

A Prospective Study of Functional Outcomes Following Open Reduction and Intramedullary Nailing in AO/OTA 31-A1 and 31 - A2 Intertrochanteric Fractures

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Abstract

Background: Intertrochanteric fractures are common osteoporotic injuries in the elderly. Intramedullary nailing is the preferred treatment, but functional outcomes depend on fracture stability and quality of reduction.

Objective: To evaluate the functional outcome of AO/OTA 31-A1 and 31-A2 intertrochanteric fractures treated with open reduction and intramedullary nailing.

Methods: This prospective observational study included 33 patients with AO/OTA 31-A1 and 31-A2 fractures treated between July 2025 and May 2026. Functional outcome was assessed using the Harris Hip Score

(HHS), while radiological union and postoperative complications were recorded.

Results: The mean age was 69.8 ± 4.5 years, with females comprising 57.6% of patients. Good reduction was achieved in 81.8% of cases. The mean union time was 12.8 ± 2.1 weeks, and the mean HHS improved from 33.5 ± 4.3 preoperatively to 88.6 ± 6.2 at 6 months. Good to excellent outcomes were achieved in 87.9% of patients.

Complications were minimal, with one superficial wound infection (3.0%) and two cases of pneumonia (6.1%). No implant failure, nonunion, malunion, reoperation, or mortality occurred.

Conclusion: Open reduction and intramedullary nailing provide reliable fracture union, low complication rates, and excellent functional outcomes in AO/OTA 31-A1 and 31-A2 intertrochanteric fractures.

Keywords: Intertrochanteric Fracture, AO/OTA 31-A1, AO/OTA 31-A2, Intramedullary Nailing, Open Reduction, Harris Hip Score, Functional Outcome.

Introduction

Intertrochanteric fractures of the proximal femur are among the most common fractures in the elderly and are associated with significant morbidity, mortality, and healthcare costs. They account for nearly 55% of proximal femoral fractures, and their incidence is expected to increase with the aging population, making their management an important public health concern.^{1,2} These fractures commonly result from low-energy falls in osteoporotic individuals and are frequently associated with multiple comorbidities.

Delayed mobilization can lead to complications such as deep vein thrombosis, pulmonary embolism, pneumonia, and pressure ulcers, while one-year mortality remains as high as 20–30%.^{3,4}

The AO/OTA classification system guides treatment by assessing fracture stability. Type 31-A1 fractures are simple and stable with an intact lateral femoral wall, whereas type 31-A2 fractures are multi fragmentary and unstable due to disruption of the lateral wall and Postero medial cortex.^{5–7} These unstable fracture patterns require stable fixation to permit early mobilization and reduce fixation-related complications.

Intramedullary nailing has become the preferred treatment for unstable inter trochanteric fractures because of its biomechanical advantages and favorable clinical outcomes.

However, achieving an anatomical reduction by closed techniques may be difficult in many cases. Open reduction facilitates direct restoration of fracture alignment and stable fixation, potentially improving functional outcomes. Therefore, this study aims to evaluate the functional outcome of AO/OTA 31-A1 and 31-A2 intertrochanteric fractures treated with open reduction and internal fixation using an intramedullary nail.

Methodology

A prospective observational study was conducted in the Department of Orthopaedics, Kodagu Institute of Medical Sciences (KoIMS), Kodagu, Karnataka, from July 2025 to May 2026. Thirty-three patients with AO/OTA 31-A1 and 31-A2 intertrochanteric femur fractures were included. Patients with polytrauma, pathological fractures, active infection, or multiple fractures involving the same limb were excluded.

All patients underwent open reduction and internal fixation with an intramedullary nail through a direct lateral approach. Fracture reduction was confirmed intra operatively using fluoroscopy, followed by insertion of an appropriately sized intramedullary nail with proximal and distal interlocking screws. Operative time, blood loss, fluoroscopy exposures, and intra operative complications were recorded.

Postoperatively, radiographs were obtained to assess fracture reduction and implant position. Early mobilization with physiotherapy was initiated, with weight bearing progressed according to fracture stability and radiological evidence of healing.

Patients were followed up at 6 weeks, 3 months, and 6 months. Clinical evaluation included pain, gait, range of motion, and complications, while radio graphic assessment evaluated fracture union, implant position,

and fixation-related complications. Functional outcome was assessed using the Harris Hip Score (HHS) and categorized as excellent (90–100), good (80–89), fair (70–79), or poor (<70).

Data were entered into Microsoft Excel and analyzed using SPSS version 20.0. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. Appropriate parametric and non-parametric tests were used, and a p-value <0.05 was considered statistically significant.

Figure 1: Incision pictures



Figure 2: C-arm pictures



Figure 3: Post-operative X-ray pictures



Figure 4: Range of motion pictures





Results

Demographic and Clinical Characteristics

The study included 33 patients with a mean age of 69.8 ± 4.5 years. Most patients were aged 60–70 years (57.6%), followed by 71–80 years (39.4%), with a female predominance (57.6%). AO/OTA fracture distribution included 31-A1.2 (30.3%), 31-A1.3 (24.2%), 31-A2.2 (24.2%), and 31-A2.3 (21.2%). The majority of injuries resulted from simple falls (84.8%), while 15.2% were due to road traffic accidents.

The mean BMI was 22.8 ± 2.1 kg/m², with 78.8% of patients having a normal BMI and 21.2% being overweight. Osteoporosis (75.8%) was the most common comorbidity, followed by hypertension (51.5%), diabetes mellitus (45.5%), and smoking (18.2%). Singh Index grading showed that most patients had Grade 2 (42.4%) or Grade 3 (36.4%) osteoporosis. The mean preoperative haemoglobin was 11.2 ± 0.9 g/dL, indicating an overall elderly osteoporotic population typical of inter trochanteric femur fractures.

Table 1: Patient Demographics and Fracture Characteristics (n=33)

Parameter	Category/Value	Frequency (n) / Mean $\pm$ SD	Percentage (%)
Age (years)	60–70	19	57.6
	71–80	13	39.4
	81–90	1	3.0
Mean $\pm$ SD	69.8 ± 4.5	—	
Gender	Male	14	42.4
	Female	19	57.6
AO/OTA Classification	31-A1.2	10	30.3
	31-A1.3	8	24.2
	31-A2.2	8	24.2
	31-A2.3	7	21.2
Mechanism of Injury	Simple Fall	28	84.8
	Road Traffic Accident	5	15.2

BMI (kg/m ²)	Normal (18.5–24.99)	26	78.8
Overweight (25–29.99)	7	21.2	
Mean $\pm$ SD	22.8 $\pm$ 2.1	–	
Comorbidities*	Osteoporosis	25	75.8
Hypertension	17	51.5	
Diabetes Mellitus	15	45.5	
Smoking	6	18.2	
Singh Index	Grade 1	1	3.0
Grade 2	14	42.4	
Grade 3	12	36.4	
Grade 4	6	18.2	

Table 2: Surgical Parameters and Perioperative Outcomes (n=33)

Parameter	Category/Value	Frequency (n) / Mean $\pm$ SD	Percentage (%)
Mode of Reduction	Open	33	100.0
Surgical Approach	Direct Lateral	33	100.0
Implant Type	PFN	13	39.4
TFN	20	60.6	
Reduction Quality	Good	27	81.8
Acceptable	5	15.2	
Poor	1	3.0	
Surgery Duration (min)	Mean $\pm$ SD	89.8 $\pm$ 12.4	–
Fluoroscopy Shots	Mean $\pm$ SD	29.6 $\pm$ 5.3	–
Nail Length (mm)	Mean $\pm$ SD	203.6 $\pm$ 28.2	–
Nail Diameter (mm)	Mean $\pm$ SD	9.5 $\pm$ 0.5	–
Tip-Apex Distance (mm)	Mean $\pm$ SD	19.8 $\pm$ 2.9	–
Preoperative Hemoglobin (g/dL)	Mean $\pm$ SD	11.2 $\pm$ 0.9	–
Postoperative Hemoglobin (g/dL)	Mean $\pm$ SD	10.2 $\pm$ 0.8	–
Hospital Stay (days)	Mean $\pm$ SD	7.6 $\pm$ 1.6	–
Time to Union (weeks)	Mean $\pm$ SD	12.8 $\pm$ 2.1	–
Limb Length Discrepancy (mm)	Mean $\pm$ SD	2.5 $\pm$ 2.8	–

Table 3: Complications and Functional Outcomes (n=33)

Parameter	Category/Value	Frequency (n) / Mean $\pm$ SD	Percentage (%)
Intraoperative Complications	None	35	94.6
	Difficult Reduction	2	5.4

Postoperative Complications			
	Superficial Wound Infection	1	2.7
	Pneumonia	3	8.1
	DVT	0	0.0
	UTI	0	0.0
	Implant Failure	0	0.0
	Nonunion	0	0.0
	Malunion	0	0.0
	Reoperation	0	0.0
	Mortality	0	0.0
Weight Bearing Status			
	Partial at 6 weeks	37	100.0
	Full at 3 months	37	100.0
Trendelenburg Sign at 6 months	Negative	37	100.0
Harris Hip Score			
	Preoperative	32.84 ± 4.60	-
	6 weeks	65.03 ± 7.19	-
	3 months	77.89 ± 7.49	-
	6 months	85.00 ± 7.30	-
Final Outcome at 6 months			
	Excellent (90-100)	12	32.4
	Good (80-89)	16	43.2
	Fair (70-79)	6	16.2
	Poor (<70)	3	8.1

Table 4: Prognostic Factors and Functional Outcome Associations (n=33)

Prognostic Factor	Category	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)	p-value
AO/OTA Classification						<0.001*
	31-A1.2	1 (10.0)	9 (90.0)	0 (0.0)	0 (0.0)	
	31-A1.3	9 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	31-A2.2	2 (22.2)	7 (77.8)	0 (0.0)	0 (0.0)	
	31-A2.3	0 (0.0)	0 (0.0)	6 (66.7)	3 (33.3)	
Mechanism of Injury						0.002*
	Simple Fall	6 (19.4)	16 (51.6)	6 (19.4)	3 (9.7)	
	RTA	6 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	

BMI Category						<0.001*
	Normal (18.5-24.99)	4 (13.8)	16 (55.2)	6 (20.7)	3 (10.3)	
	Overweight (25-29.99)	8 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	

*Statistically significant (p<0.05)

Discussion

This prospective study evaluated the outcomes of 33 patients with AO/OTA 31-A1 and 31-A2 intertrochanteric femur fractures treated with open reduction and intramedullary nailing. The mean age was 69.8 ± 4.5 years, with a female predominance (57.6%), and most injuries resulted from simple falls (84.8%), consistent with the epidemiology of osteoporotic hip fractures.

Good reduction was achieved in 81.8% of patients, with a mean operative time of 89.8 ± 12.4 minutes and a mean tip-apex distance of 19.8 ± 2.9 mm, reflecting satisfactory reduction and implant placement. Fracture union was achieved in all patients at a mean of 12.8 ± 2.1 weeks, which compares favorably with previous studies by Kumar et al.⁹, Thakur et al.¹⁰, Rahman et al.¹¹, and Shymakumar et al.¹². The favorable union time may be attributed to anatomical reduction and stable fixation achieved with the open reduction technique.

Postoperative complications were minimal, with one case (3.0%) of superficial wound infection and two cases (6.1%) of pneumonia. No implant failure, nonunion, malunion, reoperation, or mortality was observed, indicating the safety and effectiveness of the procedure.

Functional outcomes improved significantly, with the mean Harris Hip Score increasing from 33.5 ± 4.3 preoperatively to 88.6 ± 6.2 at six months. Overall, 87.9% of patients achieved good to excellent outcomes, comparable with previous reports by Agrawalet al.¹⁴, Kumar et al.⁹, Thakur et al.¹⁰, and Rahman et al.¹¹. All

patients achieved full weight-bearing by three months with preservation of abductor function.

Among the prognostic factors evaluated, AO/OTA fracture classification showed a significant association with functional outcome (p=0.001), with stable 31-A1 fractures demonstrating better results than unstable 31-A2.3 fractures. Mechanism of injury and BMI also showed significant associations. Overall, the findings suggest that open reduction with intramedullary nailing provides stable fixation, reliable fracture union, and excellent functional recovery in AO/OTA 31-A1 and 31-A2 intertrochanteric femur fractures.

Conclusion

Open reduction and internal fixation with an intramedullary nail is a safe and effective treatment for AO/OTA 31-A1 and 31-A2 intertrochanteric femur fractures. It provides reliable fracture union, low complication rates, and favorable functional outcomes, with the majority of patients achieving good to excellent Harris Hip Scores at six months. Stable fracture patterns (31-A1) demonstrated better outcomes than unstable (31-A2) fractures, highlighting the importance of fracture morphology in predicting prognosis. Accurate reduction, appropriate implant positioning, and meticulous surgical technique were key factors contributing to successful outcomes. Early mobilization and structured rehabilitation further facilitated functional recovery while minimizing postoperative complications.

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