

Comparative Study of Proximal Femoral Nailing in Trochanteric and Subtrochanteric Fractures with or Without Cerclage Cable Augmentation

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Abstract

Objective

This study aimed to examine the effect of the use of proximal femoral nail (PFN) and cable cerclage on the radiological and functional results and correlation with complications such as non-union and malunion, in cases of trochanteric and subtrochanteric femur fractures.

Material and Method

The study included patients treated with PFN and/or cable cerclage because of closed, isolated spiral/oblique subtrochanteric and trochanteric fractures with a minimum follow-up period of 1 year. Patients were excluded if they had a pathological fracture, open fracture, any additional fracture, or if the epiphyseal line was open. The fractures were classified according to the AO/OTA classification. Bone union was evaluated on anteroposterior and lateral/oblique radiographs taken at postoperative 2, 4, 6, and 12 months. Functional evaluation was made according to the lower extremity functional scale and visual analog scale.

Results

The time to union was a mean of 20 weeks (range, 16-28 weeks) for patients treated with PFN + cable and a mean of 17 weeks (range, 17-32 weeks) for the group treated with PFN alone. In the lower extremity functional evaluation scale, the mean score was 74

(range, 74-80) and the percentage was calculated as 93% (88-100%) in the study group, and the mean score was 55 (range, 20-74) and 56% (35-93%) in the control group. According to the Baumgartner et al criteria for radiological reduction quality evaluation, 33 patients were reported as good, 17 patients as acceptable, and 8 patients as poor. Radiological and clinical union was obtained within 6 months in 45 patients. Delayed union was determined in 1 patient in the study group and in 3 patients in the control group. Although the PFN-only group showed slightly faster union, this may reflect differences in age distribution or fracture complexity rather than treatment superiority. (Figure 1 shows a representative postoperative X-ray of a PFN with cerclage).

Conclusion

The results of this study demonstrated that the use of PFN and cable cerclage is a reliable method in the treatment of trochanteric and subtrochanteric fractures, which increases fixation stability, allows early mobilisation and weight-bearing, and may provide improved functional outcomes. Surgical success and patient functionality will be increased with the additional use of cable cerclage in patients with a free unstable fracture where an acceptable closed reduction cannot be made.

Keywords: Cable; cerclage; pfn; trochanteric fracture; subtrochanteric fracture.

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Introduction

In proximal femur trochanteric fractures, the fracture line generally extends from the trochanter major to the minor. In reverse oblique fractures, it extends from distal to medial (1). The subtrochanteric femur is defined as 5cm distal to the proximal and mid-third junction or inferior to the trochanter minor (2). Subtrochanteric femur fractures show a bimodal distribution. They develop as a result of high-energy trauma in young individuals, and in the elderly, even low-energy trauma can lead to fracture (3). This is the body region exposed to the highest tension and compressive forces and has limited blood circulation (4). Deformation occurs with the effect of adherent muscles in the procurvatum, abduction, and external rotation positions (5).

Intertrochanteric fractures form as a result of direct or indirect forces. Compression of the region of cancellous structures is caused by the effect of sudden forces applied to the trochanter major and minor, resulting from the direct or indirect effect of forces applied along the femur axis (6). Intertrochanteric fractures are seen more in individuals aged ≥ 65 years (6). Several series have reported that they are seen at rates of 2-8-fold more in females than males. The reasons that they are seen more in females include greater exposure to metabolic bone disease, the pelvic structure is wider and the femoral neck-shaft angle is smaller, and longer life expectancy (7).

In the treatment of patients with femur trochanteric region fractures, the main aim is to regain the pre-fracture living standard, avoid being bedridden with early mobilisation, and minimise complications that could occur after the fracture. There is a question of instability in hip fractures, which are fractures of the trochanter minor, those where the fracture line is reverse oblique, those with varus angulation and a vertical fracture line, when there is displacement evident on lateral radiographs, and in fractures with 4 fragments extending to the subtrochanteric region (8). The main aim in trochanteric region fractures is to obtain anatomic reduction and apply rigid fixation that can be maintained. Implant failure and the development of associated non-union can lead to serious problems of shortness and deformity. However, a standard treatment method remains a matter of debate.

Better reduction is obtained with open reduction. However, fracture hematoma evacuation causes extensive soft tissue and periosteal stripping, and this hurts union (9). In intramedullary fixation, reduction is generally obtained indirectly, and the biology

of the soft tissue is damaged less than in open reduction. Moreover, among the fixation materials, it is accepted as the most advantageous treatment method biomechanically (9, 10). Sometimes it may not be possible to obtain an acceptable reduction with an indirect method, and therefore, open reduction is required. To increase the stability of fixation after this reduction, the application of cerclage or cable has been widely used in recent years (11). This cerclage, or the number of cables and placement, depends to a great extent on the fracture configuration and the surgeon operating. Increased complexity of fracture patterns and the need for anatomic reduction have caused an increase in their use (12). Although the use is not as frequent as it is thought to hurt trochanteric region vascularity, recent studies have shown that the application of cerclage does not impair microvascular circulation (13, 14).

Fixation is required, which allows weight-bearing and early mobilisation, and which will have the least effect on the postoperative biological healing process. Therefore, this study aimed to evaluate the potential effect of applying cable cerclage in addition to intramedullary nailing, not only in subtrochanteric femur fractures but also in unstable trochanteric region fractures.

Material and Method

The study included 65 patients with a closed isolated spiral /oblique subtrochanteric or trochanteric femur fracture applied with fixation using PFN or PFN plus cable cerclage between January 2014 and August 2020, and had a minimum 1-year follow-up period. Approval for the study was granted by the Ethics Committee (Decision No:293, dated:10.09.2021). All the study participants provided a signed informed consent form. Patients were excluded if they had a pathological fracture, open fracture, any additional fracture, or if the epiphyseal line was open. Of the 65 patients who met the defined criteria, mortality occurred in 3 patients during follow-up, and 4 could not be contacted, so the evaluation was made of 58 patients who completed regular follow-up and attended the final follow-up examination.

The fractures were classified according to the AO/OTA classification system (15). Bone union was evaluated on anteroposterior and lateral/oblique radiographs taken at postoperative 2, 4, 6, and 12 months. The presence of callus tissue in 3 of the 4 cortices in the fracture line was evaluated as union. Cases not showing union in the 6th month were recorded as non-union, and those with incomplete

union as delayed union. Reduction quality (shortness, angulation, rotation) was evaluated according to the modified Baumgartner et al criteria (good, acceptable, and poor, based on cortical displacement <4mm and angulation <10°) (16, 17). Functional evaluation was made according to the lower extremity functional scale, and visual analog scale (VAS) (18, 19). To eliminate any conflicting results, all the patients were evaluated by two different surgeons. Complications such as infection, shortness, deformity, or reoperation observed during follow-up were recorded. Cases with implant failure and implant extraction were reported.

Surgical Technique and Postoperative Protocol

All the operations were performed on a radiolucent table with the patient in the lateral decubitus position. Regional anaesthesia was administered to 37 patients and general anaesthesia to 21. First-generation cephalosporin at a dose of 1gr was administered preoperatively to all patients. By making controlled traction under fluoroscopy, an image in the anteroposterior plane was obtained. After confirmation with fluoroscopy of the region where the cable was to be applied from the lateral of the fracture line, a 5cm incision was made. The fracture was reduced with the mini-open method. While reducing the fracture with a reduction clamp, fixation was applied with one or more cables. Then the proximal femoral nail (PFN) was placed, checking that the tip-apex distance was sufficient with fluoroscopy. A thick K-wire was advanced to the column over the proximal guide. The anteroposterior position of the K-wire was checked with fluoroscopy. While maintaining the temporary fixation position with the K-wire, lateral fluoroscopic images were obtained in internal and external rotation by moving the hip into 90° flexion and 45° abduction. The version of the K-wire was confirmed. Compression was applied by placing lag screws in the femoral neck. All the distal locking screws were locked statically (Figure 1).

Statistical Analysis

Data obtained in the study were analyzed statistically using IBM SPSS version. 25.0 software (SPSS Inc., Chicago, IL, USA). Conformity of the data to normal distribution was assessed with the Kolmogorov-Smirnov test. Descriptive statistics were stated as mean±standard deviation (SD), median, minimum, and maximum values for continuous variables, and as number (n) and percentage (%) for categorical variables. In the analyses of the data, the Chi-square test, Mann-Whitney U-test, Kruskal-Wallis test, and Spearman correlation analysis were used. A value of $p < 0.05$ was considered statistically significant.

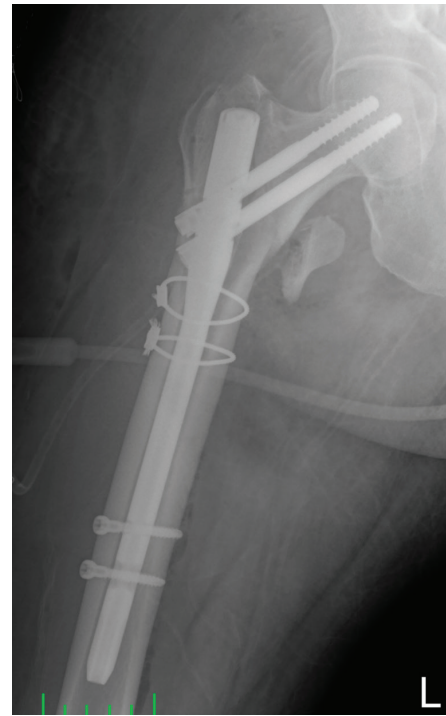


Figure 1

Sample postoperative X-ray image of a patient treated with PFN and cerclage cable.

Results

Evaluation was made of 58 patients, comprising 30 females and 28 males. PFN+cable cerclage was applied to 33 patients and PFN alone to 25 patients as a control group. The hip fracture was right-sided in 32 patients and left-sided in 26. The etiology of the fracture was a traffic accident in 20 patients and a fall from height in 38. According to the AO/OTA fracture classification, 13 fractures were 31-A.1, 11 fractures were 31-A.2, and 34 fractures were 31-A.3. The fracture pattern was determined as oblique in 28 patients and spiral fracture in 30 patients (Table 1).

The operation duration was 90 mins (range, 50-120 mins) in the PFN+cable group and 70 mins (range, 35-100 mins) in the control group. The intraoperative duration of fluoroscopy use was a mean of 96 secs (range, 34-321 secs) in the PFN+cable group and 100 secs (range, 40-150 secs) in the control group. The mean follow-up period was 33 months (range, 12-80 months) for all the patients.

The time to union was a mean of 20 weeks (range, 16-28 weeks) for patients treated with PFN + cable and a mean of 17 weeks (range, 17-32 weeks) for the group applied with PFN alone. In the lower extremity

Table 1 Demographic data of patients.

	Cable-cerklage group (n=33)	Control group (n=25)	p score
Age	49 ± 17	62 ± 11	<0.001
Sex			
F	17	13	0.671
M	16	12	
Side			
R	18	14	0.412
L	15	11	
Etiology			
Motor accident	13	7	0.366
Falling from high	20	18	
Type of fracture			
Spiral	19	11	0.306
Oblique	14	14	
AO Class. (%)			
31A1.1	-		
31A1.2	2 (6.1%)	4 (16%)	
31A1.3	2 (6.1%)	5 (20%)	
31A2.1	-	1 (4%)	
31A2.2	1 (3%)	2 (8%)	
31A2.3	-	7 (28%)	
31A3.1	15 (45.6%)	1 (4%)	
31A3.2	-	-	
31A3.3	13 (39.2%)	5 (20%)	

Abbreviations: F:female, M:male, R:right, L:left.

Table 2 Radiological and Clinical data of the patients

	Cable-cerklage group (n=33) Med. (min-max)	Control group (n=25) Med.(min-max)	p score
Union time (w)	20 (16-28)	17 (17-32)	0.048*
Surgery Time (min.)	90 (50-120)	70 (35-100)	< 0.001*
Fluoroscopy time (sec.)	96 (34-321)	100 (40-150)	0.626
Tip-apex distance(mm)	16 (12-24)	23 (17-28)	< 0.001*
Shortness (mm, mean)	0.9	3.4	< 0.001*
Coronal angulation (x°)	0.6 (-3, 4)	0.9 (-6, 10)	0.729
Sagittal angulation (x°)	0.4 (-4,4)	1.4 (-4,7)	0.261
VAS (med/min-max)	0.8 (0-4)	4 (2-7)	< 0.001*
LEFS	74 (74-80)	55 (20-74)	<0.001*
LEFS %	93 (88-100)	56 (35-93)	<0.001*

Abbreviations: w:week, min:minute, sec: second, VAS: visual analog score, LEFS: Lower Extremity functionale scale.

Table 3 Baumgaertner reduction quality criteria

Reduction quality	Cable-cerklage group (n=33)	Control group (n=25)
Good	28	5
Acceptable	5	12
Poor	0	8

Table 4 Complication data of patients who underwent cable cerclage and control group

Complication	Cable-cerklage group (n=33)	Control group (n=25)
Serous discharge	1	3
Superficial infection	2	2
Delayed union	1	3
Failure	-	4
Re-operation	-	5

functional evaluation scale, the mean score was 74 (range, 74-80) and the percentage was calculated as 93% (88-100%) in the study group, and the mean score was 55 (range, 20-74) and 56% (35-93%) in the control group. The tip-apex distance was measured radiologically as 16mm (range, 12-24mm) in the PFN+cable group and 23mm (range, 17-28mm) in the control group. Shortness developed in 24 patients, evaluated a mean of 0.9mm in the study group and a mean of 3.4mm in the control group. Coronal angulation was measured radiologically as mean 0.6° (-3° to 4°) in the study group and as 0.9° (-6° to 10°) in the control group, and sagittal angulation as mean 0.4° (-4° to 4°) in the study group and as 1.4° (-4° to 7°) in the control group (Table 2). Although the PFN-only group showed slightly faster union, this may reflect differences in age distribution or fracture complexity rather than treatment superiority.

According to the Baumgartner et al criteria for radiological reduction quality evaluation, 33 patients were reported as good, 17 patients as acceptable, and 8 patients as poor (Table 3). (Figure 1 shows a representative postoperative X-ray of a PFN with cerclage).

Radiological and clinical union was obtained within 6 months in 45 patients. Superficial infection was

observed in 4 patients with serous discharge continuing after the operation, which recovered with antibiotic treatment in 3 patients. In one of these 4 patients, one patient required reoperation due to superficial infection. Delayed union was determined in 1 patient in the study group and in 3 patients in the control group. There was no implant failure, and reoperation was not required in any of the PFN+cable group, and in the control group, implant failure developed in 4 patients, and reoperation was required in 5 (Table 4).

Discussion

The results of this study demonstrated that the application of cable cerclage with open reduction provided ideal reduction appropriate to normal anatomy. This technique is generally difficult to achieve using closed reduction alone. In cases of closed reduction, when an acceptable reduction cannot be obtained, reliance on fracture hematoma does not make a positive contribution to union. Good reduction not only facilitates the nailing procedure but can also be considered to make the whole reduction more stable, because the majority of weight-bearing forces are transferred through aligned bone fragments.

Trochanteric and subtrochanteric spiral/oblique fractures are difficult fractures for treatment and

rehabilitation. Open and closed methods are used in treatment. Open reduction and internal fixation provide better visualisation of the fracture line, and anatomic reduction is obtained. Wide surgical exposure causes soft tissue damage, periosteal stripping, and fracture hematoma evacuation. The biological environment required for fracture healing is damaged. Although excellent bone union is obtained with the use of a plate as fixation material, it has been reported that the mechanical performance of plates is lower than that of intramedullary fixation materials (20). Intramedullary fixation methods are biomechanically superior in trochanteric and subtrochanteric fractures, but the disadvantage of the method is indirect reduction of the fracture.

The effect of deforming muscle forces can cause incorrect selection of trochanteric entry and malreduction of the fracture. Therefore, better reduction can be provided minimally invasively with reduction clamps and cable cerclage in fracture types where it is required (21). The results of the current study show that the cable cerclage method provided an anatomic reduction or close to an anatomic reduction. Generally, this technique is not possible with closed reduction alone.

In a study by Boopalan et al, it was reported that, as intramedullary nailing showed a supportive function in intertrochanteric fractures, there was a limited effect of the instability created by an unstable lateral femoral cortex. However, in fractures where the lateral femoral cortex has been displaced during the injury, it is not clear whether or not the supportive function provided by intramedullary nailing contributes to stability and union. Therefore, there is no clear guideline for additional treatment of displaced and free lateral femoral cortex fragments. The findings of recent studies in the literature have shown that, in contrast to what has been assumed, the application of cable cerclage does not have any harmful effect, such as lateral thigh pain or delayed bone union (22, 23).

Recommendations can be found in orthopaedic literature related to the addition of minimally invasive cable cerclage to subtrochanteric fractures with a similar effect to reverse intertrochanteric fractures (24). The application of cable cerclage has been advocated in interventions for failed closed reduction. With the help of a clamp, reduction combinations are used in spiral and oblique fractures (3). It has been reported that following cable cerclage use, the reoperation rates and reduction quality are better, and there is a smaller amount of fracture displacement (25).

When weight-bearing is permitted early in the postoperative period, it is important that weight transfer is obtained with aligned bone fragments to protect the reduction and to reduce complication rates. In a biomechanical study, additional cable cerclage was reported to provide significant posteromedial support and to reduce the risk of osteosynthetic failure in complex fractures (10). In the current study, reoperation because of mechanical problems was not required for any patient treated with cable cerclage. Moreover, the application of cable cerclage reduced lateral femoral cortex displacement and was seen to provide good posteromedial support. In contrast to expectations, fewer complications were seen in the patient group with cable cerclage applied with a minimally invasive method compared to the control group.

There is a belief that non-union emerges as a result of impaired blood support and bone vascularity associated with the use of cable cerclage (11). This is associated with excessive dissection of periosteal and soft tissue. If minimally invasive techniques are applied, the disruption in soft tissue and bone vascularity is reduced (26). In an animal model without fracture, vascular support was seen to be preserved following the use of cable cerclage (27). The results of the current study showed that there was no negative effect of the use of cable cerclage. In all the cases treated with cable cerclage, full bone union was obtained, and no difference was determined between the cable cerclage group and the control group with respect to the time to bone union.

In a study by Codesido et al, the mean time to union in patients applied with cerclage was reported as 4.35 ± 1.75 months, complications were seen in 1 (3.3%) patient, and reduction success was good in 29 (96.7%) patients, acceptable in 1 (3.3%), and poor in none (28). Gong et al reported a mean time to union of 20 weeks (range, 16-24 weeks) with no major complications such as non-union, malunion, or implant breakage. The neck-shaft angle was restored up to 5° , and translation reduced from 2.05cm to 0.15cm (29). In a study of 20 patients who underwent cerclage, Hoskins et al did not observe any major complications, and while major complications were reported in 9.7% of a group of 135 patients, it was stated that this rate would be 11.4% when cerclage was not applied (30). In the current study, the time to union was a mean of 20 weeks (range, 16-28 weeks) for patients treated with PFN + cable and a mean of 17 weeks (range, 17-32 weeks) for the group treated with PFN alone. In the lower extremity functional evaluation scale, the mean score was 74 (range, 74-80) and the percentage

was calculated as 93% (88-100%) in the study group, and the mean score was 55 (range, 20-74) and 56% (35-93%) in the control group. According to the Baumgartner et al criteria for radiological reduction quality evaluation, 33 patients were reported as good, 17 patients as acceptable, and 8 patients as poor. The mean VAS scores were recorded as 1 (range, 0-4) in the study group and 4 (range, 2-7) in the control group.

Limitations of this study were that it was retrospective in design, the number of patients was relatively low, and, because of an optimal fracture classification system, some fracture types were labelled according to the closest fracture type. There is a need for further prospective, randomised controlled, multicentre studies to compare different fixation materials in the same fracture patterns in homogenous age ranges.

Conclusion

The results of this study demonstrated that the use of PFN and cable cerclage is a reliable method in the treatment of trochanteric and subtrochanteric fractures, which increases fixation stability, allows early mobilisation and weight-bearing, and may provide improved functional outcomes. Surgical success and patient functionality will be increased with the additional use of cable cerclage in patients with a free unstable fracture where an acceptable closed reduction cannot be made.

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Ethical Approval

Approval for the study was granted by the Ethics Committee (Decision No:293, dated:10.09.2021-Suleyman Demirel University). The study was conducted in accordance with the principles set forth in the Declaration of Helsinki.

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Availability of Data and Materials

Data availability: Data available on request from the authors. Data sets generated and/or analyzed during the current study can be requested from the authors' e-mail addresses.

Artificial Intelligence Statement

No artificial intelligence (AI) tools were used in this article.

Authors Contributions

SEK: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing-original draft.

RD: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing-original draft; Writing-review & editing.

DC: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing-original draft; Writing-review & editing.

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