ORIGINAL ARTICLE

Intraoperative Guidewire Loosening, Intraoperative and Postoperative Treatment Outcomes in Traditional versus Modified Medullary Fixation Techniques in Patients with Intertrochanteric Femoral Fractures

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Background: The authors' pilot study found that when the femoral guidewire passes through to the acetabulum during an intramedullary fixation, it led to less guidewire loosening and shorter operative times.

Objective: To compare the incidence of femoral guidewire loosening once passed through to the acetabulum and other treatment outcomes between traditional and modified medullary fixation techniques in patients with intertrochanteric fractures.

Materials and Methods: Therapeutic research with retrospective observational cohort data collection was conducted on patients with intertrochanteric fractures who had surgery with cephalomedullary fixation at Nong Bua Lamphu Hospital. Two study groups were divided by surgical technique. The traditional technique inserted a femoral guidewire within 5 mm of the subchondral bone of the femoral neck. The modified technique inserted a femoral guidewire within 5 mm of the surface of the acetabular joint, and the femoral guidewire was used as a counteracting force while the screws or blade were removed. Patients were followed up during their postoperative inpatient stay and at one-, three-, and six-months postoperatively. The comparison focused on perioperative femoral guidewire loosening and other treatment outcomes between the two groups during the follow-up period.

Results: Of the 109 patients, which included 55 patients with modified techniques, there were no differences in patient characteristics, except for the mechanism of femoral fracture, preoperative status, and type of material used for fixation. After adjusting for these factors, the occurrence of femoral guide wire loosening was lower in the modified technique group (risk difference –10.15, 95% CI –18.64 to –1.67, p=0.019) with less blood loss during both intra- and post-operation. Moreover, the modified technique indicated a lower, limited range of motion for the hip compared to the traditional group.

Conclusion: The authors recommend using a modified technique for cephalomedullary fixation in patients with intertrochanteric fractures of the femur because it has a lower chance of the femoral guidewire coming loose during surgery, less bleeding, and better hip movement after surgery.

Keywords: Intertrochanteric; Fractures; Intramedullary fracture fixation; Intraoperative complications; Postoperative complications; Orthopedic fixation devices; Weight bearing

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The rise in incidence of femoral fractures is associated with increased aging population. The majority of femoral fractures are caused by falls and injury to the hip area in tandem with osteoporosis. Femoral fractures carry an annual mortality risk as high as 20% to 30%[1,2]. Patients with metabolic bone disease most commonly develop osteoporosis, affecting over 40% of post-menopausal females[3]. Femoral fracture patients who do not receive surgical treatment have a one-year mortality risk of 60%, and 33% require hospital admission for treatment of complications[4]. Surgical treatment should be promptly delivered in these patients to facilitate their return to daily life with a normal range of motion and reduce complications that contribute to mortality. Literature suggests one-year mortality risk can be reduced by up to two times when femoral fracture patients receive surgical treatment[5]. Pincus

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et al. (2017) demonstrated that surgical intervention within 24 hours, when contraindications were absent, significantly lowers mortality rates[6]. There are different surgical options for treating femoral fractures[7], such as using a proximal femur nail anti-rotation (PFNA), and the choice depends on the location of the fracture and the severity the osteoporosis, as well as other factors that can affect the range of motions of the patient. The surgical fixation of the intertrochanteric fracture of the femur can be performed using a cephalomedullary nail or PFNA I and II, which has been established to be superior to the sliding hip screw or blade plate[8] due to their range of uses in stable and unstable fractures[9,10]. The traditional technique employs fluoroscopy, however, femoral guidewires often become loose during the insertion of femoral blades or screws, which increases operative time[11,12] and increases the risk of intraoperative bleeding[13]. Hence, a modified technique has been developed for inserting femoral guidewires deeper into the acetabulum, which improves the stability and ease during blade and screw insertion without further complications, especially in the elderly with osteoporosis.

The authors' pilot study indicated that the new method of placing a femoral guidewire into the acetabulum lowers the chance of the guidewire becoming loose during surgery compared to the standard technique, subsequently reducing the operating time. Although the modified technique may result in more errors in the length measurement of femoral blade screws, no differences were seen in the treatment outcome and complications of the pilot study. No therapeutic study has evaluated this new modified technique to date. The objective of the present study was to compare the therapeutic outcomes, complications, and risk of intraoperative guidewire loosening in cephalomedullary fixation of femoral fractures, comparing the traditional versus the modified technique. The results of the present data will be implemented to further develop surgical techniques for intertrochanteric fractures using PNFA I and II in the future.

Materials and Methods

Patients and study design

After obtaining approval from the Human Research Ethics Committee (Nong Bua Lamphu Hospital, number 012/2567, signed on 21 June 2024), the present therapeutic efficacy research was conducted at Nong Bua Lamphu Hospital using a retrospective cohort data-collecting design between January 3, 2018 and August 30, 2023 in patients over 18 with intertrochanteric fracture who received cephalomedullary fixation using PNFA I and II at Nong Bua Lamphu Hospital. The retrospective design of the present study waived informed consent. The study excluded patients with bleeding disorders, those lost follow-up more than once, and patients who died after surgery but during hospitalization. The present study divided the patients into two groups based on their surgical technique. The control group included patients with intertrochanteric fractures who underwent traditional cephalomedullary fixation technique, which meant a femoral guidewire was placed into the femoral neck within 5 mm of the subchondral bone. The study group consisted of intertrochanteric fracture patients who underwent a modified cephalomedullary fixation technique, defined by a femoral guidewire inserted within 5 mm of the surface of the acetabular joint. The data was collected starting from the pre-operative period, through the intra-operative period, and during the follow-up period at the orthopedics clinic at one-, three-, and six-month post-operation (Figure 1).

Clinical endpoint

Primary endpoint:

Intraoperative loosening of the femoral guidewire

Secondary endpoint:

1. Intraoperative outcomes:
   a. Intraoperative blood loss
   b. Operative time.
2. Postoperative inpatient outcomes:
   a. Blood loss within 72 hours postoperatively
   b. Postoperative complications
   c. Barthel Index upon discharge
   d. Pain score upon discharge
   e. Length of stay during postoperative admission (days)
3. Postoperative outcomes at one-, three, and six-months:
   a. Pain score (using numerical rating scale, NRS)

Sample size estimation and statistical analysis

According to the pilot study, the estimation of the femoral guidewire loosening with the traditional technique was 20% versus 2% with the modified technique. Statistical power was predetermined at 0.80 and alpha at 0.05 as a two-sided test with equal sample proportions between the two groups. A study size estimation was derived to be 44 samples in each

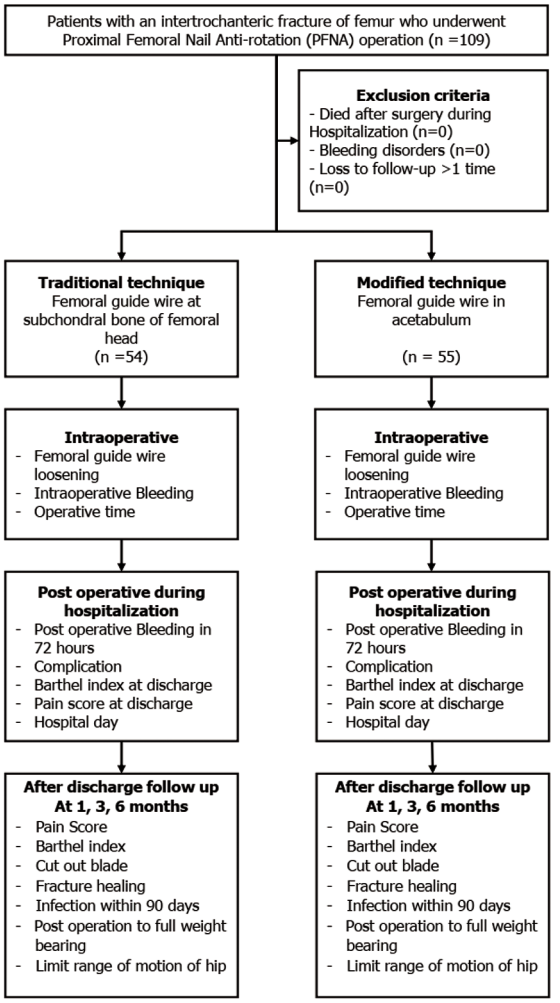

Figure 1. Flow of the study.

group, for a total of 88 samples. Accounting for an attrition rate of 20% being lost to follow-up, a final sample size estimation was derived at 110 patients.

Depending on the data characteristics, the authors presented the data qualitatively using percentages, mean, standard deviation, median, and interquartile range. The authors examined the differences in treatment results for the primary and secondary endpoints between the two groups using various statistical methods such as the independent samples t-test, Mann-Whitney U test, exact probability test, or non-parametric test for trend. The authors also analyzed multiple follow-up points at one-, three-, and six-months using similar statistical techniques.

Pain score and Barthel index were follow-up at one-, three-, and six-months, and analyzed using multivariable and multilevel mean difference regression.

Results

Of the 109 patients with intertrochanteric fracture of the femur, 54 patients underwent treatment with the traditional technique, where a femoral guidewire was inserted within 5 mm of the subchondral bone of the femoral neck, the another 55 patients underwent treatment with the modified technique where a femoral guidewire was inserted through to the acetabulum within 5 mm of the surface of the acetabular joint. Both groups were predominantly female within similar baseline characteristics, namely the average body mass index (BMI), comorbidities such as diabetes, hypertension, chronic kidney disease, and cerebrovascular disease.

Regarding fracture classification differences, Evan's classification was similar in both groups, being the unstable type. Similarly, the American Society of Anesthesiologists classification was class III in both groups.

The mechanism of fracture between the two patient groups was similar, being from falls and road traffic accidents. The group that underwent treatment using the traditional technique included patients who experienced falls from heights. The preoperative surgical status of patients in both groups were mobile with or without a walking stick. However, there were bedridden patients who underwent treatment with the traditional technique. Additionally, patients in the traditional technique group received the PNFA I implant material, whereas the modified technique group received the PNFA I implant, with a minority having received the PNFA II implant, or 20.1% (Table 1). Both groups had similar baseline lab results, namely the complete blood count, blood urea, creatinine, and electrolytes, specifically sodium, potassium, chloride, and bicarbonate (Table 2).

The prevalence of intraoperative femoral guidewire loosening in the present study was 11.1% in the traditional technique compared to none in the modified technique. Comparing differences between groups after adjusting for the cause of fracture and type of implant using the risk difference regression, the authors found a reduced risk of femoral guide wire loosening in the modified group compared to the traditional group by 10.15% (p=0.019). The operative times for both techniques were similar, with an average of one hour. Although the modified technique was found to have reduced intraoperative blood loss after having adjusted for cause of the fracture and the type of the implant, the volume was 5.63 mL (95% CI –8.89 to 2.36, p=0.01) (Table 3).

In the postoperative period, the modified

Table 1. Patients' characteristics

Characteristics	Traditional technique (n=54)	Modified technique (n=55)	p-value
Female; n (%)	35 (64.8)	43 (78.2)	0.141
Age (years); mean±SD	71.8±16.9	72.6±12.0	0.780
Weight (kg); mean±SD	51.3±7.0	52.8±8.0	0.294
Height (cms); mean±SD	156.0±5.8	157.3±6.6	0.265
BMI (kg/m^2); mean±SD	21.1±2.7	21.3±3.1	0.650
Underlying; n (%)			
Diabetes mellitus	19 (35.2)	16 (29.1)	0.542
Hypertension	24 (44.4)	22 (40.0)	0.700
Chronic kidney disease	9 (16.7)	5 (9.1)	0.266
Dyslipidemia	5 (9.3)	8 (14.6)	0.556
Old cerebrovascular accident	4 (7.4)	4 (7.3)	1.000
Chronic obstructive pulmonary disease	3 (5.6)	2 (3.6)	0.679
Cirrhosis	1 (1.9)	0 (0.0)	0.495
Seizure	1 (1.9)	0 (0.0)	0.495
Cancer	0 (0.0)	1 (1.9)	1.000
Osteoporosis (suspected); n (%)	43 (79.6)	45 (81.8)	0.812
Cause of facture; n (%)			0.032
Falling	41 (75.9)	48 (87.3)	
Falling from height	5 (9.3)	0 (0.0)	
Traffic accident	8 (14.8)	7 (12.7)	
Site of leg; n (%)			0.700
Right	22 (40.7)	25 (45.5)	
Left	32 (59.3)	30 (54.5)	
Type of facture (Evan's classification); n (%)			0.696
Stable	20 (37.0)	23 (41.8)	
Unstable	34 (63.0)	32 (58.2)	
American Society of Anesthesiologist classification; n (%)			0.159
I	3 (5.6)	0 (0.0)	
II	7 (13.0)	8 (14.6)	
III	44 (81.4)	47 (85.4)	
Number of days before surgery; median (IQR)	2.5 (1, 4)	3 (1, 5)	0.495
Status before surgery; n (%)			0.334
Walk/crutches or walker	27 (50.0)	30 (54.5)	
Quadriparesis, paraparesis	24 (44.4)	25 (45.5)	
Bedridden	3 (5.6)	0 (0.0)	
Type of implant; n (%)			<0.001
PFNA I	54 (100)	39 (70.9)	
PFNA II	0 (0.0)	16 (20.1)	

BMI=body mass index; PFNA=proximal femur nail anti-rotation; SD=standard deviation; IQR=interquartile range

technique group experienced 13.28 mL less blood loss than the traditional technique group using Poisson mean difference regression analysis (95% CI –15.25 to –11.32, p<0.001). Nevertheless, both treatment groups had a similar duration of postoperative hospital stay. Furthermore, over a six-month period, the proportion of patients with postoperative complications such as cut-out blade, fractured healing, and surgical site infection within 90 days were not different between the two treatment groups. Additionally, there was no significant difference in the duration from postoperative to full weight-bearing between the two groups.

Furthermore, the modified technique group demonstrated a reduced incidence of postoperative limited range of hip motion by 7.87% compared to the traditional technique group with risk difference regression analysis (95% CI –15.08 to –0.65,

Table 2. Laboratory parameter on admission

Laboratory parameter	Traditional technique (n=54); mean±SD	Modified technique (n=55); mean±SD	p-value
Blood urea nitrogen (mg/dL)	20.5±12.1	18.4±10.6	0.378
Creatinine (mg/dL)	1.1±0.6	1.1±0.9	0.778
Electrolyte (mmol/L)			
Sodium	136.3±4.5	136.1±4.2	0.792
Potassium	3.9±0.6	3.9±0.5	0.894
Chloride	101.4±4.3	101.0±4.4	0.623
Bicarbonate: Total CO_2	24.7±3.1	24.6±4.0	0.886
Complete blood count			
Hematocrit (%)	30.7±5.4	30.1±5.5	0.616
Hemoglobin (g/dL)	10.1±2.0	9.9±1.8	0.604
White blood count (*10^3 cells/mm^3)	101.5±3.3	103.0±3.7	0.824

SD=standard deviation

Table 3. Clinical endpoints comparing between groups

Clinical endpoints	Traditional technique[a] (n=54)	Modified technique (n=55)	Parameter	Effect	95% CI	p-value
Intraoperative period						
Femoral guide wire loosening; n (%)	6 (11.1)	0 (0.0)	Risk difference*	−10.15	−18.64 to −1.67	0.019
Bleeding (mL); median (IQR)	30(20, 100)	50(30, 50)	Poisson mean difference*	−5.63	−8.89 to −2.36	0.001
Operative time (minutes); mean±SD	48.4±22.1	44.4±14.7	Mean difference*	−2.89	−10.11 to 4.33	0.433
Postoperative period						
Bleeding (mL); median (IQR)	20(20, 30)	10(10, 20)	Poisson mean difference*	−13.28	−15.25 to −11.32	<0.001
Hospital stay (days); mean±SD	9.1±4.4	9.6±4.0	Mean difference*	0.15	−1.62 to 1.93	0.864
Cut out blade/nail; n (%)	1 (1.9)	2 (3.6)	Risk difference**	0.13	−6.54 to 6.79	0.970
Fracture healing; n (%)			Ordinal odds ratio**	2.07	0.83 to 5.19	0.120
• Union	18 (33.3)	21 (38.2)				
• Delayed	1 (1.9)	0 (0.0)				
• Mal-union	35 (64.8)	34 (61.8)				
• Non-union	0 (0.0)	0 (0.0)				
Infection within 90 days (SSI); n (%)	1 (1.9)	0 (0.0)	Risk difference**	−2.27	−6.62 to 2.08	0.306
Post-operation to full weight bearing (months); mean±SD	5.68±0.53	5.67±0.51	Mean difference**	−0.01	−0.19 to 0.17	0.907
Limit range of motion of hip; n (%)	4 (7.4)	0 (0.0)	Risk difference**	−7.87	−15.08 to −0.65	0.033

CI=confidence interval; SD=standard deviation; IQR=interquartile range; SSI=surgical site infection

(a) Traditional technique: reference group

* Adjusted for cause of fracture and type of implant; ** Adjusted for cause of fracture, type of implant, pain score, and Barthel index at discharge, using the proportional odds assumption

p=0.033) (Table 3).

After hospital discharge, the authors compared the pain score trend during the follow-up period. After adjusting for the following differences between groups, the cause of fracture, type of implant, pain score, and Barthel index at discharge using multivariable and multi-level mean difference regression, no difference was found in postoperative pain levels between the two groups (Figure 2a). However, the modified technique group significantly improved their Barthel index compared to the traditional technique (Figure 2b). Nevertheless, all the patients in both treatment groups were able to return to self-care after six months with a Barthel index in the independent range of 12 to 20, except for those who were bedridden preoperatively (Table 4).

Discussion

The present study found that using a modified technique for fixing intertrochanteric femoral fractures with cephalomedullary fixation leads to a lower chance of the guidewire coming loose during surgery and less blood loss. Additionally, at the six-month postoperative follow up, the modified

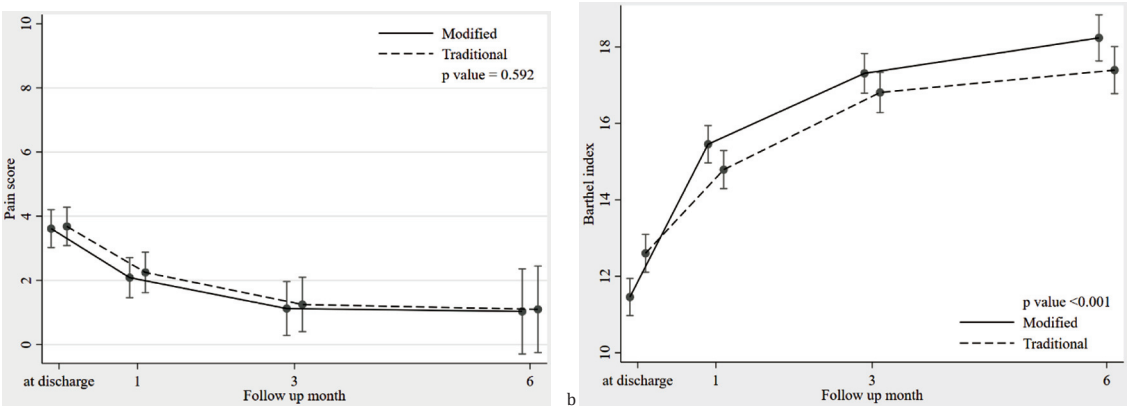

Figure 2. Pain score (0 to 10) and Barthel index (0 to 20) along follow up period: (a) Pain score; (b) Barthel index.

Table 4. Activity status using Barthel score between groups

At discharge	Traditional technique (n=54) at 3 months			Modified technique (n=55) at 3 months		
	Dependent	Partial dependent	Independent	Dependent	Partial dependent	Independent
Dependent	3	0	0	0	0	0
Partial dependent	0	0	17	0	0	27
Independent	0	0	34	0	0	28

treatment demonstrates a reduced incidence of postoperative limited hip range of motion without any differences in other postoperative complications between the two treatment groups.

Intraoperative loosening of femoral guidewires during cephalomedullary fixation is a potential complication with multifactorial causes such as osteopenia and osteoporosis in the elderly, overtly applied counteraction force, errors during the surgical procedure, and inadequate positioning or fixation that can contribute to femoral guidewire loosening during insertion. Conversely, selecting an appropriate implant size and shape, or utilizing alternative surgical methods like implants with extended lengths or screw threads, can enhance the stability of the fixation. Quental et al. demonstrated in their study that the positioning of the femoral guidewire deep and inferiorly significantly impacted the strength of the fixation of the nail or screw[12]. Yang et al. used an external guidewire that runs parallel with an internally penetrating femoral guidewire to find the adequate placement site for PFNA implantation[11]. Yu et al. found PFNA II to be more adequate for unstable femoral fractures[13], particularly among Asian populations[14]. An incidence of guidewire broken during femoral blade insertion has been reported[15], and surgical removal of the broken wire can be technically challenging[16,17]. Feeney et al. recommended avoiding over-penetration of the guidewire into the acetabulum to minimize the risk of intrapelvic organ injury[18]. Moreover, no comparable studies have been conducted to assess impact, such as hip joint infection or degenerative alterations related to this surgical method. A survey showed that orthopedic surgeons who routinely perform the traditional technique of inserting a femoral guidewire into the femoral neck within 5 mm of the subchondral bone also experienced frequent intraoperative guidewire loosening, especially in the elderly with osteoporosis.

In the present study, all PFNA I and II implants are from the same manufacturer, performed by a single surgeon. The choice of PFNA I or II implant depends on the stability of the intertrochanteric fracture, the former and latter for stable and unstable fractures, respectively, according to Evan's classification. The present study found that PFNA II implants result in longer operative times and bleeding than PFNA I. However, the PFNA II also results in fewer instances of varus collapse and fracture of femoral shaft when compared to PFNA I, with no differences in other complications between the two implants[19,20].

The limitation to the present study is the inability to clearly define the status of osteoporosis for patients in the study due to the unavailability of a bone mineral density (DEXA) scanner. Instead, the authors used

the FRAX score, using data such as age, mechanism of fracture, comorbidities, and bone quality in assessing whether to employ the modified technique during cephalomedullary fixation of intertrochanteric fractures by inserting femoral guidewires to within 5 mm of the acetabulum. The contraindication is in cases of intertrochanteric femoral fractures requiring reinforcement with femoral blades or screws with cement and cases at risk of guidewires penetrating into the acetabulum in cases of osteoporosis or cases requiring excessive force in drilling. Although the number of participants in the present study was lower than initially anticipated and adjustments were required, the authors conducted a post hoc power calculation. The back-calculated power demonstrated that the study retained sufficient power, with at least 80% to detect the intended effect. The present study can be applied in practice, especially in elderly patients with osteoporosis, for a procedure with a quick learning curve that is quick and safe without additional complications when compared to the traditional technique.

Conclusion

For patients with intertrochanteric femoral fractures, the authors recommend using the modified cephalomedullary fixation technique to lower the risk of intraoperative femoral guidewire loosening, to minimize blood loss during and post operation, and to decrease the risk of having post operative limited range of motion of the hip.

What is already known about this topic?

The operation for treating femoral fractures using a PFNA, employs fluoroscopy. However, femoral guidewires often become loose during the insertion of femoral blades or screws, which increases operating time and increases the risk of intraoperative bleeding.

What does this study add?

This study indicated that the new method of placing a femoral guidewire into the acetabulum lowers the chance of the guidewire becoming loose during surgery.

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Conflicts of interest

The authors declare no conflict of interest.

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