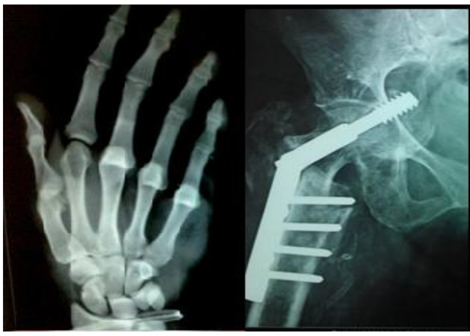

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Dr. RM Subramanian
Department of Orthopaedics, Saveetha Medical College and Hospital, Thandalam, Chennai, Tamil Nadu, India

Dr. Partheeswar
Department of Orthopaedics, Saveetha Medical College and Hospital, Thandalam, Chennai, Tamil Nadu, India

Dr. S. Navaneetha Krishnan
Department of Orthopedics, Saveetha Medical College and Hospital, Thandalam, Chennai, Tamil Nadu, India

Dr. Mithun Athiraj
Department of Orthopedics, Saveetha Medical College and Hospital, Thandalam, Chennai, Tamil Nadu, India

Corresponding Author:
Dr. Yeshwanth Subash
Department of Orthopaedics, Saveetha Medical College and Hospital, Thandalam, Chennai, Tamil Nadu, India

Comparison of Proximal femur nail (PFN) and proximal femur locking compression plate (PFLCP) for the treatment of subtrochanteric fractures of femur

Dr. RM Subramanian, Dr. Partheeswar, Dr. S. Navaneetha Krishnan, Dr. Mithun Athiraj and Dr. Yeshwanth Subash

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Abstract

Background: The surgical management of subtrochanteric femur fractures includes a range of implant options, such as cephalomedullary interlocking nails, PFLCP (Proximal Femoral Locking Compression Plate), sliding hip screws, fixed-angle blade plates, and dynamic condylar screws. Our study aims to compare the functional outcomes between patients with subtrochanteric fractures who underwent treatment using either a 'Proximal femur nail' or a 'Proximal femur locking compression plate'.

Method: 30 patients with subtrochanteric fractures between May 2021 to Jan 2022 were randomly allocated into 2 groups: Group 1 received Proximal Femur Locking Compression Plate (N=15) and Group 2 received Proximal Femur Nail (n=15). They were followed up for a minimum of 2 years, and functional outcomes were assessed using the Harris hip score.

Results: Both groups were similar in terms of age, sex, side involvement, and mode of injury. Type IB fractures were the most common according to the Russell Taylor fracture classification, followed by type IA and IIB fractures in both groups. The average follow-up duration was 12 months for group 1 and 10 months for group 2. Group 2 showed significant differences ($p < 0.001$) in operative time, blood loss, and radiation exposure.

Conclusion: We conclude that, our study demonstrates that PFN presents various benefits over PFLCP, such as decreased blood loss, shorter surgery time, and reduced devascularization of fracture fragments. These advantages stem from the higher probability of achieving closed reduction with PFN, resulting in minimal disruption to the fracture hematoma.

Keywords: Subtrochanteric fracture, PFLCP, PFN, Harris hip score

Introduction

Subtrochanteric femur fractures are considered unstable injuries and are typically characterized as fractures that happen within 5 cm of the lower end of the lesser trochanter. These fractures occur in three distinct groups of patients: young individuals involved in high-energy accidents, older individuals with osteoporosis who experience low-energy trauma, and patients who have been exposed to chronic or high-dose bisphosphonate therapy.

Subtrochanteric fractures make up around 10% to 30% of hip fractures and can occur in individuals of any age [1]. There is a higher occurrence of these fractures in two distinct age groups: individuals between 20 and 40 years old, as well as those over 60 years old, showing a bimodal distribution [2].

The subtrochanteric region of the femur consists predominantly of cortical bone, which results in lower vascularity compared to intertrochanteric fractures. As a consequence, the healing potential of subtrochanteric fractures is diminished. Due to the unique anatomical characteristics of this area, this type of fracture is associated with higher rates of malunion and non-union compared to other types of femoral fractures. Russell-Taylor classification is commonly used for subtrochanteric femur fractures.

Treatment options for subtrochanteric femur fractures can be divided into non-operative and operative approaches. In non-operative treatment, conservative management methods are employed.

On the other hand, operative treatment involves the use of various implants, including cephalomedullary interlocking nails, PFLCP (Proximal Femoral Locking Compression Plate), sliding hip screws, fixed-angle blade plates, and dynamic condylar screws. Each of these implants has its own set of advantages and disadvantages.

Locking plates were developed in the 21st century as a means of stabilizing subtrochanteric fractures. They serve as a buttress for the lateral trochanteric wall, aiding in its stabilization.

The objective of our study is to perform a comparative analysis of the functional outcomes in patients with subtrochanteric fractures treated with either a 'Proximal femur nail' or a 'Proximal femur locking compression plate'.

Materials and Methods

A prospective study was conducted at our hospital between May 2021 and May 2022, involving 30 patients with subtrochanteric fractures. The study received approval from the ethical committee of our institution. The patients were divided into two treatment groups using systematic sampling technique: one group comprising 15 cases treated with a Proximal Femur Nail, and the other group comprising 15 cases treated with a Proximal Femur Locking Compression Plate. All patients with subtrochanteric fractures who consented to surgery and follow-up were eligible for inclusion in our study. We specifically enrolled skeletally mature patients who sustained their injuries within a two-week period. However, we excluded certain groups of patients, such as those with pathological subtrochanteric fractures, individuals for whom surgery was contraindicated due to systemic diseases, patients with immature skeletons, individuals with open fractures, and those whose injuries occurred more than three weeks prior to presentation. Upon admission, all patients underwent a comprehensive clinical and radiological assessment. This included evaluating the airway, breathing, and circulation, as well as promptly assessing and addressing any life-threatening injuries. If necessary, blood transfusion was administered. Vital parameters were continuously monitored throughout the hospital stay. Additionally, all vital organs and associated injuries were examined and managed appropriately. Intravenous analgesics were administered to provide pain relief. In cases where there were no contraindications, the patient was immobilized with skeletal traction. All routine investigations were done and the patients were evaluated for fitness for surgery. Any associated comorbid conditions were noted and documented in the case records. The patients in the study were randomly assigned to two groups. Group 1 consisted of patients with subtrochanteric fractures who were designated to receive treatment with a Proximal Femur Locking compression plate (n=15), while Group 2 included patients who were to be treated with a Proximal Femur Nail(n=15). Anteroposterior and lateral radiographs of the proximal femur were obtained to assess the fracture type and pattern. The fractures were classified based on the Russell and Taylor classification system. Following the acquisition of informed and written consent for surgery, the patients underwent the surgical procedure. The surgery was conducted under spinal anaesthesia with intravenous antibiotic coverage. At the time of anesthesia induction, a 1 gm intravenous dose of cefazolin was administered, and postoperatively, it was continued for at least three days.

In Group 1, patients received treatment with Proximal Femur Locking Compression Plate (PFLCP), and a lateral approach was utilized for all cases. The patient was positioned in a supine position on a fracture table. Traction was applied, and a satisfactory reduction and alignment were achieved and confirmed using C-arm guidance. Alternatively, the patient could also be positioned laterally for the procedure. The length of the incision is determined based on the specific fracture pattern. Typically, a lateral longitudinal incision ranging from 10-15 cm in length is made, starting from 2 cm below the tip of the greater trochanter. Following the incision through the skin and subcutaneous tissues, the fascia of the vastus lateralis muscle is carefully divided at its proximal insertion. This allows for the muscle to be gently flipped, exposing the lateral aspect of the proximal femur for better visualization during the procedure. The fracture was successfully reduced primarily through open reduction techniques, employing bone holding forceps and collinear reduction clamps. It was imperative to verify the reduction in both anteroposterior (AP) and lateral views using fluoroscopy. Following the successful reduction, a plate was positioned on the lateral aspect of the proximal femur. Initially, the plate was temporarily secured to the shaft using K wires, and the alignment and reduction of the plate were assessed in AP and lateral views. Under C-arm guidance, 3.2 mm guide wires were inserted into the proximal hooded position, and their position was confirmed through both AP and lateral views. The most distal screw of the proximal hooded portion was inserted first to maintain the femoral neck shaft angle. Once the correct position of the guide wires was ensured, they were removed, and a drill bit was inserted through the drill sleeve. Subsequently, screws of appropriate length were inserted to achieve satisfactory subchondral purchase. The position and length of all screws were further verified under image intensifier in both AP and lateral views. Finally, the plate was fixed to the distal shaft using minimum cortical screws of 4.5 mm (with 6 cortical purchases). In Group 2, patients underwent treatment with PFN (Proximal femoral nail). The procedure was performed with the patient in a supine position on a fracture table, allowing for effective radiological evaluation and improved manipulation of the leg with the application of traction. The patient's body was positioned at a 15-degree inclination towards the unaffected side. The unaffected limb was flexed, abducted, and externally rotated to create ample space for optimal positioning of the image intensifier.

The affected lower limb was placed in traction and adduction, secured to the foot piece. Reduction was accomplished by applying traction to disengage the fracture fragments and internally rotating the limb while maintaining traction. The reduction was confirmed using the image intensifier. If closed reduction couldn't be achieved successfully, an open approach was employed using a lateral incision. An anatomic reduction of the fracture fragments was accomplished using bone clamps and K wires, followed by the insertion of the nail for stabilization. A 3cm incision is made dorsally, starting from the proximal tip of the greater trochanter. The incision follows the lines of the skin incision, extending through the subcutaneous tissue and deep fascia. Blunt dissection is used to separate the fibers of the gluteus maximus muscle. The entry point for the procedure is determined by palpating the tip of the trochanter with a finger. This approach is typically employed for closed reductions of fractures. In cases requiring an open reduction of subtrochanteric fractures, a lateral approach is utilized to facilitate the reduction of the fracture. Achieving proper reduction of the fracture is crucial before determining the entry point. Once the reduction is confirmed to be satisfactory with the assistance of C-arm guidance, the entry point is established. The entry point is either the tip of the trochanter or slightly medial to the tip of the greater trochanter. In cases where longitudinal traction and internal rotation alone do not result in successful reduction, temporary fixation using K wires and Steinman pins may be necessary to maintain reduction without obstructing the trajectory of the nail. The entry point is then confirmed in both anteroposterior (AP) and lateral views, following which the awl is driven up to the level of the lesser trochanter. A 3.2 mm guide wire is carefully inserted through the established entry point and driven distally into the femur. Proximal reaming is performed using a 15mm cannulated awl, which is passed along the guide wire to create sufficient space for the wider proximal part of the nail compared to its distal part. Distal reaming is then carried out incrementally, ensuring a diameter 1mm larger than the desired size of the nail. To prevent soft tissue injuries during reaming, protective sleeves can be utilized. After inserting the guide wire, its position is verified using fluoroscopic guidance to ensure its central alignment. This step helps prevent unnecessary eccentric reaming and other deformities. The guide wire is advanced up to approximately 5mm proximal to the intercondylar notch. Gentle tapping of the guide wire into the bone is performed to secure its position, reducing the risk of inadvertent displacement during subsequent removal and reamer exchange.

The appropriately sized nail, matching the neck-shaft angle of the unaffected hip, is assembled in a zig configuration. The nail is then inserted over the zig and carefully guided through the entry point in a distal direction using gentle twisting movements. The mounted Proximal Femoral Nail (PFN) of the appropriate width is further passed distally into the medullary canal, accommodating the placement of the proximal two screws into the femoral neck. Before insertion of screws, the alignment of the nail with the zig configuration is carefully checked to ensure proper alignment of the proximal and distal targeting guides with the corresponding holes in the nail. To facilitate the placement of screws, a stab incision is made along the lateral aspect of the femoral shaft. Drill sleeves are then inserted into the proximal targeting guide, reaching the lateral cortex. Subsequently, a trocar is inserted through the drill sleeve. Guide wires for the lag screw and derotation screw are passed through guide pin sleeves, stopping approximately 5 mm from the articular surface of the femoral head. The position of the guide wires is assessed using fluoroscopic guidance. In the anteroposterior (AP) view, the guide wire for the lag screw should be inferior to the neck, while in the lateral view, it should pass centrally.

Using a cannulated drill bit, drilling is performed, and the length of the lag screw and derotation screw is verified using depth gauges. Appropriate length lag screws and derotation screws are then inserted. For cases requiring distal targeting, a distal targeting guide and drill sleeves are used with a 4.0 mm drill bit in situations involving a short Proximal Femoral Nail (PFN). In cases where a long nail is used, distal locking is accomplished through a free-hand technique under C-arm guidance. Following the surgery, the patient received intravenous administration of third-generation cephalosporin and aminoglycosides for antibiotic prophylaxis. Oral antibiotics were initiated starting from the 7th day postoperatively. Parenteral analgesics were administered for the first two days, considering the patient's pain tolerance level.

On the 2nd day post-surgery, the drainage tube was removed. Physical therapy, including static and quadriceps strengthening exercises, as well as physiotherapy, commenced on the same day. For patients treated with Proximal Femoral Nail (PFN), Weight-bearing walking with the assistance of a walker was initiated on the 3rd day. However, in cases managed with Proximal Femur Locking Compression Plate (PFLCP), weight-bearing was delayed for up to 8 weeks, depending on the presence of callus formation as evidenced on radiographs. Suture removal took place on the 12th day after the operation. Radiological assessments were conducted at the 8-week mark and then monthly until evidence of bone union was observed. Additional radiographic evaluations were performed at 6 months and 1 year. Further decisions regarding weight-bearing and rehabilitation were based on the radiographic evidence of callus formation and union. At the end of 6 months, the patients were evaluated using the Harris Hip Score to assess their hip function and overall outcomes. Patient case records documented all follow-up data and scores. IBM SPSS Version 22.0 was used for data analysis. Continuous variables were expressed as mean ± SD, while categorical variables were presented as numbers and percentages. Chi-square test compared categorical variables. A p-value <0.05 indicated statistical significance.

Results

30 patients with subtrochanteric fractures from May 2021 to May 2023 were randomly assigned to 2 surgical treatment groups and followed for 2 years.

Group 1: **Patients managed by PFLCP (n=15)**

The patients in this group had a mean age of 46.93±7.4 years, ranging from 37 to 75 years. Out of the total, there were 10 males and 5 females, with the right side being more frequently affected, observed in 8 of the patients. In accordance with the Russell Taylor fracture classification, type IB fractures were the predominant type observed, followed by type IA and IIB fractures. RTA was the most commonly mode of injury as seen in 9 patients followed by slip and fall in 6 patients. ORIF with PO was performed through the lateral approach using a locking compression plate. The average operating time for patients undergoing PFLCP was determined to be 104 minutes (Figure 1), while the average blood loss for PFLCP patients was measured at 152.50 ml (Figure 2). Patients who underwent PFLCP had an average follow-up duration of 12 months. The average time to fracture union was 16.1 weeks ranging from 13 to 18 weeks.

Out of the patients, 2 achieved an excellent Harris Hip Score (HHS), 6 had a fair HHS, 5 attained a good HHS, and 2 exhibited a poor HHS (Figure 3). There was no change in the score after the 1 year period. In our study screw breakage of proximal locking screws were seen in 2 cases managed by PFLCP and varus collapse was seen in 3 cases managed by PFLCP.

Shortening was observed 5 cases. Screw loosening was seen in 1 patient and plate breakage was seen in 1 patient. None of the patients were lost to follow up.

Group 2: Patients managed by PFN(n=15)

The patients in this group had a mean age of 47.20±16.4 years, ranging from 33 to 68 years. Out of the total, there were 11 males and 4 females, with the right side being more frequently affected, observed in 10 of the patients. In accordance with the Russell Taylor fracture classification, type IB fractures were the predominant type observed, followed by type IA and IIB fractures. RTA was the most commonly mode of injury as seen in 8 patients followed by slip and fall in 7 patients. The average operating time for patients undergoing PFN was determined to be 80 minutes (Figure 1), while the average blood loss for PFN patients was measured at 78.00 ml (Figure 2). Patients who underwent PFN had an average follow-up duration of 10 months. The average time to fracture union was 15.56 weeks ranging from 13 to 17 weeks.

Out of the patients, 6 achieved an excellent Harris Hip Score (HHS), 4 had a fair HHS, 5 attained a good HHS, and none of them exhibited a poor HHS (Figure 3). There was no change in the score after the 1year period. Shortening was observed 3 cases. Nail breakage was seen in 1 patient and no complications were encountered for others in this group. None of the patients were lost to follow up (Table 1).

Discussion

Subtrochanteric fractures pose a significant challenge for orthopaedic surgeons due to the difficulty in controlling deforming forces and the prolonged healing time required for union. Currently, orthopedicians commonly rely on three primary implant systems: the intramedullary hip screw system, intramedullary interlocking nails, and plate screw systems. Each of these systems has its own set of advantages and disadvantages. In comparison to extramedullary implants, intramedullary fixation offers several advantages, including a more biologically favorable fixation with reduced devascularization, decreased bleeding, shorter surgical duration, and faster achievement of functional recovery. The use of the proximal femoral locking compression plate (PFLCP) offers the advantage of achieving a precise anatomical reduction and providing a stable fixation. However, it is important to consider potential drawbacks associated with this approach. These may include the requirement for long incisions, extensive tissue dissection, and prolonged exposure time, all of which could theoretically increase the risk of infection. Moreover, there is a possibility of iatrogenic damage to neurovascular structures due to errors in dissection or excessive retraction. Additionally, excessive stripping of the periosteum during PFLCP placement can negatively impact the bone's blood supply. In contrast, the proximal femoral nail (PFN) presents multiple advantages over PFLCP. It avoids excessive soft tissue dissection and periosteal stripping, thus preserving vascularity and facilitating fracture healing. In our study, we ensured that both groups were similar in terms of age, sex, mode of injury, side dominance, and fracture classification, thus establishing a fair comparison. Notably, the duration of surgery was found to be shorter in the proximal femoral nail (PFN) group compared to the proximal femoral locking compression plate (PFLCP) group. The differences in surgery duration, blood loss, and radiation exposure were statistically significant (P value < 0.001). While the time taken for fracture union was relatively faster in the PFN group, this difference did not reach statistical significance. To assess functional outcomes, we employed the HARRIS HIP score, and interestingly, both groups exhibited comparable scores with minimal difference between them. In our study, the majority of patients experienced fractures as a result of road traffic accidents (RTAs), accounting for 60% of the cases. Accidental falls were the cause of fractures in 40% of the cases. These findings align with a study conducted by Subramanyam Yadlapalli *et al*., which reported similar results [3]. In our study, a significant proportion of cases were categorized as Russel Taylor Type IB subtrochanteric fractures. Specifically, the majority of cases fell under this classification. A study conducted by French *et al*. also observed 45 cases of Russel Taylor Type IB subtrochanteric fractures, supporting our findings [4]. In the PFLCP group, the average blood loss observed was 152.50 ml, whereas in the PFN group, the average blood loss was 78.00 ml. A notable and statistically significant difference was found in the amount of blood loss between the PFN and PFLCP groups (p value of 0.00). Similar findings were reported in a study conducted by V. Srivastava *et al*., where PFN was compared to PFLCP, and the obtained p value was also less than 0.001 [5]. The PFN group had significantly shorter operating time compared to the PFLCP group. In the PFN group, reduction of fractures was also achieved more easily. A study by Sadowski *et al*. reported a mean surgery duration of 82 minutes for PFN, which is consistent with our findings of 80 minutes [6]. In contrast, the mean surgery duration for PFLCP in our study was 104 minutes. Another study by Diarmuid Murphy *et al*. reported an operating time of 163.2 minutes for PFLCP [7]. Our study demonstrated a high union rate among the cases treated with PFN, with 90% of fractures achieving union. The mean union time for PFN cases was 15.56 weeks. In contrast, the union rate for PFLCP cases was 70%, with a mean union time of 16.1 weeks. These findings align with the results of other studies, indicating the comparability of our study outcomes with existing research. PFN prevents varus collapse of the subtrochanteric medial cortex, reducing failure rates.

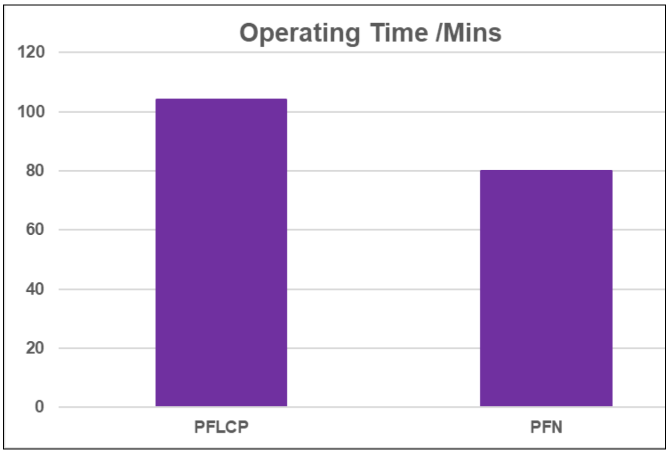

Fig 1: Operating Time/mins

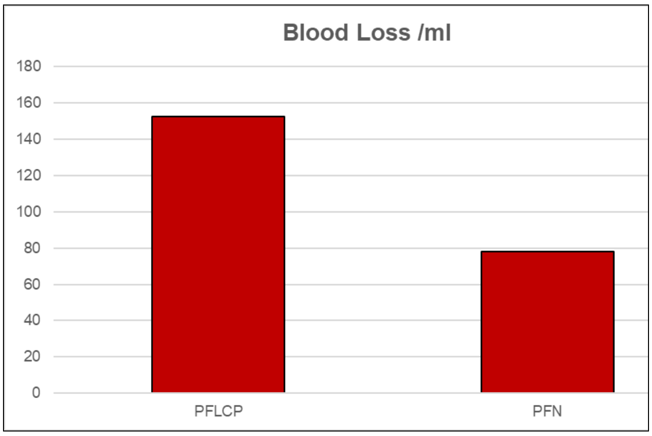

Fig 2: Blood Loss/ml

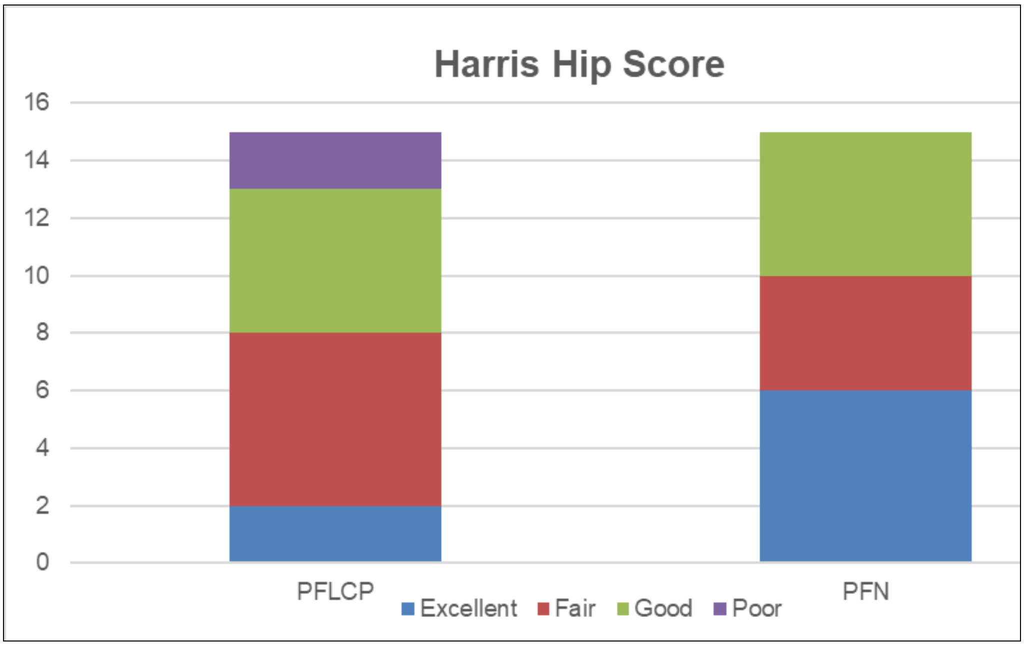

Fig 3: Harris Hip Score

Table 2: Patients Demographics and Data

S.no	Age/sex	Mode of injury	Side	Classification russel and taylor	Operating time (minutes)	Blood loss (ml)	Reduction	Implant	Harris hip score 3mon	Harris hip score 1 year	Bone grafting	Complications Infection, shortening, implant failure, varus collapase, lurching	Associated injuries
1	33/m	RTA	Right	1a	80	70	Closed	Long PFN	85	85	Primary	Nil	Nil
2	45/m	Slip and fall	Right	1b	90	75	Closed	PFLCP	83	83	Nil	Nil	Nil
3	48/m	Slip and fall	Right	2b	100	95	Open	PFLCP	84	84	Nil	Nil	Dm
4	37/m	Slip and fall	Right	1a	110	100	Closed	PFLCP	89	89	Nil	Nil	Htn
5	57/f	RTA	Right	1b	90	110	Closed	Long PFN	87	87	Nil	Nil	Nil
6	53/f	RTA	Right	1a	120	150	Closed	Long PFN	86	86	Nil	Screw loosening	Nil
7	64/f	RTA	Right	2b	70	200	Open	Long PFN	92	92	Nil	Nil	Nil
8	66/m	RTA	Right	2b	80	175	Open	PFLCP	95	95	Nil	Nil	Nil
9	69/m	RTA	Left	1a	60	180	Closed	PFLCP	81	81	Nil	Nil	Nil
10	75/m	RTA	Left	1b	85	100	Closed	PFLCP	88	88	Primary	Nil	Nil
11	38/m	RTA	Left	2b	95	120	Closed	PFLCP	85	85	Nil	Nil	Nil
12	47/m	RTA	Left	1a	70	110	Closed	Long PFN	80	80	Nil	Nil	Nil
13	45/m	RTA	Left	2b	120	90	Open	Long PFN	79	79	Nil	Nil	Nil
14	54/f	RTA	Left	1b	100	80	Closed	Long PFN	80	80	Nil	Screw breakage	Dm
15	58/f	Slip and fall	Right	1a	80	80	Closed	PFLCP	75	75	Nil	Nil	Nil
16	59/f	Slip and fall	Left	2b	95	100	Open	PFLCP	84	84	Nil	Nil	Nil
17	50/m	Slip and fall	Left	1b	75	120	Open	Long PFN	76	76	Nil	Nil	Nil
18	52/m	Slip and fall	Right	1a	110	120	Closed	Long PFN	80	80	Nil	Nil	Nil
19	61/m	Slip and fall	Right	2a	85	125	Open	PFLCP	74	74	Nil	Nil	Dm
20	63/m	RTA	Left	2a	85	185	Open	PFLCP	89	89	Nil	Nil	Htn
21	62/m	RTA	Left	1b	120	195	Open	Long PFN	73	73	Nil	Varus collapse	Nil
22	66/f	RTA	Left	1a	60	200	Closed	Long PFN	80	80	Primary	Nil	Nil
23	37/f	RTA	Left	2a	70	185	Open	PFLCP	86	86	Nil	Nil	Nil
24	54/f	RTA	Right	2a	75	200	Open	PFLCP	82	82	Nil	Nil	Nil
25	59/m	RTA	Right	1a	65	150	Closed	Long PFN	88	88	Nil	Nil	Nil
26	57/m	RTA	Right	1a	85	145	Closed	PFLCP	80	80	Nil	Nil	Nil
27	49/f	RTA	Left	1b	95	200	Closed	PFLCP	89	89	Nil	Nil	Nil
28	46/f	RTA	Left	2a	100	180	Open	Long PFN	82	82	Nil	Nil	Nil
29	42/m	RTA	Right	1a	110	190	Closed	Long PFN	83	83	Nil	Nil	Nil
30	40/m	Slip and fall	Right	1b	95	155	Open	Long PFN	82	82	Nil	Nil	Nil

Conclusion
The effectiveness of both PFN and PFLCP has been established in the management of subtrochanteric fractures. Subtrochanteric fractures are known to require a longer time for proper bone union. Our findings did not reveal significant differences in functional outcomes or complications between the two methods. However, PFN offers several advantages over PFLCP, including reduced blood loss, shorter surgery duration, and less devascularization of fracture fragments. This is attributed to the increased likelihood of achieving closed reduction with PFN, which minimizes disturbance to the fracture hematoma.

Declarations
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Conflict of Interest: None declared

Ethical Approval: Not required

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