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Functional Outcome Of Unstable Trochanteric Fractures Fixed Using Proximal Femoral Nail (Pfn)

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Abstract
Background: *Unstable trochanteric fractures are a frequent cause of morbidity, particularly in the elderly, due to poor bone quality and high biomechanical stresses. Proximal femoral nails (PFN) have gained popularity over sliding hip screws owing to biomechanical advantages, but outcomes in unstable patterns remain an area of active investigation. This study aimed to evaluate functional outcomes, complications, and prognostic factors in unstable trochanteric fractures managed with PFN.*
Methods: *A prospective observational study was conducted on 45 patients with unstable trochanteric fractures (Boyd and Griffin Type III/IV; AO/OTA 31-A2.2, A2.3, A3.2) treated with PFN between February 2023 and February 2025. Demographic data, comorbidities, and fracture classifications were documented. Surgeries followed a standardized technique, and patients were followed up at admission, 1 month, and 3 months. Functional outcomes were assessed using the Modified Harris Hip Score (MHHS). Complications and associations between injury mechanism and outcome were analysed.*
Results: *The mean age was 61.4 years, with a male predominance (68.9%). Right-sided fractures were more common (60%), and falls were the most frequent cause of injury (37.8%). By Boyd and Griffin classification, Type III fractures predominated (57.8%), while AO/OTA classification showed 31-A2.2 as most common (40%). At admission, all patients had poor MHHS. By three months, 48.8% achieved good, 22.2% excellent, and 28.9% fair outcomes. The complication rate was 11.1% (malunion 6.7%, non-union 4.4%), with no implant failures. A statistically significant association (p = 0.04) was observed between mode of injury and functional outcome, with "other" mechanisms showing the highest proportion of excellent results.*
Conclusion: *PFN provides stable fixation and favourable early outcomes in unstable trochanteric fractures, with 71% of patients achieving good to excellent function by three months. Complication rates were low, and outcomes were significantly influenced by mechanism of injury. PFN should be considered the preferred implant in these challenging fracture patterns, though longer-term studies are required to confirm durability of outcomes.*
Keywords: *Gallstones, Cholelithiasis, Endoscopy, Digestive System, Ultrasonography, Postcholecystectomy Syndrome, Gastritis, Duodenitis, Esophagitis, Hiatal Hernia, Dyspepsia, Abdominal Pain*

INTRODUCTION:

Trochanteric fractures of the proximal femur represent a major clinical and public health challenge, particularly in aging populations. They account for nearly half of all proximal femoral fractures and are associated with high morbidity, mortality, and healthcare costs. The global incidence of hip fractures is projected to reach 6.3 million by 2050, with intertrochanteric patterns contributing a substantial proportion [1]. Unstable trochanteric fractures, characterized by posteromedial comminution, reverse obliquity, or subtrochanteric extension, are biomechanically complex and prone to fixation failure, malunion, and poor functional recovery [2].
Historically, extramedullary devices such as the sliding hip screw (SHS) were considered the gold standard for these fractures. However, in unstable patterns, SHS has been associated with excessive collapse, medialization of the femoral shaft, and higher implant failure rates [3]. The introduction of intramedullary devices, particularly

the Proximal Femoral Nail (PFN), has provided biomechanical advantages including a shorter lever arm, load-sharing properties, and enhanced rotational stability through dual proximal locking [4,5]. These features, combined with a minimally invasive approach, allow earlier mobilization and reduced perioperative morbidity, which are critical in elderly and comorbid patients [6].
Despite these theoretical benefits, the superiority of PFN over other fixation devices in terms of long-term functional outcomes remains debated. Meta-analyses have shown mixed results, with some studies reporting clear advantages of intramedullary fixation in unstable fracture patterns [7,8], while others suggest comparable outcomes with SHS in stable fractures [9]. Furthermore, functional recovery is influenced not only by the implant but also by patient age, comorbidities, injury mechanism, and rehabilitation potential.
Given these uncertainties, evaluating PFN outcomes in specific clinical contexts remains important. The present prospective study was undertaken at a tertiary care teaching hospital in South India to assess the functional outcomes of unstable trochanteric fractures treated with PFN, with particular emphasis on Modified Harris Hip Score (MHHS), complications, and the influence of injury mechanism on recovery.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics, Adichunchanagiri Hospital and Research Centre, B.G. Nagara, Karnataka, between February 2023 and February 2025. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement, and all patients provided written informed consent in accordance with the Declaration of Helsinki.

Sample Size and Selection

The sample size was calculated using the formula

$$n = \frac{z^2pq}{d^2},$$

where z = 1.96, p = 15% prevalence, q = 1–p, and d = 15% allowable error, yielding 45 patients.
Inclusion criteria were patients above 18 years of age presenting with acute (<1 week) unstable trochanteric fractures, both displaced and undisplaced, without associated fractures. **Exclusion criteria** were pathological fractures, old malunited or non-united intertrochanteric fractures, and fractures with arthritic changes in the ipsilateral hip joint.

Preoperative Evaluation

Demographic data, comorbidities, and pre-fracture mobility status were recorded in a standardized proforma. The mechanism of injury was categorized as low-energy trauma (fall from standing height) or high-energy trauma (road traffic accidents, falls from height). Standard anteroposterior and lateral radiographs of the hip and femur were obtained, with computed tomography performed selectively for complex cases. Fractures were classified according to Boyd and Griffin [10] and AO/OTA classification systems [11].
Preoperative optimization included correction of anemia (hemoglobin ≥10 g/dL), stabilization of comorbidities, and deep vein thrombosis (DVT) prophylaxis with low molecular weight heparin unless contraindicated.

Surgical Procedure

All surgeries were performed under spinal or general anesthesia on a fracture table. Closed reduction was attempted under fluoroscopic guidance. A standard Proximal Femoral Nail (PFN) (130°–135°, 9–12 mm diameter, 36–42 cm length) was inserted through a greater trochanteric entry point after reaming. Proximal fixation was achieved with an 8 mm lag screw and a 6.5 mm anti-rotation hip pin, while distal locking was performed in static or dynamic mode depending on fracture stability [12].
Intraoperative parameters including operative time, blood loss, fluoroscopy time, and reduction quality were documented. Acceptable reduction was defined as varus–valgus angulation <10°, displacement <5 mm, and restoration of the neck–shaft angle within 5° of the contralateral side, with a tip–apex distance <25 mm considered optimal [13].
Figure A illustrates the surgical steps of PFN fixation, Figure B shows the PFN implant design, and Figure C demonstrates the instrumentation used.

Postoperative Care and Rehabilitation

Patients received prophylactic antibiotics for 24–48 hours. Mobilization was initiated on the first postoperative day, progressing from bed-to-chair transfers to partial weight-bearing as tolerated. Physiotherapy included range-of-motion exercises, quadriceps strengthening, gait training, and balance exercises.

Follow-up was conducted at 2 weeks, 1 month, 3 months, 6 months, and 12 months. At each visit, clinical assessment included pain (VAS), hip range of motion, and functional status, while radiographs were evaluated for implant position and union.

Outcome Measures

The primary outcome was functional recovery assessed by the Modified Harris Hip Score (MHHS) [14]. Scores were categorized as excellent (90–100), good (80–89), fair (70–79), and poor (<70). Secondary outcomes included complications (malunion, non-union, implant failure, wound infection, DVT), hospital stay, and radiological union (defined as bridging callus on at least three cortices with painless weight-bearing).

Statistical Analysis

Data were analyzed using SPSS v26.0 (IBM Corp., Armonk, NY). Continuous variables were presented as mean ± standard deviation and categorical variables as frequencies and percentages. Associations between functional outcomes and categorical variables (e.g., mechanism of injury) were tested using the Chi-square test. A *p*-value <0.05 was considered statistically significant.

RESULTS

The present study included 45 patients with unstable trochanteric fractures treated with a proximal femoral nail (PFN). All patients were followed up for at least three months, and functional outcomes were evaluated using the Modified Harris Hip Score (MHHS).

Demographics

The mean age of the study population was 61.4 years (range 20–90 years). Distribution by age revealed that the largest group was 41–60 years (31.1%), followed by 61–80 years (24.4%) and >80 years (24.4%). The youngest age group, 20–40 years, constituted 20% of the sample (Table 1, Figure 1).

There was a male predominance, with 31 males (68.9%) compared to 14 females (31.1%) (Table 2, Figure 2).

Laterality analysis showed that fractures were more common on the right side (60%) compared to the left (40%) (Table 3, Figure 3).

Mechanism of Injury and Comorbidities

The most common mechanism of injury was a simple fall (37.8%), typically in the elderly population, followed by road traffic accidents (28.9%), which predominated among younger patients. Other mechanisms (such as falls from height and direct trauma) accounted for 33.3% of cases (Table 4, Figure 4).

One-third of the patients (33.4%) had no associated comorbidities. Among those with comorbidities, diabetes mellitus (26.7%) and coronary artery disease (26.7%) were equally common, while hypertension was observed in 13.3% (Table 5, Figure 5).

Fracture Classification

According to the Boyd and Griffin classification [15], Type III fractures were the most frequent (26 cases, 57.8%), followed by Type IV fractures (19 cases, 42.2%) (Table 6, Figure 6).

By AO/OTA classification [16], the majority of fractures were 31-A2.2 (40%), followed by 31-A2.3 (31.1%) and 31-A3.2 (28.9%) (Table 7, Figure 7).

Functional Outcomes

At admission, all patients (100%) had poor MHHS scores. By the first postoperative month, functional improvement was evident, with 37.7% improving to fair, while the remaining 62.2% still had poor outcomes. At the third month, functional recovery was significantly better: 48.8% achieved good outcomes, 22.2% excellent, and 28.9% fair outcomes, with no patient remaining in the poor category (Table 8, Figure 8).

This pattern reflects a steady and progressive improvement in mobility, pain, and hip function with time following PFN fixation.

Complications

The overall complication rate was 11.1%. Malunion occurred in three patients (6.7%), manifesting as varus deformity and limb shortening. Non-union occurred in two patients (4.4%). The majority (88.9%) had no complications. Importantly, there were no cases of implant cut-out, Z-effect, screw back-out, or nail breakage (Table 9, Figure 9).

Association Between Mechanism of Injury and Outcome

Statistical analysis demonstrated a significant association between the mode of injury and functional outcome at three months (p = 0.04). Patients injured by “other” mechanisms (e.g., fall from height, direct trauma) had the highest proportion of excellent outcomes (60%). Patients with fall-related injuries showed mostly good outcomes (59.1%), while road traffic accident cases displayed more variability, with 30% excellent, 22.7% good, and 38.5% fair outcomes (Table 10, Figure 10).

Representative Cases

To highlight typical outcomes, representative radiographic images are shown:

- **Case 1:** Pre-operative radiograph demonstrating an unstable trochanteric fracture (Figure D) and six-month postoperative radiograph showing union following PFN fixation (Figure E).
- **Case 2:** Pre-operative radiograph of an unstable fracture (Figure F) and postoperative radiograph at six months showing good consolidation (Figure G).
- **Case 3:** Pre-operative radiograph of a complex unstable fracture (Figure H) and postoperative radiograph showing satisfactory healing at six months (Figure I).

DISCUSSION

Trochanteric fractures of the proximal femur remain a significant orthopedic challenge, particularly unstable patterns with comminution or reverse obliquity that predispose to fixation failure [17,18]. Intramedullary devices such as the proximal femoral nail (PFN) have gained preference over sliding hip screws, owing to biomechanical advantages including a shorter lever arm and enhanced rotational stability [19,20].

In this study, the mean age was 61.4 years, with the largest group between 41 and 60 years. Male predominance (68.9%) contrasts with Western reports where elderly women are most affected due to osteoporosis [21]. Indian series such as Kumar et al. [22] similarly noted male predominance, reflecting the higher incidence of high-energy trauma in this demographic. The mechanism of injury displayed a bimodal pattern: low-energy falls in the elderly and road traffic accidents in younger patients, consistent with findings by Gadegone and Salphale [23].

Fracture distribution showed a majority of Boyd and Griffin Type III and AO/OTA 31-A2.2 subtypes, both inherently unstable [24,25]. Ozkan et al. [26] also reported predominance of A2 patterns among unstable fractures, underscoring their clinical importance.

Functional recovery was encouraging: at three months, 71% of patients achieved good to excellent outcomes using the Modified Harris Hip Score [27]. This aligns with results from Gadegone and Salphale [28], who reported 82% good-to-excellent outcomes, and Kashid et al. [29], who observed 76%. More recent studies echo these trends: Agrawal et al. [30] documented steady recovery with both short and long PFNs, while Kumar et al. [31] demonstrated high scores with no major complications. Although slightly lower percentages were noted here, this is likely due to shorter follow-up, as maximum functional recovery is often reached between 6 and 12 months [32].

Complications were minimal, with malunion (6.7%) and non-union (4.4%) comprising the total 11.1%. These rates are favorable compared to Fogagnolo et al. [33], who reported 23.4%, and Domingo et al. [34], who noted 17%. Importantly, there were no cases of implant cut-out, Z-effect, or breakage, complications often attributed to poor technique or excessive tip–apex distance [35]. This highlights the value of meticulous intraoperative technique.

A novel aspect of this study was the significant association between mechanism of injury and outcome at three months ($p = 0.04$). Patients with injuries from "other" causes (falls from height, direct trauma) had the highest proportion of excellent outcomes (60%), while falls produced predominantly good outcomes, and road traffic accidents yielded more variable recovery. This finding resonates with Parker and Handoll [36], who emphasized pre-injury status as a determinant of recovery, and Tucker et al. [37], who showed that high-energy trauma leads to complex fracture patterns with slower recovery.

Overall, these results reinforce PFN as a reliable option for unstable trochanteric fractures. Its biomechanical properties support early mobilization and favorable outcomes across varied patient groups. At the same time, the mechanism of injury emerges as an important prognostic factor, warranting consideration during counseling and rehabilitation planning. Limitations include the relatively short follow-up, absence of a control group, and single-center design. Future studies should extend follow-up, compare PFN with other intramedullary devices, and explore the role of osteoporosis severity and posteromedial comminution in predicting outcomes.

CONCLUSION

The present study demonstrates that the proximal femoral nail (PFN) is a safe, reliable, and effective implant for the management of unstable trochanteric fractures. It provides stable fixation that permits early mobilization and leads to favorable functional recovery in the majority of patients. At the three-month follow-up, 71% of patients achieved good to excellent outcomes according to the Modified Harris Hip Score, with no cases remaining in the poor category. The complication rate was low, limited to malunion and non-union in a small proportion of patients, and there were no implant-related mechanical failures such as screw cut-out or breakage. An important finding was the significant association between the mechanism of injury and functional recovery, with patients injured by causes other than simple falls or road traffic accidents showing the highest proportion of excellent results. These observations highlight the role of PFN as a preferred fixation device in unstable fracture patterns and emphasize the importance of considering injury mechanism in prognostication and rehabilitation planning. While the short follow-up period and single-center design are limitations, the study provides strong evidence for the use of PFN in unstable trochanteric fractures and underscores the need for longer-term, comparative studies to validate these results.

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Table 1. Age distribution of patients with unstable trochanteric fractures (n = 45).

Age group (years)	Frequency	Percentage
20–40	9	20.0%
41–60	14	31.1%
61–80	11	24.4%
>80	11	24.4%
Total	**45**	100%

Table 2. Gender distribution of patients (n = 45).

Gender	Frequency	Percentage
Male	31	68.9%
Female	14	31.1%
Total	**45**	100%

Table 3. Laterality of fractures (n = 45).

Side	Frequency	Percentage
Right	27	60.0%
Left	18	40.0%
Total	**45**	100%

Table 4. Mode of injury (n = 45).

Mode of injury	Frequency	Percentage
Fall	17	37.8%
Road traffic accident (RTA)	13	28.9%
Others (fall from height, direct trauma)	15	33.3%
Total	**45**	100%

Table 5. Distribution of comorbidities (n = 45).

Comorbidity	Frequency	Percentage
Diabetes mellitus (DM)	12	26.7%
Hypertension (HTN)	6	13.3%
Coronary artery disease (CAD)	12	26.7%
None	15	33.4%
Total	**45**	100%

Table 6. Boyd and Griffin classification of fractures (n = 45).

Type	Frequency	Percentage
Type III	26	57.8%
Type IV	19	42.2%
Total	**45**	**100%**

Table 7. AO/OTA classification of fractures (n = 45).

Type	Frequency	Percentage
31-A2.2	18	40.0%
31-A2.3	14	31.1%
31-A3.2	13	28.9%
Total	**45**	**100%**

Table 8. Functional outcome progression based on Modified Harris Hip Score (MHHS).

MHHS Category	Admission	1 Month	3 Months
Poor (<70)	45 (100%)	28 (62.2%)	–
Fair (70–79)	–	17 (37.7%)	13 (28.9%)
Good (80–89)	–	–	22 (48.8%)
Excellent (90–100)	–	–	10 (22.2%)

Table 9. Complications following PFN fixation (n = 45).

Complication	Frequency	Percentage
Malunion	3	6.7%
Non-union	2	4.4%
None	40	88.9%
Total	**45**	**100%**

Table 10. Association of mode of injury with functional outcome at 3 months.

Mode of injury	Fair	Good	Excellent	*p*-value
Fall	3 (23.1%)	13 (59.1%)	1 (10.0%)	
RTA	5 (38.5%)	5 (22.7%)	3 (30.0%)	0.04*
Others	5 (38.5%)	4 (18.2%)	6 (60.0%)	
Total	**13 (100%)**	**22 (100%)**	**10 (100%)**	

*Significant at $p < 0.05$.

Figures

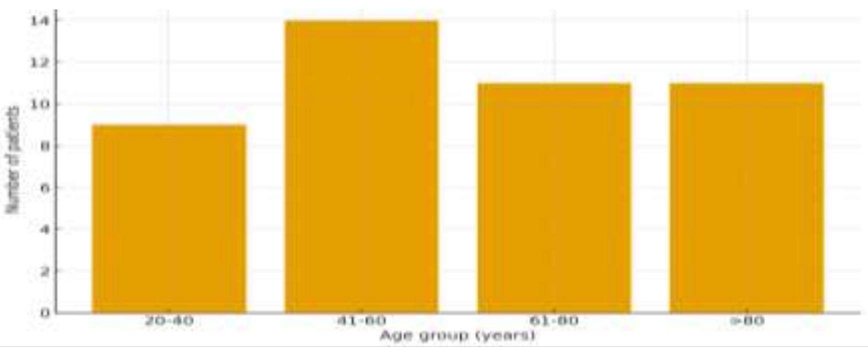

Figure 1. Age distribution of patients with unstable trochanteric fractures (n = 45).

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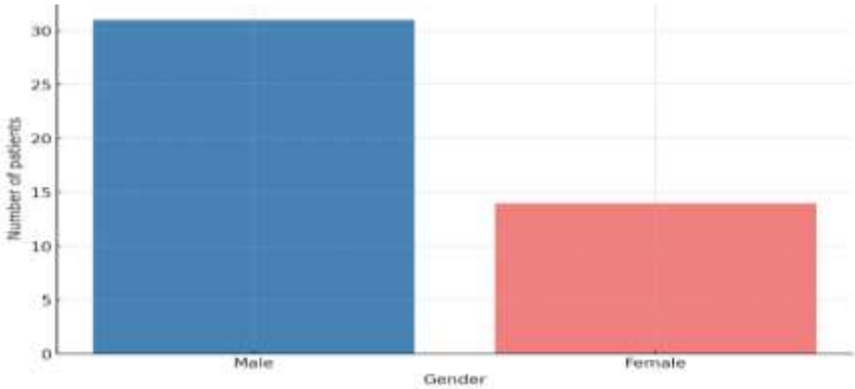

Figure 2. Gender distribution of patients (n = 45).

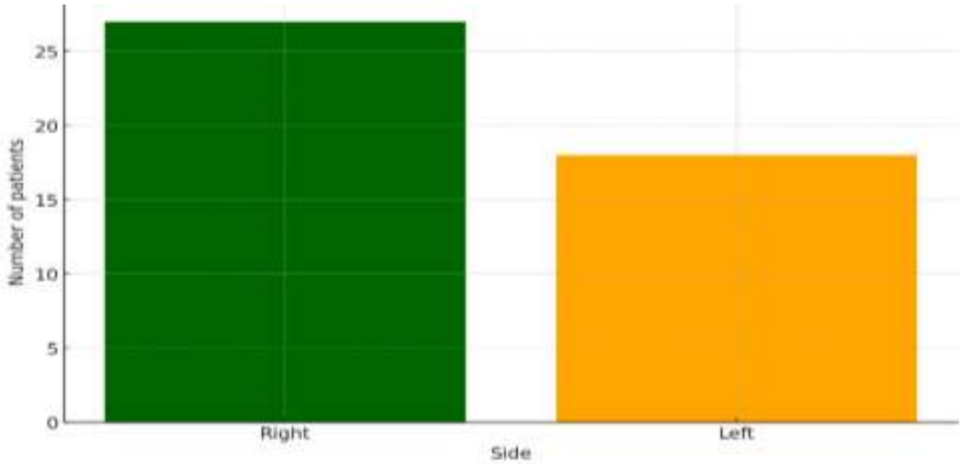

Figure 3. Laterality of fractures (n = 45).

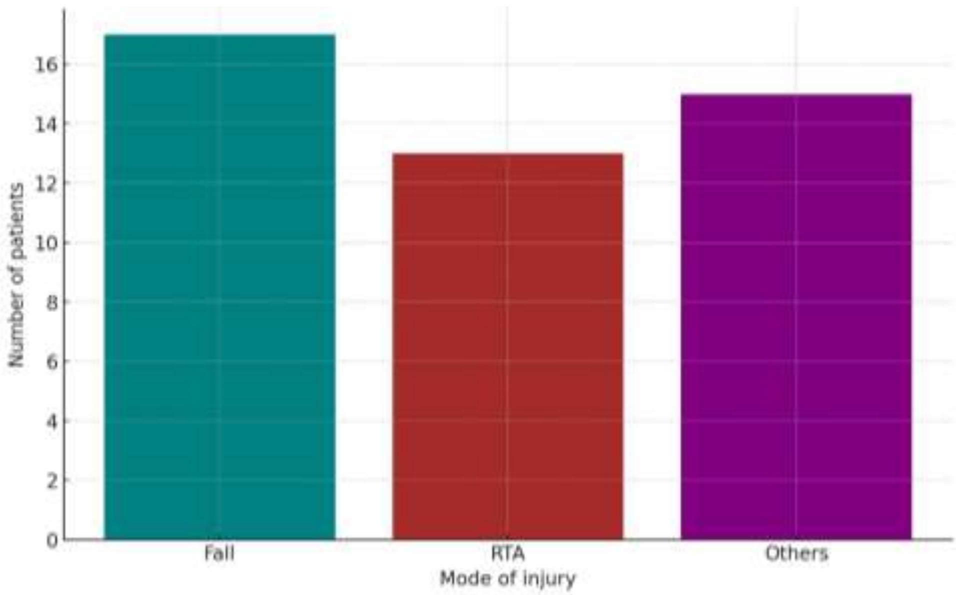

Figure 4. Mode of injury (n = 45).

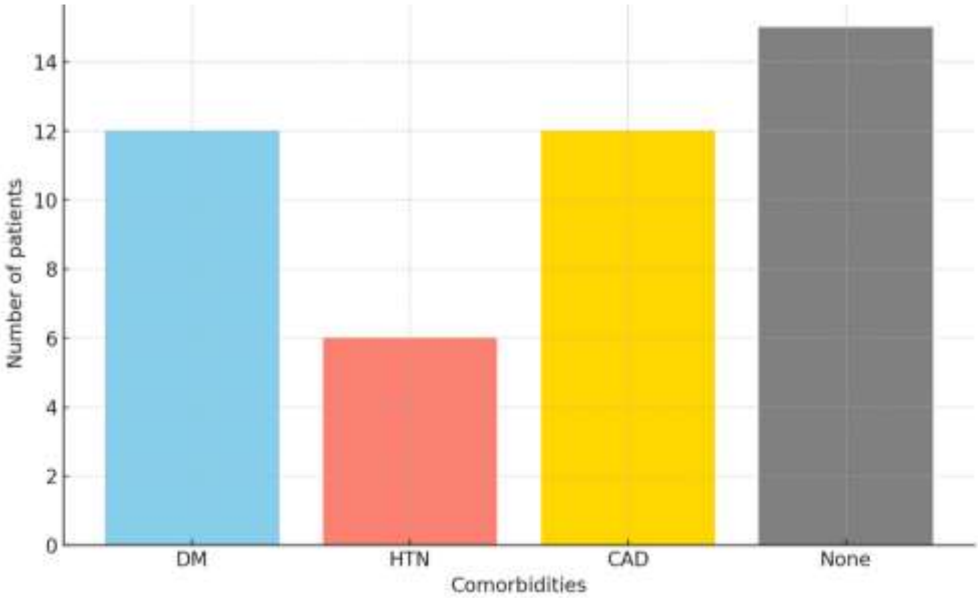

Figure 5. Distribution of comorbidities (n = 45).

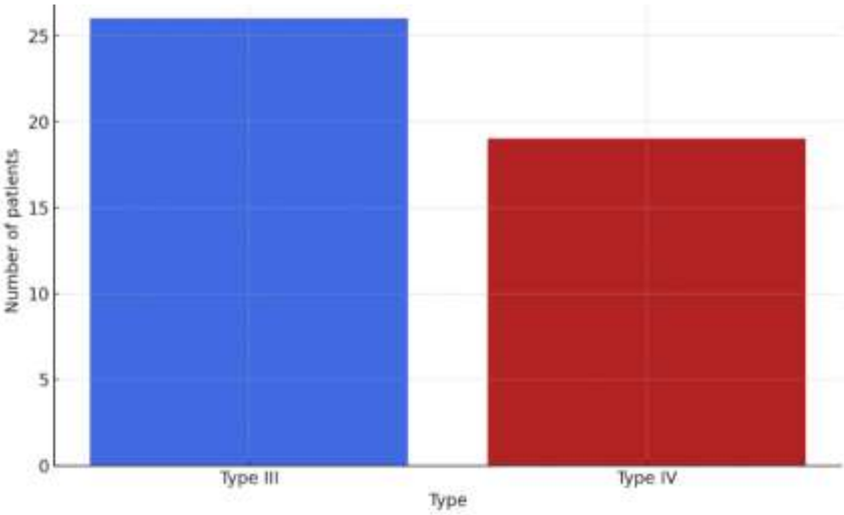

Figure 6. Boyd and Griffin classification of fractures (n = 45).

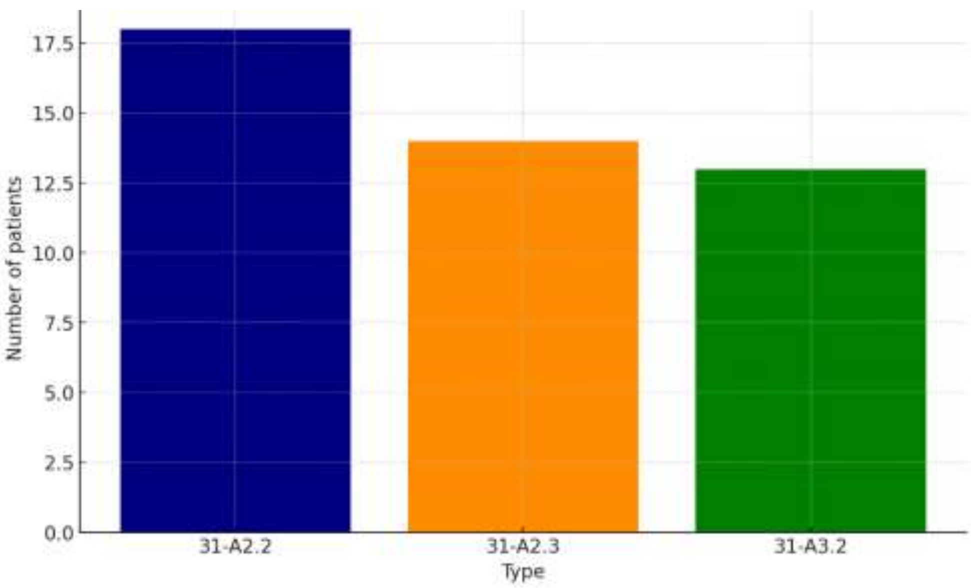

Figure 7. AO/OTA classification of fractures (n = 45).

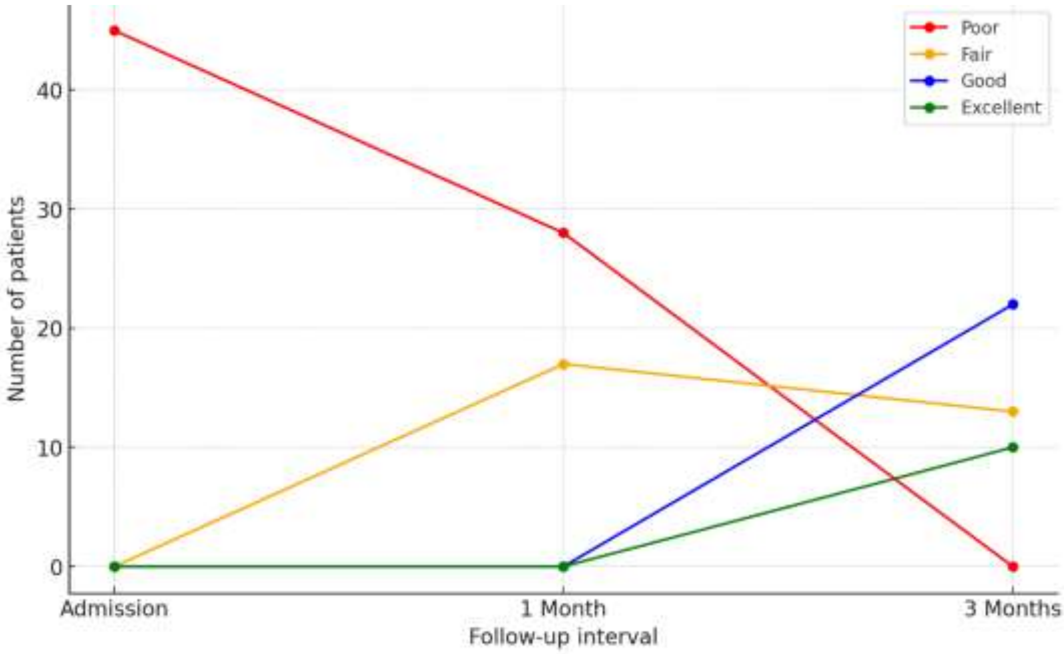

Figure 8. Functional outcome progression at admission, 1 month, and 3 months based on Modified Harris Hip Score (MHHS).

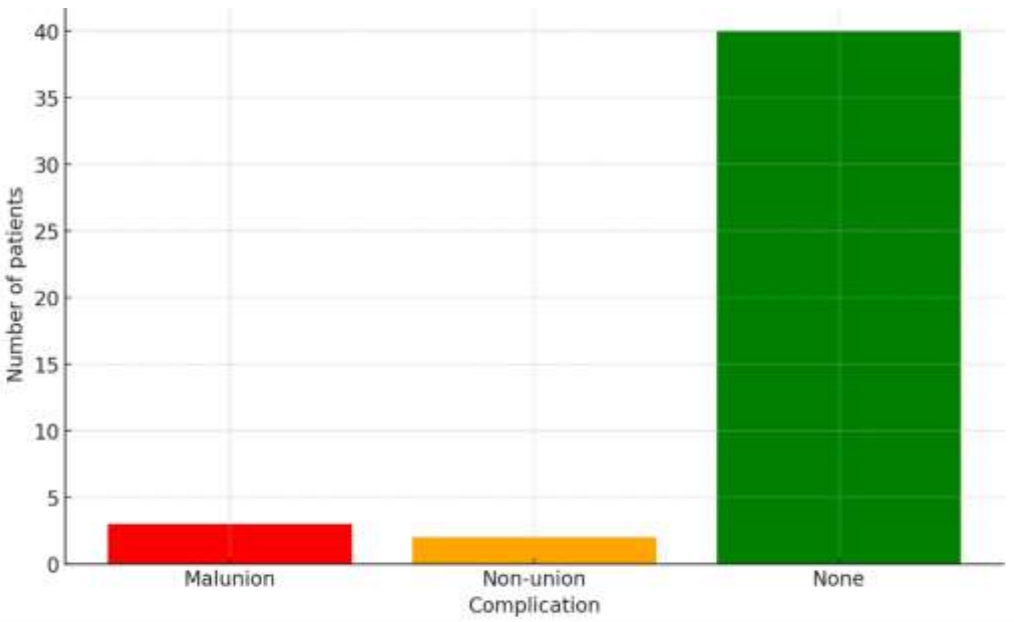

Figure 9. Complications following PFN fixation (n = 45).

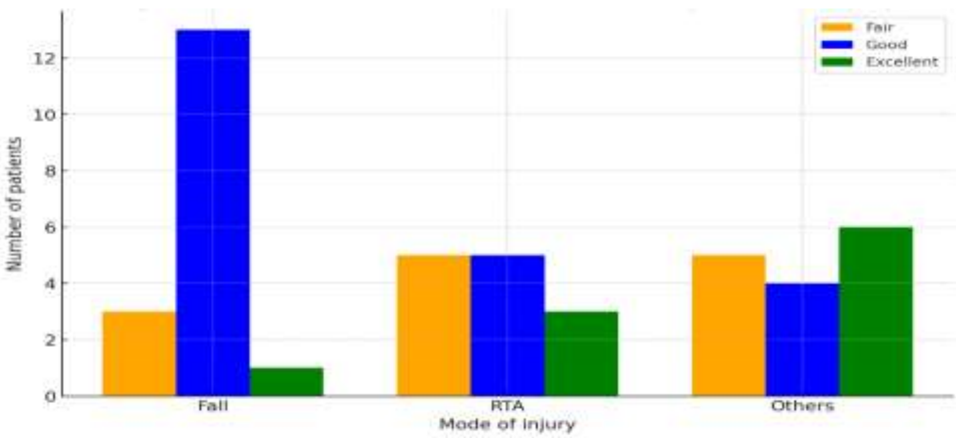

Figure 10. Association of functional outcome at 3 months with mode of injury (n = 45).

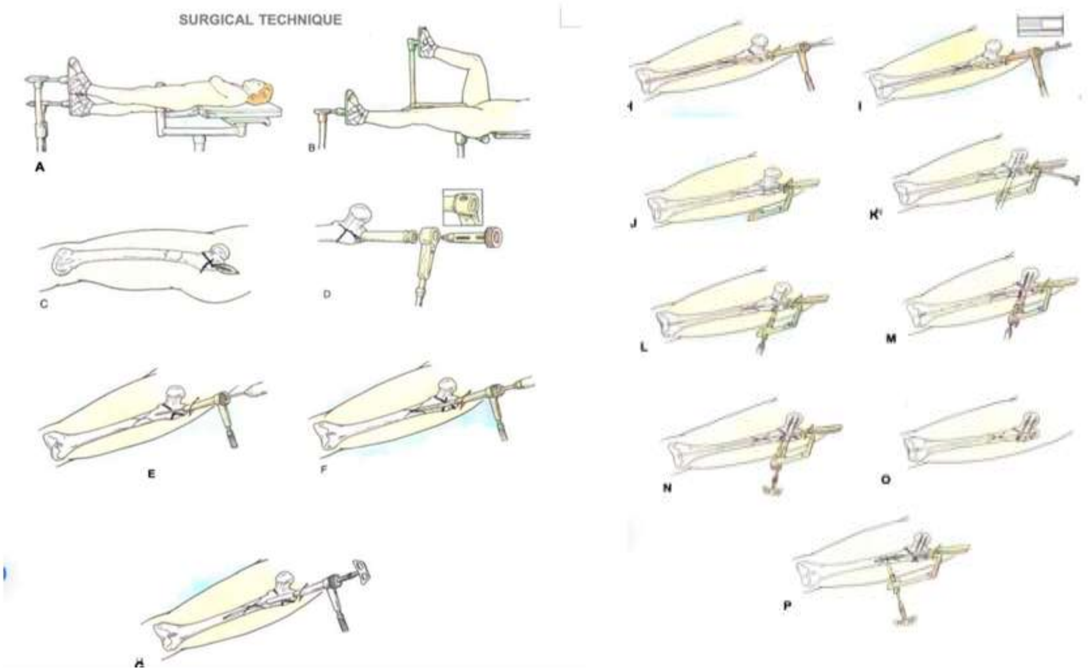

Figure A. Surgical steps of proximal femoral nail (PFN) fixation in unstable trochanteric fracture.

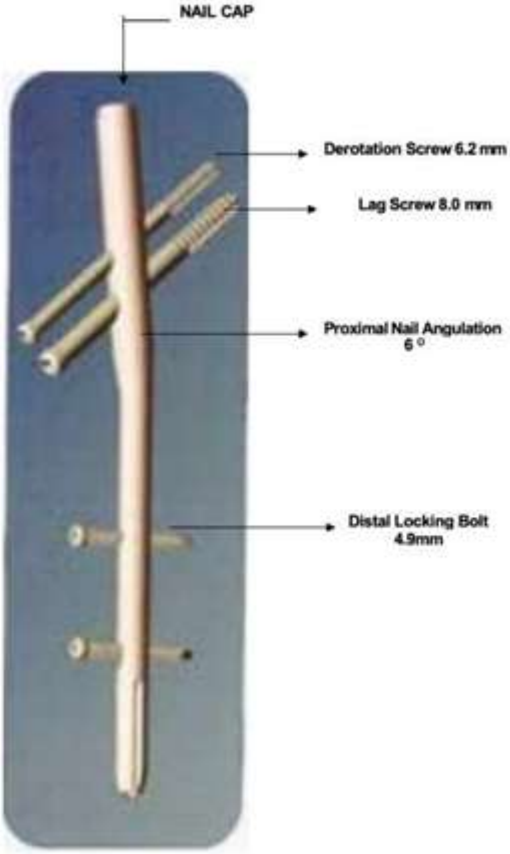

Figure B. Proximal femoral nail (135°) design showing dual proximal screws and distal locking.

Figure C. Instruments used for PFN fixation.

Figure D. Case 1: Pre-operative radiograph showing unstable trochanteric fracture.

Figure E. Case 1: Six months post-operative radiograph showing fracture union after PFN fixation.

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Figure F. Case 2: Pre-operative radiograph of unstable trochanteric fracture.

Figure G. Case 2: Six months post-operative radiograph showing good consolidation.

Figure H. Case 3: Pre-operative radiograph of complex unstable trochanteric fracture.

Figure I. Case 3: Six months post-operative radiograph showing satisfactory healing.