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Malunion after Fixation of Intertrochanteeic Fracture by Proximal Cephalomedu Nail Fixation

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ABSTRACT

Background: Intertrochanteric fractures (ITFs) of the proximal femur are common in the elderly, causing high morbidity, mortality, and healthcare costs. Proximal cephalomedullary nail (CMN) fixation is preferred for its biomechanical benefits and early mobilization, though malunion and nonunion can impair outcomes. Aim: This study aimed to assess the incidence and predictors of malunion following fixation of intertrochanteric fractures with proximal cephalomedullary nail fixation. Methods: A retrospective study was conducted on 80 patients with intertrochanteric fractures treated by CMN fixation at Tobruk Medical Centre. Patients were evaluated clinically and radiologically, with outcomes assessed using the Harris Hip Score (HHS), tip–apex distance (TAD), and neck–shaft angle (NSA). Healing is classified as anatomical union, malunion, delayed union, or nonunion. Logistic regression identified predictors. Results: The mean patient age was 58.6±7.9 years, with 61.3% males and 38.7% females. According to AO/OTA classification, 36.3% had type A1 and 63.7% type A2 fractures. Radiographic union was achieved in 96.3% of patients: 75.0% anatomical unions, 13.8% malunions, 7.5% delayed unions, and 3.7% nonunions. The mean union time was 16.8±5.4 weeks. The mean TAD was 21.2±2.4 mm in anatomically united cases versus 29.1±3.1 mm in malunion or nonunion cases (p<0.001). Functional outcomes improved significantly, with the mean HHS increasing from 68.2±9.8 at three months to 76.4±10.1 at six months (p<0.001). Multivariate regression identified higher ASA score, diabetes mellitus, road traffic accident (RTA) trauma, longer operative time, A2 fracture pattern, osteoporosis, and increased TAD as independent predictors of malunion and nonunion, with TAD being the most significant determinant. Conclusion: CMN yields high union rates for ITFs with low complications. Malunion/nonunion is linked to poor function. Optimise reduction, TAD ≤25 mm, technique, comorbidities, and unstable fractures for better recovery.

1. INTRODUCTION

With the progression of aging globally, the prevalence of diseases that can adversely affect bone metabolism, such as osteoporosis, is increasing. As a result, the prevalence of femoral fractures is also increasing worldwide. Intertrochanteric fracture (ITF) may occur as a result of low-energy trauma in elderly patients with low bone density and reduced muscle mass, leading to unstable fracture patterns and a higher rate of severe complications that can be difficult to manage **(Aithal et al., 2023)**.

With the rising life expectancy of the global population, the number of elderly individuals is increasing in every geographical region. According to epidemiologic projections, the worldwide annual number of hip fractures is estimated to rise from 1.66 million in 1990 to 6.26 million by the year 2050 **(Ambati et al., 2025)**. These fractures represent one of the largest categories of orthopedic trauma worldwide, accounting for significant healthcare resource utilization. Approximately half of all hip fractures are intertrochanteric femoral fractures, defined as extracapsular fractures occurring between the greater and lesser trochanters of the proximal femur **(Barra & Barrios, 2024)**. In patients over 50 years of age, more than 90% of hip fractures are intertrochanteric fractures, with 20–30% of these cases experiencing complications and a mortality rate of approximately 17% **(Coviello et al., 2024)**. Because of the high morbidity and mortality associated with nonoperative management, surgical fixation has become the standard approach. The goal of care is to restore limb function with the lowest possible rate of surgical and medical complications. Achieving stable reduction and rigid fixation while allowing early mobilization are key principles. Dynamic hip screw (DHS) as an extramedullary construct or intramedullary nail with a cephalomedullary screw are the standard surgical options chosen by most surgeons. The literature has discussed numerous comparisons between these implants in terms of biomechanical properties, indications, complications, and outcomes **(Dhanda, 2020)**. The ultimate purpose of surgical treatment for ITF is to minimize complications by achieving anatomical reduction with stable fixation to enable recovery of pre-fracture function **(Enns et al., 2020)**. According to the AO/OTA Classification of Fractures and Dislocations, implant choice for intertrochanteric fractures depends mainly on fracture stability. There is limited evidence favoring one device over another for stable fractures (types A1 to A2.1). DHS has been shown to be the most cost-effective implant with consistent outcomes in stable fracture patterns **(Ghilzai et al., 2018)**. However, concerns persist regarding its high failure rate in unstable configurations. The Evidence-Based Working Group in Trauma reported that failure rates for unstable intertrochanteric fractures treated with DHS are unacceptably high, discouraging its use in such situations **(Ambati et al., 2025)**. Over the past decade, the cephalomedullary nail (CMN) has gradually become the preferred implant for intertrochanteric fractures due to its biomechanical advantages. Studies on implant loading confirm that mechanical stress on the implant increases with varus malreduction or decreased fracture stability, and in these cases, intramedullary devices demonstrate superior load-bearing capacity compared to extramedullary ones **(Hoffmann et al., 2019)**. Consequently, current guidelines and expert consensus recommend CMN as the fixation of choice for unstable intertrochanteric fractures. Nevertheless, the increasing use of CMN has been accompanied by reports of fixation failures, particularly in the form of nonunion or malunion, often associated with lag screw or blade cut-out or cut-through **(Ambati et al., 2025)**. Failure of fixation, nonunion, and severe malunion can necessitate revision surgery. Malunion of the proximal femur often leads to persistent hip pain and weakness, even if gross limb disability is limited **(Ghilzai et al., 2018)** . The causes of failed fixation are complex and multifactorial. Contributing factors include patient-related elements such as fracture type, age, body weight, and bone quality, in addition to surgical factors like the quality of reduction, tip–apex distance (TAD), and lag screw position within the femoral head and neck **(Irgit et al., 2015)**. Postoperative radiographic assessment defines a stable construct when the TAD is within 25 mm **(Aithal et al., 2023)**. Despite the increasing global adoption of cephalomedullary nail fixation, limited studies have addressed the incidence and contributing factors of postoperative malunion following this technique, especially in elderly osteoporotic patients.

Aim of the Work

The present study aims to assess the incidence of malunion following fixation of intertrochanteric fractures with proximal cephalomedullary nail fixation.

2. METHOD

This Retrospective study was conducted on 80 patients who presented with intertrochanteric fractures of the proximal femur and underwent surgical treatment with proximal cephalomedullary nail (CMN) fixation. All procedures were performed at the Department of Orthopedic Surgery, Tobruk Medical Center, Libya, between January 2021 and December 2023. The study population consisted of both male and female adult patients aged between 40 and 65 years, with a mean age of 58.6 ± 7.9 years at the time of surgery. All clinical data, radiographic findings, and operative details were collected retrospectively from hospital records and radiology archives. The postoperative follow-up period ranged from 6 months to 12 months, during which clinical and radiological assessments were performed at regular intervals.

Inclusion criteria were patients diagnosed with AO/OTA type 31-A1.1 to 31-A2.3 intertrochanteric fractures who were managed operatively using CMN fixation. The inclusion criteria encompassed adults and adolescents between 18 and 65 years of age, patients clinically indicated for therapeutic plasma exchange based on disease severity or poor response to conservative therapy, and individuals diagnosed with immune-mediated neurological disorders.

Exclusion criteria included pathological fractures, open fractures, associated neurovascular injuries, and fractures that had undergone prior realignment. Cases showing implant malposition defined as a tip–apex distance (TAD) exceeding 25 mm or a helical blade not centered in the femoral head on either anteroposterior (AP) or lateral radiographs were excluded. Patients with severe osteoporosis, those with normal bone density and no systemic disease, younger active individuals, and patients who received adequate postoperative care and rehabilitation were also excluded from the analysis.

Preoperative Assessment:

All patients were subjected to thorough clinical assessment comprising detailed history taking, general examination, local limb evaluation, and functional scoring. The recorded history included demographic data such as age, residence, and occupation, as well as medical and social habits of significance, particularly smoking. The main complaint and its duration, past medical and surgical history, and any known drug sensitivities were also documented. General examination was performed to exclude systemic disease, with evaluation of vital signs, signs of pallor, cyanosis, jaundice, and lymphadenopathy. The body mass index (BMI) was calculated for each case.

Local examination of the affected limb included visual inspection, palpation, and assessment of limb length, range of motion, and functional ability. During inspection, gait was analyzed for any antalgic or Trendelenburg patterns indicating gluteal weakness or altered biomechanics due to malunion. Limb alignment was assessed for varus or valgus deformity, while the condition of the surgical scar and any muscle wasting in the gluteal or thigh regions were noted. On palpation, tenderness, malalignment, and implant prominence were examined around the anterior superior iliac spine, greater trochanter, and femoral shaft. Limb length discrepancy was measured using true length (ASIS to medial malleolus) and apparent length (umbilicus to medial malleolus); a difference greater than two centimeters was considered clinically significant. Range of motion (ROM) of the hip joint was tested in all planes and compared to the contralateral side. Functional outcome was assessed using the Harris Hip Score (HHS) to evaluate pain, mobility, and daily function, while the Visual Analog Scale (VAS) was employed for pain quantification on a 0–10 scale, where 0 represented no pain and 10 indicated severe pain.

1. ***Operative Procedure***

All patients underwent laboratory investigations, including complete blood count (CBC), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP). Radiological assessment consisted of standard anteroposterior (AP) and cross-table lateral radiographs of the hip. For the AP view, the patient was placed supine with approximately 15–20° of internal limb rotation to align the femoral neck parallel to the image receptor, as demonstrated in **Figure 1a**. The X-ray beam was centered midway between the anterior superior iliac spine and the pubic symphysis. The cross-table lateral view (**Figure 1b**) was obtained with the patient supine, the unaffected leg flexed and elevated to prevent obstruction, and the affected leg extended in its natural position. These views were used to evaluate fracture reduction, implant position, neck–shaft angle, and hip joint congruity.

Surgical Technique:

In cases complicated by infection after the initial fixation, a staged surgical protocol was followed, consisting of complete debridement, implant removal, and placement of antibiotic-loaded bone cement beads, followed by a six-week course of targeted intravenous antibiotics before definitive fixation. Patients presenting with malunion and a head–shaft angle (HSA) of 90° or less underwent valgus intertrochanteric osteotomy (VITO) fixed with either a sliding hip screw (SHS) or an angled blade plate (ABP) of 110°–120°. For cases with an HSA greater than 90°, osteoclasis at the fracture site was performed with traction-assisted realignment. Fixation device selection was based on the thickness and integrity of the lateral trochanteric wall; if the wall thickness exceeded 20 mm, either SHS or CMN fixation was used, whereas thinner walls required an angled blade plate or CMN to achieve adequate stability. In nonunion cases, bone grafting (autologous or synthetic) was utilized to address partial metaphyseal bone loss and enhance osteogenesis. Complex cases with significant deformity, bone loss, osteoporosis, or coexisting hip arthritis were managed by uncemented total hip replacement or bipolar cemented hemiarthroplasty to restore function.

Outcome Assessment

Postoperative follow-up included serial radiological evaluation immediately after surgery and at regular intervals for up to one year. The principal parameters assessed were the neck–shaft angle (NSA), normally around 125°, where a postoperative decrease indicated varus collapse and malunion; femoral neck shortening (FNS), measured as the difference in length between the distal end of the helical blade and the lateral nail border on serial radiographs; and mechanical complications, such as screw or blade cutout, cut-through, and implant migration. These parameters collectively indicated the stability of fixation and the degree of malunion.

3. ETHIC APPROVAL

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Tobruk Medical Center prior to data collection. All patients provided informed verbal consent for participation and for the use of their anonymized medical records for research purposes. Ethical standards were maintained in accordance with the principles outlined in the Declaration of Helsinki and the Good Clinical Practice (GCP) guidelines for human subject research.

4. RESULT

This retrospective study included eighty patients with intertrochanteric fractures, all treated with proximal cephalomedullary nail (CMN) fixation. The mean age of the studied cohort was 58.6 ± 7.9 years (range: 40–65 years). Males represented 61.3% (n = 49) of cases, while females accounted for 38.7% (n = 31). The right hip was involved in 43 patients (53.8%), whereas 37 patients (46.2%) had left-sided fractures. Based on the AO/OTA classification system, 29 patients (36.3%) were categorized as type A1 and 51 patients (63.7%) as type A2. Radiographic evidence of osteoporosis was observed in 27 cases (33.8%). The mean ASA score was 2.4 ± 0.6, with most patients classified as ASA II (52.5%) or ASA III (33.8%). Comorbid conditions were identified in 41 patients (51.3%). The most prevalent comorbidities included diabetes mellitus (26.3%), hypertension (22.5%), cardiac disease (8.8%), and chronic kidney disease (5.0%). Multiple comorbidities (≥2 systemic illnesses) were documented in 11 patients (13.8%). The predominant mechanism of injury was domestic falls, reported in 49 patients (61.3%), followed by road traffic accidents (RTAs) in 15 cases (18.7%), workplace injuries in 9 cases (11.2%), and sports or other causes in 7 patients (8.8%). The mean operative time was 92.5 ± 15.7 minutes. The demographic and baseline characteristics of the study population are summarized in Table 1.

Radiological Outcomes

Radiological outcomes were evaluated according to four healing categories: anatomical union, malunion, delayed union, and nonunion. *Anatomical union* was defined as radiographic consolidation with acceptable alignment achieved within six months postoperatively. *Malunion* referred to radiographic union within six months but with unacceptable alignment, such as varus collapse, limb shortening, or rotational deformity. *Delayed union* indicated cases that united beyond six months without the need for reoperation, whereas *nonunion* referred to lack of radiographic healing at or beyond nine months or the need for revision surgery. Within six months, 71 patients (88.8%) achieved radiographic union, including 60 anatomical unions (75.0%) and 11 malunions (13.8%). *Delayed union* was recorded in 6 cases (7.5%), while *nonunion* occurred in 3 cases (3.7%). By the final follow-up, the overall union rate including anatomical, malunion, and delayed union reached 96.3%. The mean union time among patients achieving union within six months was 16.8 ± 5.4 weeks, ranging from 12 to 28 weeks. The mean tip–apex distance (TAD) in successfully united cases was 21.2 ± 2.4 mm, compared to 29.1 ± 3.1 mm in patients who developed malunion or nonunion, highlighting the influence of technical accuracy on radiographic outcome. These findings are summarized in Table 2, and the distribution of healing outcomes is illustrated.

Functional Outcomes

Functional recovery was assessed using the Harris Hip Score (HHS) at both 3 and 6 months postoperatively. At six months, the mean HHS was 76.4±10.1, showing a significant improvement from 68.2 ± 9.8 at three months ($p < 0.001$). Overall, 62.5% of patients achieved good-to-excellent outcomes (HHS ≥ 80), 23.7% had fair results (HHS 70–79), and 13.8% demonstrated poor results (HHS < 70). Specifically, excellent scores (≥90) were observed in 17 patients (21.3%), good in 33 patients (41.2%), fair in 19 patients (23.7%), and poor in 11 patients (13.8%) at the 6-month follow-up. These results are detailed in Table 3, and the trend of improvement over time is depicted .

Complications

Postoperative complications occurred in 16 patients (20%). The most frequent complication was malunion (13.7%), followed by implant-related mechanical failures such as screw cutout, migration, or breakage (6.3%). Nonunion was observed in 3 patients (3.7%), while 4 patients (5%) required reoperation. A single case (1.2%) developed superficial wound infection that responded to conservative management. The detailed distribution of complications is presented in Table 4.

Predictors of Malunion

Patients were classified into three groups based on radiological outcome: anatomical union (n = 60), malunion (n = 11), and nonunion (n = 3). Comparative analysis revealed several significant predictors of impaired healing. Patients with malunion or nonunion exhibited higher ASA scores, more frequent comorbidities (particularly diabetes mellitus and hypertension), and poorer bone quality than those with successful union. High-energy trauma such as RTAs was significantly associated with malunion and nonunion, indicating the role of injury severity.

Operatively, prolonged surgical time and higher tip–apex distance (TAD) were both strong predictors of malunion and nonunion, underscoring the importance of surgical precision. Functionally, these groups demonstrated significantly lower Harris Hip Scores at both 3 and 6 months, reflecting poorer clinical recovery. The detailed comparisons among the three groups are summarized in Table 5.

On multivariate multinomial logistic regression analysis (Table 6), TAD emerged as the strongest independent predictor of both malunion and nonunion ($p < 0.001$ and $p = 0.022$, respectively). Higher ASA scores, diabetes mellitus, RTA mechanism of injury, prolonged operative time, and A2-type fractures were also independently associated with adverse outcomes. Osteoporosis was a stronger predictor of malunion than nonunion. These findings emphasize that systemic health status, fracture pattern, bone quality, and intraoperative technical accuracy collectively determine the final radiological and functional outcomes in patients treated with CMN fixation for intertrochanteric fractures.

5. DISCUSSION

In the present retrospective series of 80 patients treated with proximal CMN at a single center, the cohort profile (mean age 58.6 years; 61.3% males; predominance of AO/OTA A2 over A1) reflects a relatively younger operative population compared with several published CMN cohorts, which often include septuagenarians and octogenarians **(Jegathesan & Kwek, 2022); (Khanna & Tiwari, 2021); (Koyuncu et al., 2015); (Kren, 2023)**. Mechanisms of injury were mainly low-energy domestic falls, in line with the classic epidemiology of ITF, although a notable proportion of high-energy trauma (RTA) was observed and later proved prognostically relevant. The comorbidity profile (DM 26.3%, HTN 22.5%) and mean operative time (~92 minutes) were broadly comparable to prior reports using modern CMN systems **(Jegathesan & Kwek, 2022); (Khanna & Tiwari, 2021); (Koyuncu et al., 2015)**.

Radiologically, the study achieved an overall union rate of 96.3% by final follow-up, with 75.0% anatomical unions at ≤6 months, 13.8% malunions, 7.5% delayed unions, and 3.7% nonunions. Mean union time among those uniting ≤6 months was approximately 17 weeks consistent with healing windows reported for intramedullary fixation in comparable settings **(Kumar et al., 2022)** . A key technical correlate was the tip–apex distance (TAD): anatomically united cases had a mean TAD of 21.2 mm, whereas malunion/nonunion cases averaged 29.1 mm, corroborating the centrality of TAD optimization to reduce mechanical failure and malalignment **(Martinho & Stoffel, 2021); (Paes et al., 2025)**. These observations align with literature identifying TAD as a dominant modifiable predictor of cut-out and adverse radiographic outcomes, including specific thresholds in double-screw constructs **(Pang et al., 2020)** and multivariate models highlighting TAD as the sole independent predictor of cut-out when reduction quality is controlled **(Ryu et al., 2023)**.

Functional recovery mirrored radiological success. Harris Hip Score (HHS) improved significantly from 3 to 6 months (68.2 to 76.4), with 62.5% achieving good-to-excellent outcomes at 6 months paralleling trajectories reported in CMN series where early mobilization and stable reduction are prioritized **(Sukati et al., 2023), (Zelle et al., 2018)**. Although our 6-month mean HHS remained below some series of older populations, cross-study variation in age, baseline function, fracture stability, and rehabilitation intensity complicates direct comparisons. Importantly, HHS was significantly lower in malunion/nonunion groups at both timepoints, reinforcing the clinical relevance of achieving and maintaining alignment.

The overall complication rate was 20%, dominated by malunion (13.7%) and implant-related mechanical issues (6.25%), with low infection incidence (1.2% superficial) and a modest reoperation rate (5%). This safety profile aligns with contemporary CMN literature reporting low deep infection and variable mechanical failure rates depending on fracture complexity, reduction quality, and implant positioning **(Jegathesan & Kwek, 2022); (Khanna & Tiwari, 2021); (Koyuncu et al., 2015); (Zhu et al., 2024)**. Differences between studies likely reflect heterogeneity in case mix (e.g., proportion of A3/subtrochanteric extension), surgeon experience, nail design, and postoperative protocols. Notably, (**Ambati et al., 2025)** reported higher varus deformity but no nonunion/implant failure in their cohort, underscoring how construct selection, reduction targets, and rehabilitation strategies can influence complication spectra.

Multivariable modeling in the current study identified TAD as the most consistent independent predictor of both malunion and nonunion, with each 1-mm increase conferring a substantial rise in risk. Beyond TAD, higher ASA class, diabetes mellitus, RTA mechanism, longer operative time, and AO/OTA A2 pattern independently predicted adverse outcomes, while osteoporosis more strongly predicted malunion than nonunion. These findings integrate patient frailty (ASA), systemic biology (DM, bone quality), injury severity (RTA, unstable pattern), and technical execution (TAD, operative time) into a unified framework explaining healing trajectories after CMN. The results resonate with prior evidence emphasizing meticulous reduction, central–inferior head placement, and strict TAD control to mitigate failure **(Martinho & Stoffel, 2021); (Pang et al., 2020); (Ryu et al., 2023)**.

This study has several strengths: a uniform fixation strategy (proximal CMN) at a single center, standardized radiographic definitions for healing categories, and concurrent assessment of functional outcomes alongside detailed technical metrics. Nonetheless, limitations warrant consideration. The retrospective design is susceptible to selection and information bias; follow-up to one year, while clinically meaningful, may miss late mechanical sequelae; and generalizability is constrained by the single-center setting and the relatively younger mean age compared with many geriatric ITF cohorts. Additionally, although we recorded key technical variables such as TAD and operative time, other granular intraoperative parameters (e.g., calcar support restoration, precise screw/blade zone, reduction indices) were not analyzed in depth, and rehabilitation adherence was not quantified.

Clinically, the data reinforce several actionable priorities. First, preoperative optimization of medical comorbidities particularly glycemic control in diabetics and risk stratification of higher-ASA patients may improve healing potential. Second, operative strategies should target anatomic or slight valgus reduction, restore medial cortical support, and rigorously control **TAD** (ideally in the low-20-mm range), since incremental increases materially worsen outcomes. Third, unstable patterns (A2) and high-energy injuries merit heightened vigilance, careful intraoperative imaging, and possibly augmented fixation strategies. Finally, early, structured rehabilitation remains essential to translate radiographic success into functional recovery.

In summary, cephalomedullary nailing provided high union rates and acceptable complication profiles in our cohort, but **malunion** remained the dominant adverse outcome and was strongly associated with modifiable technical factors chiefly **TAD** as well as systemic and injury-related variables. These findings align with and extend prior literature **(Kumar et al., 2022); (Martinho & Stoffel, 2021); (Paes et al., 2025); (Pang et al., 2020); (Ryu et al., 2023)**, underscoring that optimal reduction and precise implant positioning are pivotal to minimizing malun.

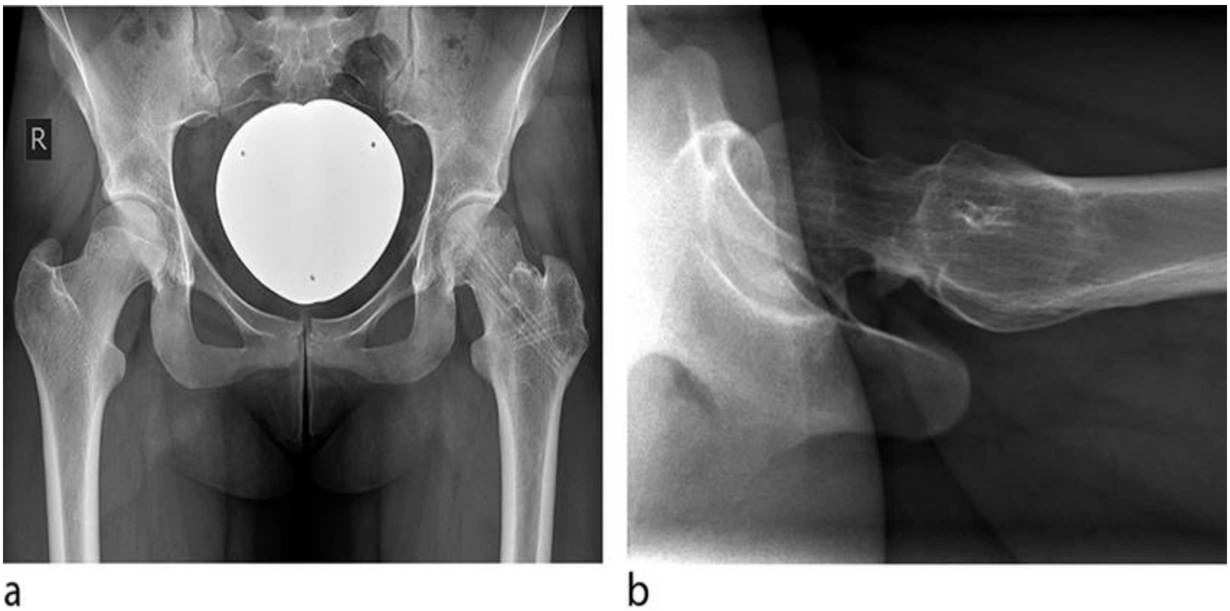

Fig 1. (a) Anteroposterior (AP) View of the Hip , (b) Cross-table Lateral View of the Hip

Table 1. Demographic and baseline characteristics of patients (n = 80)

Variable	Descriptive statistics (n=80)
Age (years)	
Mean ±SD	58.6 ± 7.9
Range	40-65
Gender	
Male	49 (61.3%)
Female	31 (38.7%)
Side	
Right	43 (53.8%)
Left	37 (46.2%)
AO/OTA classification	
Type A1	29 (36.3%)
Type A2	51 (63.7%)
Osteoporosis present	27 (33.8%)
ASA score	
mean ± SD	2.4 ± 0.6
range	1-3
ASA	
I	11 (13.7%)
II	42 (52.5%)
III	27 (33.8%)
Comorbidities	
Any	41 (51.3%)
Diabetes mellitus	21 (26.3%)
Hypertension	18 (22.5%)
Cardiac disease	7 (8.8%)
Chronic kidney disease	4 (5.0%)
Multiple comorbidities (≥2 conditions)	11 (13.75%)
Mode of trauma	
Domestic fall	49 (61.3%)
RTA	15 (18.7%)
Workplace injuries	9 (11.2%)
Sports/other	7 (8.8%)
Operative time (minutes)	92.5 ± 15.7

Table 2 Radiological outcomes (n = 80)

Parameter	Descriptive statistics (n=80)
Anatomical union < 6 months	60 (75%)
Malunion < 6 months	11 (13.8%)
Delayed union (united >6 months)	6 (7.5%)
Nonunion at final follow-up	3 (3.7%)
Union time (weeks)	
Mean ±SD	16.8 ± 5.4
Range	12-28
Mean TAD (successful union) (mm)	
Mean ±SD	21.2 ± 2.4
Range	15-28
Mean TAD (malunion) (mm)	
Mean ±SD	29.1 ± 3.1
Range	23-35

Table (3) Harris Hip Score outcomes (n = 80)

Outcome Category (HHS)	At 3 months	At 6 months	P- Value
Excellent (≥90)	8 (10%)	17 (21.3%)	<0.001*
Good (80–89)	21 (26.3%)	33 (41.2%)	
Fair (70–79)	29 (36.3%)	19 (23.7%)	
Poor (<70)	22 (27.5%)	11 (13.8%)	
Overall HHS score	68.2 ± 9.8	76.4 ± 10.1	

Table 4. Postoperative complications (n = 80)

Complication	n (%)
Malunion	11 (13.7%)
Nonunion	3 (3.7%)
Implant-related failure (cutout, migration, breakage)	5 (6.25%)
Reoperation required	4 (5.0%)
Superficial infection	1 (1.2%)

Table 5. Comparison of predictors across union, malunion, and nonunion groups

Variable	Union (n=60)	Malunion (n=11)	Nonunion (n=3)	p-value (global)
Age (years) mean ± SD)	58.2 ± 7.5	61.9 ± 6.8	63.0 ± 5.1	0.09
ASA score (mean ± SD)	2.3 ± 0.6	2.8 ± 0.5	3.0 ± 0.0	0.01*
Osteoporosis present	20 (33.3%)	7 (63.6%)	2 (66.7%)	0.02*
Diabetes mellitus	12 (20.0%)	6 (54.5%)	3 (100%)	<0.001*
Hypertension	11 (18.3%)	5 (45.5%)	2 (66.7%)	0.01*
Cardiac disease	4 (6.7%)	2 (18.2%)	1 (33.3%)	0.10
Mode of trauma – RTA	7 (11.7%)	4 (36.4%)	2 (66.7%)	0.004*
Operative time (min)	91.1 ± 15.3	102.3 ± 13.5	110.0 ± 10.0	0.03*
TAD (mm)	21.2 ± 2.4	29.1 ± 3.1	27.5 ± 2.8	<0.001*
Union time (weeks)	15.9 ± 2.7	21.0 ± 3.8	–	0.001*
HHS at 3 months	69.8 ± 9.2	60.3 ± 8.7	55.0 ± 6.5	0.01*
HHS at 6 months	77.8 ± 9.4	67.1 ± 9.1	60.0 ± 7.5	0.002*

* Statistically significant at $p < 0.05$

Table 6. Multivariate multinomial logistic regression analysis of predictors of malunion and nonunion (Union = reference group)

Predictor	Malunion vs Union OR (95% CI)	p-value	Nonunion vs Union OR (95% CI)	p-value
Age (per year ↑)	1.05 (0.98–1.12)	0.12	1.09 (0.97–1.24)	0.14
ASA score (per ↑)	1.85 (1.12–3.05)	0.016*	2.45 (1.05–5.68)	0.037*
Osteoporosis	2.41 (1.09–5.34)	0.029*	3.15 (0.82–12.1)	0.092
Diabetes mellitus	3.78 (1.24–11.6)	0.019*	9.25 (1.12–76.4)	0.039*
Hypertension	2.25 (0.84–6.01)	0.10	3.62 (0.71–18.4)	0.12
Trauma – RTA	4.10 (1.14–14.7)	0.031*	8.50 (1.26–57.1)	0.027*
Operative time (per 10 min ↑)	1.30 (1.02–1.66)	0.034*	1.55 (1.02–2.36)	0.041*
Fracture type – A2	2.85 (1.06-7.7)	0.039*	3.9 (1.01-15.1)	0.048*
TAD (per mm ↑)	1.55 (1.20–2.00)	<0.001*	1.48 (1.05–2.08)	0.022*

Limitations

This study has several limitations that should be acknowledged. First, its retrospective design inherently carries the risk of selection bias and limits the ability to establish causal relationships between the identified predictors and the outcomes. Second, the study was conducted at a single center, which may restrict the generalizability of the findings to other populations or healthcare settings with different surgical expertise or protocols. Third, although the sample size of 80 patients provided valuable insights, a larger cohort would increase statistical power and allow for more robust subgroup analyses.

Additionally, the follow-up duration was limited to one year, which may not have been sufficient to capture late mechanical failures, implant-related complications, or long-term functional deterioration. Some potentially relevant factors such as the exact position of the helical blade within the femoral head, degree of fracture reduction, or postoperative rehabilitation adherence were not quantitatively analyzed and could influence outcomes. Finally, all surgeries were performed by different surgeons with variable levels of experience, introducing potential inter-operator variability in reduction quality and implant placement.

Despite these limitations, the study provides important real-world data on the predictors of malunion and nonunion following proximal cephalomedullary nail fixation and offers a foundation for future prospective and multicenter investigations

6. CONCLUSION

In conclusion, proximal cephalomedullary nail fixation for intertrochanteric fractures demonstrated a high overall union rate of 96.3%, with the majority of fractures achieving anatomical union within six months. Nevertheless, malunion occurred in 13.8% and nonunion in 3.7% of cases, both of which were associated with significantly inferior functional recovery as indicated by lower Harris Hip Scores. Multivariate analysis revealed that higher ASA score, diabetes mellitus, road traffic accident (RTA) trauma, prolonged operative time, A2-type fracture configuration, and osteoporosis were significant predictors of compromised healing. Among all variables, an increased tip–apex distance (TAD) emerged as the strongest independent determinant of both malunion and nonunion. These findings affirm that while cephalomedullary nailing remains an effective and reliable technique for managing intertrochanteric fractures, the success of fixation depends critically on meticulous surgical execution, precise implant placement, and optimal reduction quality, alongside comprehensive management of systemic comorbidities. Integrating these principles can minimize mechanical and biological complications, thereby enhancing both radiological and functional outcomes in patients undergoing CMN fixation for intertrochanteric fractures.

7. REFERENCES

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