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ORIGINAL ARTICLE

Assessment of Proximal Femoral Nail in Management of Unstable Intertrochanteric Femur Fractures

Omar Abdelwahab Elkilany, Tarek Abdelsamad Elhewala, Hosam Fekry, Ahmed Mostafa Fathi Alghool*

Orthopedic and Traumatology
Corresponding author*
Ahmed Mostafa Fathi Alghool*

Email:
alghool46@gmail.com

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ABSTRACT

Background: For the management of intertrochanteric fractures, the proximal femoral nail (PFN) has an extra anti-rotational screw (hip pin) to prevent rotation of the cervicocephalic fragments during weight bearing. This study aimed to evaluate of the outcome of proximal femoral nailing for unstable intertrochanteric femur fracture fixation. **Methods:**A prospective cohort study was carried out at the Department of Orthopedic and Traumatology Department, Faculty of Medicine, Zagazig University Hospital. Thirty-five cases with unstable trochanteric fractures were managed by proximal femoral nails; according to Evans classification thirty were of type Id while five were of type II. After at least 6 months to 2 years of follow-up, the Harris hip score was used to evaluate the functional outcome of these cases. **Results:** The average time of operation was 105 minutes, ranging from 60 minutes to 150 minutes. Two patients experienced local complications; one had a superficial infection that was managed with medicines and the other had a deep infection that necessitated the removal of hardware, debridement, and the insertion of a spacer. The overall rate of local complications was 14.2%. As of the last follow-up, no peri-prosthetic fractures had occurred. With 23 patients, 71.4% were satisfied with the outcome (11 were rated "Excellent," 14 were rated "good," and 10 were rated "not satisfied") (6 fair and 4 poor).**Conclusions:** Theproximal femoral nail is considered the ideal treatment option to fix an unstable intertrochanteric fracture in ambulatory elderly cases with low perioperative mortality risk.

Keywords: proximal femoral nail, intertrochanteric fractures, femur fracture fixation

INTRODUCTION

Extracapsular fractures of the proximal femur between the greater and lesser trochanters are known as intertrochanteric fractures. These fractures can happen to anyone, regardless of age, although the older population with osteoporosis is particularly susceptible to them because of the low-energy mechanism involved. These breaks often occur due to a high-energy mechanism in the young population **[1]**.

Intertrochanteric fractures cause the patient's lower extremity to be abnormally short and turned outward. To provide the best possible perioperative care and to plan for postoperative rehabilitation, it is important to collect relevant medical and social information. Both the skin's integrity (open

vs. closed fracture) and the patient's neurovascular condition must be assessed. Pain prevents most people from undergoing a range-of-motion evaluation **[2].**

The need for surgical treatment of these fractures is urgent but not life-threatening. This allows patients' multiple comorbidities to be optimized before surgery, decreasing the risk of complications. Arthroplasty is a less common treatment option for these fractures than either a sliding hip screw or an intramedullary hip screw **[2].**

An extra anti-rotational screw (hip pin) is inserted into the femoral neck of the proximal femoral nail (PFN) to prevent the cervicocephalic fragments from rotating. Peri-trochanteric, intertrochanteric, and sub-trochanteric femoral fractures have all shown stability with this implant **[3].**

Mehta et al. **[4]**determined the long-term functional results of PFN for patients with intertrochanteric fractures. They concluded that PFN was a great way to treat intertrochanteric fractures. Most cases have a positive outcome, and there are few complications.

This study hypothesizesthat compared with extramedullary implants, intra-medullary implants have several biomechanical advantages with benefits, including less soft tissue dissection, dynamic locking, ease of insertion, potentially less blood loss, restoration of the mechanical axis, and, most importantly, allowance for immediate weight bearing after fixation.

Therefore, this study was performed toevaluate the outcome of proximal femoral nailing for unstable intertrochanteric femur fracture fixation.

METHODS

This study was performed on thirty-five cases who were diagnosed by radiography as having intertrochanteric fracture femur. The study was conducted in Zagazig University Hospitals and aimed at evaluating the results of the treatment of unstable intertrochanteric fractures in patients using proximal femoral nails during the period from June 2021 to June 2023.

Written informed consent was obtained from all participants and the study was approved by the research ethical committee of the Faculty of Medicine, Zagazig University, Institutional Research Board (IRB) number (#10238/18-12-2022) The Declaration of Helsinki, issued by the World Medical Association to ensure the protection of people participating in medical research, was strictly followed during this study.

Inclusion Criteria: Adults (aged from 18 to80 years) from both sexes, cases with unstable intertrochanteric fractures of the femur who were managed by PFN, mode of trauma included both low and high-velocity injury, cases with normal or osteoporotic bones, and cases with closed fractures.

Exclusion Criteria: We excluded all participants who had any of the following conditions; pathological fractures, ipsilateral femur fractures, any associated fractures around the hip, skeletally immature patients and the presence of tumor-like, and cases who had inflammation of any kind that could interfere with a follow-up functional assessment, including rheumatoid arthritis and psoriatic arthritis.

All cases were subjected to the following:

Clinical evaluation: Full history including Patient complaint, present, past, and family history. In young patients, for whom high-energy trauma is most likely to be the cause, a thorough clinical examination was recorded to rule out the likelihood of polytrauma and multiple fractures.

Radiologically: An anteroposterior (AP) view of the pelvis and an AP and a cross-table lateral view of the involved proximal femur. X-ray (AP and lateral view) of the ipsilateral knee joint. Because osteoporosis is a prevalent cause of intertrochanteric fractures

in the elderly after apparently little trauma, X-rays were also evaluated for its existence. The fracture pattern of the hip was evaluated by a physician-assisted internal rotation view. Computed tomography (CT) was done for nondisplaced or occult fractures that were not apparent on plane radiographs and magnetic resonance imaging (MRI) to exclude pathological fractures.

Clinical and Functional assessment: Fractures were classified according to Evans classification, Clinical assessment: was done according to Harris hip score (HHS) to assess hip function more specifically [5].

Surgical Technique: A broad-spectrum antibiotic given intravenously one hour before surgery. Patients were evaluated to determine the best course of an anesthetic; seven had general anesthetic, whereas 14 received spinal. The patient was then positioned supine on a radiolucent orthopedic traction table and given more anesthetic, traction was applied along the limb's length. With the finger, the greater trochanter's tip was located, and the correct entrance point was decided upon at the greater trochanter's tip. This procedure was followed by a 5 cm proximal incision to the trochanter's top.

The awl was inserted into the greater trochanter at the point where the anterior and posterior thirds meet, and then the awl was removed to make room for the reamer guide wire, which was then threaded through the greater trochanter and into the femoral shaft. The femur shaft was reamed using flexible reamers, beginning at a diameter of 9 mm, and progressing in 0.5 mm increments. The reamers were introduced only to approximately 8 cm, after being assembled onto the introducer handle, the chosen nail was screened by hand before being introduced.

When the distal part of the femoral neck was screwed in just above the calcar and the guide sleeve for the lag screw guide wire is inserted and pushed firmly till the lateral cortex, the nail has been placed to the proper depth, 5 mm before the tip of the guide wire, Once the correct length lag had been threaded through the guide sleeve and over the guide wire to the subchondral part of the head and the correct position of the lag screw and reduction of the fracture had been confirmed using the image intensifier, the distal locking screws were inserted via the target device.

Follow-up: The Harris hip score was used to evaluate the patient's functional outcome at 3, 6, and 12 weeks, and then again at 2 years after surgery. Pain, limping, and the occurrence of complications were also recorded.

The morphometric evaluation was done by radiograph of the normal hips and the fractured hip (AP Pelvis), the measurement was taken and evaluated the results of the effect of the implant on the normal proximal femur morphology, femoral neck length (FNL), femoral neck width (FNW), neck-shaft angle (NSA), femoral axis length (FAL), as well as great trochanter-pubic symphysis distance (GTPSD) were assessed.

Statistical analysis:

The normality of data distribution was evaluated using the Shapiro–Wilk test. Means, standard deviations, frequencies, and percentages were all calculated in SPSS Version 22.0 to describe quantitative data (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

RESULTS:

A total of thirty-five cases with unstable intertrochanteric femoral fractures were managed surgically by fixation with a proximal femoral nail. Table 1 summarizes the basic demographic data of the entire cohort, including age, gender, and associated medical comorbidities. The mean age of cases was 74.2 ± 10 years, ranging from 56 to 95 years, cases were classified into three age

subgroups, less than 70 (n = 13), between 70 and 80 (n = 12), and more than 80 (n = 10).

About 25 (71.4%) patients sustained a simple fall, whereas 10 (28.6%) patients reported falling off stairs, 20 (57.1%) patients sustained a right-sided fracture, whereas 15 (42.9%) patients reported a left-sided fracture, All patients sustained closed intertrochanteric fractures, type I fracture was reported in one (2.9%) patient, type II fracture was reported in 23 (65.7%) patients, type III fracture was reported in five (14.3%) patients, and type IV fracture was reported in six (17.1%) patients (Table 2).

A good reduction was observed in 11 (31.4%) patients. An acceptable reduction was found in 14 (40%) patients, On the other hand, poor fracture reduction was reported in 10 (28.6%) patients, and 15 (42.9%) patients showed full fracture union within less than 3 months. However, delayed union, more than 3 months, was reported in 20 (57.1%) patients, excellent hip function, HHS ranging from 90 to 100, was reported in seven (20%) patients. The majority of patients (68.6%) had good hip function, with HHS ranging from 80 to 89. Only four (11.4%) patients had poor hip function, with HSS less than 70 (Table 3).

In all, the overall complication rate in our cohort was 37.1%, and non-union was reported in four (11.4%) patients. Two (5.7%) patients suffered from deep infection. Lag screw cut-out was reported in another two (5.7%) patients. One (2.9%) patient developed impingement. DVT was reported in four (11.4%) patients (Table 4).

A 95-year-old male patient, suffered a simple fall at home caused by right intertrochanteric femoral fracture type Id according to Evans classification. The operation was done on the 8th day after trauma. Open reduction was done, and the fracture united after 16 weeks, and he had a good functional score according to the Harris Hip score (Figure 1).

Table (1): Demographic data of the studied groups (N= 35 patients)

Variables	No.	%
Age, years	**74.2 ± 10 (Range, 56 – 95)**	
Less than 70	**13**	**37.1**
70 – 80	**12**	**34.3**
More than 80	**10**	**28.6**
Gender		
Male	**20**	**57.1**
Female	**15**	**42.9**
Medical Comorbidities		
HTN	**11**	**31.4**
DM	**11**	**31.4**
IHD	**5**	**14.3**
CKD	**4**	**11.4**
ILD	**1**	**2.9**

HTN: hypertension, DM: Diabetes mellitus, IHD: Ischemic heart disease, CKD: Chronic kidney disease, ILD: Ischemic liver disease

Table (2):Fracture Characteristics

Variables	No.	%
Mechanism of Injury		
Simple fall	25	71.4
Fall off stairs	10	28.6
Duration of Injury, days	2.7 ± 2 (Range, 1 – 9)	
Less than 3 days	21	60
3 – 5 days	10	28.6
More than 5 days	4	11.5
Side of Injury		
Right hip	20	57.1
Left hip	15	42.9
Boyd and Griffin Classification		
Type I	1	2.9
Type II	23	65.7
Type III	5	14.3
Type IV	6	17.1

Table (3): Radiological and Functional Outcomes

Variables	No.	%
Fracture Reduction		
Good	11	31.4
Acceptable	14	40
Poor	10	28.6
Time to Union		
Less than 3 months	15	42.9
More than 3 months	20	57.1
Harris Hip Score		
Excellent	7	20
Good	24	68.6
Poor	4	11.4

Table (4): Postoperative Complications

Variables	No.	%
Complications	13	37.1
Non-union	4	11.4
Deep Infection	2	5.7
Impingement	1	2.9
Lag Screw Cut-out	2	5.7
Deep Venous Thrombosis	4	11.4

Figure 1: Case study; (A): Preoperative X-ray, (B): Postoperative X-ray, (C): Six-month follow-up X-ray

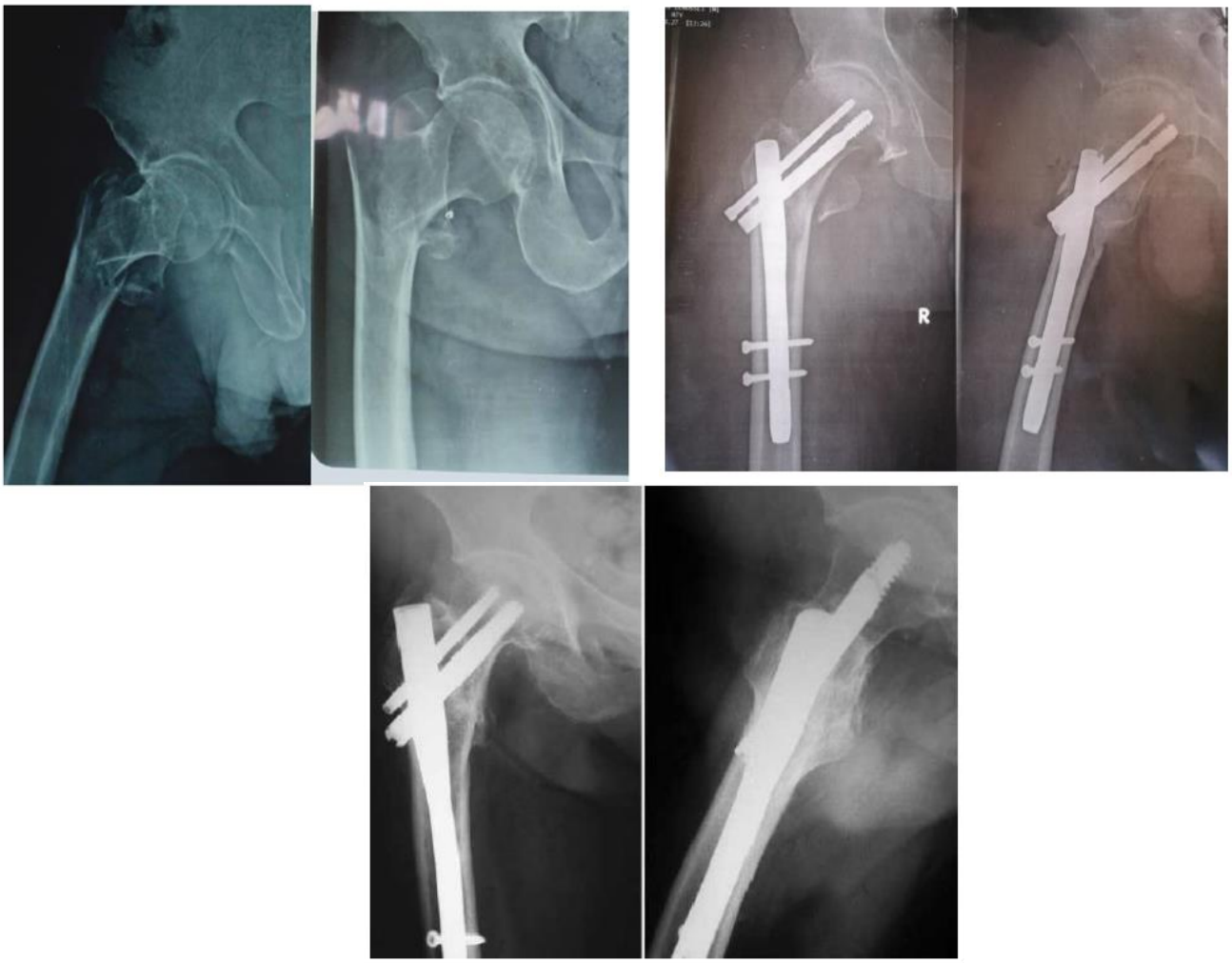

Figure 2: Case study; (A): Preoperative X-ray, (B): Postoperative X-ray, (C): Six-month follow-up X-ray

DISCUSSION

Most proximal femoral fractures, known as intertrochanteric fractures, develop between the extracapsular basilar neck and the region along the lesser trochanter, just proximal to where the medullary canal begins. Elderly people seem to be more susceptible to them. Trivial falls are the leading cause of injury in women with osteoporosis, increasing the risk of fracture by a fold of three to four [6]. The occurrence of proximal femur fractures has grown along with the overall life expectancy during the previous two decades, resulting in higher rates of death and morbidity [7]. Proximal femur fractures are more common in the elderly than in younger people because of factors such as osteoporosis, diminished muscle power, poor vision,impaired reflexes, as well as labile blood pressure [8].

Treatment should prioritize early mobility to reduce the risk of subsequent problems. Intertrochanteric fractures can be treated with a variety of surgical techniques and implants [9]. The proximal femoral nail (PFN), gamma nail (intramedullary fixation), and dynamic hip screw (extramedullary fixation) are all possible choices for the management of intertrochanteric fractures [10].

Although the hip screw is often recommended, it can cause problems including a collapsed femoral neck and leg shortening if used incorrectly. It's normal for there to be some give in the hip joint, but too much can be harmful to the hip's function [11].

The intramedullary location of a PFN considerably shortens the lever arm distance, while also providing support against lateral movement and decreasing bending strain on the implant, Hence, in contrast to the Dynamic hip screw. In peritrochanteric, intertrochanteric, or subtrochanteric femoral fractures, the AO/ASIF-designed proximal femoral nail (PFN) is a stable implant [12].

The current study showed revealed a mean age of enrolled cases that was 74.2 ± 10 years, ranging from 56 to 95 years. The patients were predominantly females 25 (71.4%). In line with the current Hasan et al. [13] included 1534 cases with intertrochanteric femur fractures and revealed that the ages ranged from 60 years to 85 years and patients were predominantly females 833 [54.3%]. As well,Mohamed et al. [14] showed that about two-thirds of elderly patients with Intertrochanteric Femur Fractures were females.Also,Mostafa et al. [15] showed that the mean age was 62.6±14.9 years with a female predominance (55.3%) among 38 patients with intertrochanteric femur fractures.

However, Gunaki et al. [12] showed that the majority of the patients with intertrochanteric femur fractures were males (65%) with a mean age of 71.58 ± 12.37 years. Also, Mehta et al. [4] revealed that among 60 patients with intertrochanteric femur fractures, there were 37 (61.67%) males and 23 (38.33%) females.

Regarding the mechanism of injury, we found that 25 (71.4%) cases sustained a simple fall, whereas 10 (28.6%) patients reported falling off stairs. In agreement with the current study,Mostafa et al. [15] showed that the main cause of injury was falling on slippery ground (57.9%). Also, according to the research by Singh et al. [11], 85.1% of patients who suffered fractures did so because of non-injurious trauma such as a household fall or a fall down the stairs; the remaining patients were afflicted in traffic accidents. However, Gunaki et al. [12] showed that the most common mode of injury was road traffic accidents in 58% followed by falls in 30% of patients.

The current study revealed that the mean duration between injury and surgery was 2.7 ± 2 days, ranging from 1 to 9 days. However, longer than the current study Rajput et al. [8] showed that the average injury to surgery duration was 7.06 ± 1.74 days among patients who underwent PFN. Also, Mostafa et al. [15] showed that the mean duration of injury to operation was 11.7±4.7 days.

Regarding laterality, the current study showed that 20 (57.1%) patients sustained a right-sided fracture, whereas 15 (42.9%) patients reported a left-sided fracture. Consistent with the current study Mostafa et al. [15] showed that 24(63%) were injured on the right side while 14 (37%) were injured on the left side. Also, Singh et al. [11] showed that Fifty-one percent of patients experienced symptoms on their right side, whereas only 49 percent experienced symptoms on their left side.

The current study showed that the mean operative time was 60±15 min and blood loss ranged from 300 - 600 ml with 450 ml on average. Comparable with the current studyRajput et al. [9] showed that the mean PFN operative time was 67.2 ± 5.8 min with lower blood loss (103 ± 13.17 ml) than the current study. As well,Mohamed et al. [14] showed that the average operative time in PFN was 63.40 ± 15.60 min with mean blood loss of 165.00 ±51.58 ml.

However, Singh et al. [11] showed that the average duration of PFN surgery was 90 minutes. The average blood loss was about 100ml. Also, the minimum PFN duration was found to be 40 minutes, the maximum PFN duration was found to be 150 minutes and the mean PFN duration was found to be 80 minutes by the research of Pushkarna and Vikram. [16].

Furthermore, Singh et al. [11] found that the average duration of hospital stay was 12.5 days. However,Mostafa et al. [15] showed that the mean duration of hospital stay was 18.3± 4.2 days ranging from 10 days to 29 days. According to the meta-analysis by Hasan et al. [13] the hospital stay ranged between 6.8 and 37.8 days in patients who underwent PFN procedure.

Regarding outcome, the current study showed that a good reduction was observed in 11 (31.4%) patients. An acceptable reduction was found in 14 (40%) patients, On the other hand, poor fracture reduction was reported in 10 (28.6%) patients. However, Dave et al. [17] andPushkarna & Vikram. [16] showed that a good reduction was found among 78% of patients.

Among the studied patients 20 (57.1%) patients showed full fracture union within less than 3 months. However, delayed union, more than 3 months, was reported in 15 (42.9%) patients. With a better outcome than the current study,Singh et al. [11] showed that delayed union was seen in only 1(0.07%) patient who was identified at 6 monthsfollow-up X-ray. The patient was told to wait 3 months before returning for follow-up and that no active intervention was necessary. Non-union was detected in 3 cases (2.3%), and bone grafting was necessary for these patients after 6 months. The lower rate of non and delayed union than our results was due to the lower mean age of this study compared to our study.

Also, Jawad. [18] a study of 32 patients aged 50 years who underwent PFN for unstable intertrochanteric fractures showed that Radiological assessment showed 29 (90.6%) cases of smooth union and 3 (9.4%) cases of failure of fixation.

Regarding Functional outcome assessed by Harris Hip Score (HHS), it was revealed that excellent hip function (HHS ranging from 90

to 100) was reported in seven (20%) patients. The majority of patients (68.6%) had good hip function, with HHS ranging from 80 to 89. Only four (11.4%) patients had poor hip function, with HSS less than 70. Comparable to the current study Rajput et al. [9] showed that 25 patients (83.33%) had excellent to good results according to HHS post-PFN procedure. Also, Singh et al. [11] showed that 17(13.4%), 'Good' results were seen in 61(48.0%), 'Excellent' results were seen in 37(29.1%) patients according to HHS at the end of 6 months follow up post PFN. As well, as Pushkarna and Vikram. [16] showed that Harris Hip Score evaluations revealed that 54% of patients had outstanding functional outcomes, 26% had good outcomes, 10% had fair outcomes, and 10% had poor outcomes.

However, Mostafa et al. [15] on evaluation of 38 cases that underwent PFN showed that 20(52.6%) were excellent, 12 (31.6%) were good, 5 (13.2%) were fair and the rest 1 (2.6%) were poor according to the Harris Hip Scoring System. Also, Jawad. [18] showed that After PFN surgery, the outcomes were rated as excellent in 21 (65.6%), good in 7 (21.8%), fair in 2, and poor in 2.

As well, Mehta et al. [4] showed that Functional result was rated excellent for 41 (63.33%) patients, fair or poor for 12 (20%) patients, and very poor for 5 (8.33%) patients. Two individuals (3.33%) had a very unfavorable prognosis.

Moreover, Ghilzai et al. [19] revealed that according to Harris hip scores excellent outcomes observed in 28.6% of patients, good in 45.1%, fair outcomes in 16.5%, and only 9.9% expressed poor outcomes among 91 patients who underwent PFN procedure. No significant association of functional outcome was observed concerning gender (p=0.289), age (p=0.127), type of fracture (p=513), and mode of admission (p=0.662). The variation in functional outcome between studies may be related to differences in the mean age of patients and the presence of comorbidities

Moreover, Rajput et al. [9] showed that the average time to union of the fractures in the PFN group was 13.47 ± 1.47 weeks. Also, Mohamed et al. [14] showed that the mean time for the union was 3.33 ± 0.82 months with a range from 2 to 5 months.

Furthermore, Dave et al. [17] as well as Pushkarna and Vikram. [16] showed that after healing all their studied cases performed their routine normal activity well.

Also, Ghilzai et al. [19] stated that there is ability to perform activities of daily routine like walking, squatting, cross-leg sitting, and climbing stairs was acceptable in patients of intertrochanteric fracture fixation with PFN.

Regarding complications, the current study showed that the overall complication rate in our cohort was 37.1%. As shown in our results, non-union was reported in four (11.4%) patients. Two (5.7%) patients suffered from deep infection. Lag screw cut-out was reported in another two (5.7%) patients. One (2.9%) patient developed impingement. DVT was reported in four (11.4%) patients.

Comparable to the current study,Mohamed et al. [13] showed that the overall complication rate was 40% including 26.6% Implant failures, 13.3% infection, and DVT in (6.7%).

However, lower than the current study Mostafa et al. [14] showed that the majority of the cases (n=34, 89.5%) had no complications. Superficial wound infection was the most common complication, found in 3 (7.9%) cases and 1 (2.6%) had bedsore.

Also, Push Karna and Vikram. [15] showed that three percent of patients in the PFN group experienced implant failure, three percent

experienced Z-effect, and one percent experienced non-union (5 percent). 11 percent of all patients experienced problems. Reasons for this include osteoporosis itself, screw placement errors (particularly the use of very long de-rotation screws), implant mismatches, and variations in the neck-shaft angle.

While higher than the current study Rajput et al. [9] showed that the overall complication rate in their cohort was 53.3%. All patients in the PFN group had fracture union by the end of the one-year follow-up period, except for 5 (16.6%) who developed femoral head screw backout and lateral thigh pain and limp and required a revision with a screw exchange. In addition, 3 (10%) had a Varus malunion, and 4 (13.3%) had a luxating patella.

The current study was limited by a small sample size, being a single-center study, and a relatively short follow-up period.

The advantage of the current study is that it highlighted that intramedullary nailing allows a minimally open approach which is closely linked to "biological internal fixation", in addition to its mechanical benefits over plate fixation also allows the surgeon to minimize soft tissue dissection, thereby reducing surgical trauma, blood loss, infection and wound complications.

Further comparative studies with larger sample sizes and longer follow-ups are needed to confirm our results and to identify risk factors of poor functional outcomes.Most of the complications of proximal femoral nailing are related to the surgeon and instruments, which can be reduced by proper patient selection and good preoperative planning.

CONCLUSIONS:

The current study showed that the proximal femoral nail is considered the ideal treatment option to fix an unstable intertrochanteric fracture in ambulatory elderly cases with low perioperative mortality risk. It is a simple, easy, minimally invasive, reliable, and effective method with shorter operative time, lesser blood loss, and reasonable time for bone healing with early mobilization of the patients. The majority of the patients have good to excellent functional outcomes after surgery.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors are responsible for the content and writing of the paper.

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