54.3%) united between 12 and 16 weeks, whereas 30.9% achieved union within 12 weeks. The mean time to radiological union was 14.6 ± 3.2 weeks. Postoperative limb length discrepancy of <1 cm was observed in 80.9% of patients, while only 3.2% demonstrated shortening of >2 cm.
At the final follow-up, 96.8% of patients achieved hip flexion of >90°, 98.9% achieved hip abduction of >20°, and 98.9% attained hip rotation of >15°, indicating satisfactory restoration of hip mobility. Functional assessment using the Harris Hip Score demonstrated excellent outcomes in 59.6%, good outcomes in 30.9%, and fair outcomes in 9.6% of patients. No patient had a poor functional outcome.

Fig 2 Distribution of patients according to hip range of motion at final follow-up after PFN-A fixation.

Overall, 78.7% of patients had an uneventful postoperative recovery without complications. Superficial surgical site infection and hip stiffness were the most common complications, each occurring in 5.3% of patients, followed by cut-out/Z-effect (3.2%), deep vein thrombosis (2.1%), screw back-out (2.1%), reverse Z-effect (1.1%), deep infection (1.1%), and non-union (1.1%).

Inferential analysis demonstrated a significant association between AO/OTA fracture type and time to radiological union (p<0.001), with more complex fracture patterns requiring longer healing periods.

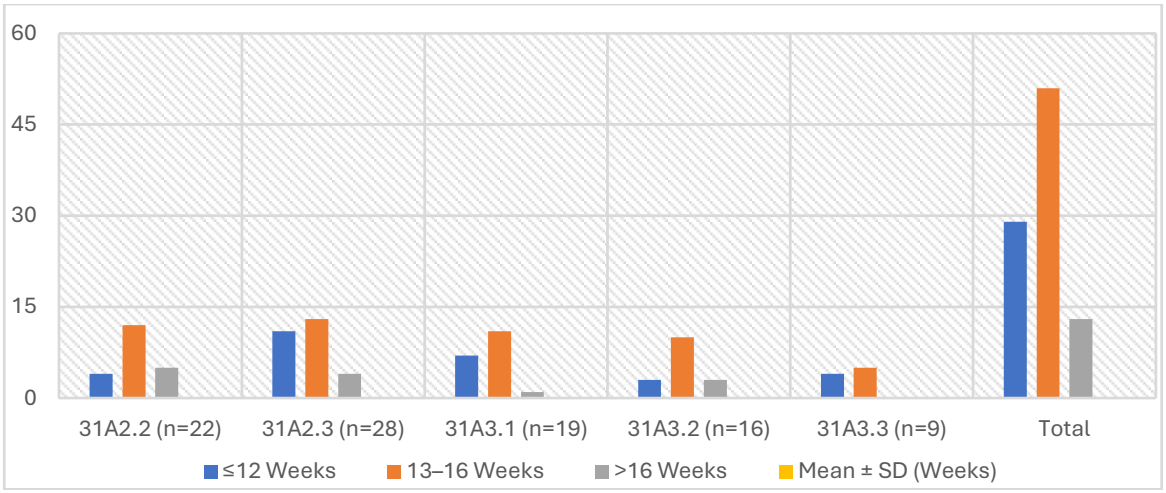

Fig 3. Association between AO/OTA fracture classification and time to radiological union following PFN-A fixation.

Patients with a tip-apex distance <25 mm achieved significantly superior functional outcomes than those with a larger tip-apex distance (p=0.049). Osteoporosis was significantly associated with a higher incidence of postoperative complications (p=0.005), while increasing age, particularly >80 years, was associated with poorer functional outcomes (p=0.009). Although anatomical reduction was associated with a trend toward better functional outcomes, this relationship did not reach statistical significance (p>0.05).

Table 3 Factors Associated with Outcome

Variable	p-value	Interpretation
AO classification vs Functional outcome	0.872	Not significant
AO classification vs Union time	<0.001	Significant
Reduction quality vs Functional outcome	0.064	Not significant
TAD vs Functional outcome	0.049	Significant
Osteoporosis vs Complications	0.005	Significant
Age vs Functional outcome	0.009	Significant

Overall, PFN-A provided excellent rates of fracture union, favorable functional recovery, reliable fracture stabilization, and a low complication rate in the management of unstable intertrochanteric femur fractures, demonstrating particular effectiveness in elderly patients with osteoporotic bone.

DISCUSSION

Unstable intertrochanteric fractures remain a major cause of morbidity among the elderly because of osteoporosis, fracture instability, and associated comorbidities. In the present prospective study, PFN-A provided excellent radiological union (97.9%), favorable functional recovery, and a low complication rate, supporting its effectiveness in managing unstable intertrochanteric fractures[2,3].

The study population predominantly comprised elderly patients (mean age 73.2 ± 7.8 years) with a female predominance, and trivial fall was the leading mechanism of injury. These findings are consistent with the established epidemiology of hip fractures and previous studies by Cooper et al.[2], Kanis et al.[3], Swaroop et al.[14], Murugan et al.[15], and Sharma BD et al.[16], which reported similar demographic characteristics in patients with unstable intertrochanteric fractures.

Radiological union was achieved in 97.9% of patients, with a mean union time of 14.6 ± 3.2 weeks, comparable with the high union rates reported by Simmermacher et al.[17], Mereddy et al.[18], Murugan et al.[15], and Avate et al.[19] The excellent union rate observed can be attributed to the biomechanical advantages of PFN-A, including intramedullary load sharing, rotational stability provided by the helical blade, and preservation of fracture biology through minimally invasive fixation.

Functional outcomes were equally encouraging, with 90.5% of patients achieving excellent or good Harris Hip Scores, accompanied by excellent restoration of hip motion. These findings are consistent with previous prospective studies demonstrating that PFN-A facilitates early mobilization and reliable recovery of hip function in unstable fracture patterns[20]. Postoperative complications were infrequent, with 78.7% of patients experiencing an uneventful recovery. Superficial infection, hip stiffness, and implant-related complications occurred in only a small proportion of patients, reflecting the safety and reliability of PFN-A when accurate reduction and optimal implant positioning are achieved[21].

Inferential analysis identified several important prognostic factors. Increasing fracture complexity was associated with delayed radiological union, while a tip-apex distance <25 mm resulted in significantly better functional outcomes. Osteoporosis was significantly associated with postoperative complications, and advancing age adversely affected functional recovery.[22,23] These findings emphasize that, in addition to implant selection, meticulous surgical technique, optimal reduction, accurate blade placement, and comprehensive osteoporosis management are critical determinants of successful outcomes.

Overall, the findings of the present study are consistent with contemporary literature and support PFN-A as an effective treatment for unstable intertrochanteric fractures, providing high union rates, excellent functional recovery, and a low incidence of complications, particularly in elderly patients with osteoporotic bone.

CONCLUSION

Proximal Femoral Nail Antirotation (PFN-A) is a safe and effective treatment for unstable intertrochanteric fractures, providing a high radiological union rate (97.9%), excellent-to-good functional outcomes (90.5%), and a low complication rate. Better outcomes were associated with a tip-apex distance <25 mm, while advancing age and osteoporosis adversely affected recovery. PFN-A can be recommended as the implant of choice for unstable intertrochanteric fractures, particularly in elderly osteoporotic patients, provided that accurate reduction, optimal implant positioning, and appropriate postoperative rehabilitation are ensured.

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