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Cerclage Cable and Long Proximal Femoral Nail Antirotation Fixation in Treatment of Subtrochanteric Fractures: Functional and Radiological Outcomes and Complications

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Abstract

Objective: We aimed to present the radiological and functional outcomes and complications of intramedullary nailing with long proximal femoral nail antirotation (PFNA) and cerclage cable for spiral and oblique subtrochanteric femoral fractures.

Methods: The study included patients who underwent intramedullary nailing with long PFNA and cerclage cable due to closed, isolated, and spiral/oblique subtrochanteric femoral fractures and were followed up for at least one year. Fracture union was evaluated with anteroposterior and oblique radiographs of patients obtained at 2, 4, 6, and 12 months, postoperatively. Functional evaluation was done using lower extremity functional scale (LEFS) and visual analog scale (VAS).

Results: The mean time to union was 20.16±2.8 (range: 16-28) weeks, mean LEFS score of the patients was 74.08±2.3 (range: 70-80), and LEFS percentage was calculated as 92.75±16.20 (range: 88-100). Radiological evaluation of the reduction quality revealed that good results were acquired in 28 (84.8%) patients, whereas acceptable results were acquired in five (15.2%). The mean VAS score was 0.84±1.17 (range: 0-4). Radiological and clinical union was achieved in 32 (97%) patients within 6 months and union was achieved with some delay in one patient (3%) within 7 months

Conclusion: Subtrochanteric femur region is an area that is subject to complications due to its anatomic position and functional characteristics. The treatment for spiral/oblique subtrochanteric femur fractures with PFNA and cerclage cable is a reliable method that increases the stability of the fixation, allows early mobilization and weight bearing, and helps in the acquisition of satisfactory radiological and functional results.

Keywords: Subtrochanteric femur, cable cerclage, fracture, union

INTRODUCTION

The subtrochanteric region of the femur is defined as the junction of proximal and middle one-third of the femur or 5 cm distal to the inferior border of the lesser trochanter (1-3). Fractures in this region show bimodal distribution and occur as a result of a high-energy trauma in young individuals and low-energy trauma in the elderly, accounting for 7-24% of all hip fractures (1,2,4-6). It is one of the areas in the body that are

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exposed to high tensile and compressive forces (7). In displaced fractures of the subtrochanteric femur, proximal fragment is most commonly abducted, externally rotated, and flexed due to the effects of muscles attached to the proximal femur (6); thus, resulting in first entry problems or malreduction at the level of greater trochanter in intramedullary nail treatment (8).

Dynamic hip screw, proximal femur anatomic plate, and intramedullary nailing are used in the treatment (2,5,9). Anatomic reduction and sustainable rigid fixation are the main targets for treating subtrochanteric femur fractures. Stability, which is adequate to resist deformation and compression during weight bearing, must be ensured. Implant failure leading to shortness, non-union, and deformities can cause severe problems.

Subtrochanteric femur fractures are very difficult to treat; therefore, it is pertinent to discuss standard treatment methods. Better reduction can be achieved with open technique. However, evacuation of the fracture hematoma, extensive soft tissue injury, and periosteal stripping impairs fracture union. Soft tissue biology is less damaged in intramedullary fixation than in open reduction. Biomechanically, intramedullary fixation is regarded as the most advantageous treatment method (10,11). Auxiliary indirect reduction techniques are frequently employed before performing permanent fixation. Some of these methods include reduction clamps, Schanz screws, blocking screws, sharp, and ball-tipped pushers (4-7,12-15). Recently, cerclage or cable applications have been widely used to increase the stability of a fixation (1,9,14). Their use was controversial because it was thought to negatively affect the vascularity of the trochanteric region. However, recent studies have shown that cerclage application does not impair microvascular circulation (16-18).

In subtrochanteric femur fractures, the fixation method should have minimal impairment of the biological healing process and should allow early weight bearing and mobilization. Therefore, intramedullary nailing is the most preferred treatment method. Intramedullary nailing alone does not have sufficient stable fixation, which leads to serious complications (3,19,20). Thus, we aimed to present the efficacy of cerclage cable application as an adjunct to intramedullary nailing in terms of functional and radiological outcomes and complication, such as malunions and non-unions in patients with spiral/oblique subtrochanteric femur fractures extending to the metaphysis.

METHODS

A total of 33 patients who underwent fixation with long proximal femoral nail antirotation (PFNA) and cerclage cable method due to isolated spiral/oblique subtrochanteric femur fracture between January 2010 and January 2017 were included in the study. Prospectively recorded patient data were retrospectively analyzed. The study was conducted at our hospital and informed consent was preoperatively obtained from all the study patients. Approval for the study was granted by University of Health Sciences Turkey, Erzurum Regional Training and Research Hospital Ethics Committee (approval no: 37732058-514.10). The study included patients who underwent long PFNA (Synthes) and cerclage cable application due to closed, isolated, and spiral/oblique subtrochanteric femur fractures and who were followed up for at least one year. Patients with a pathological fracture, open fracture, or concomitant fracture were excluded from the study. Of the 40 patients who met the inclusion criteria, 33 who completed regular follow-ups and attended the final examination were included in the study; two patients died during the follow-up period and two others could not be contacted. All patients with trochanteric fractures in whom fixation was considered as a treatment option underwent three-dimensional computed tomography (CT) for preoperative evaluation.

Demographic data, including age, sex, fracture side, trauma etiology, time from admission to surgery, operation time, fluoroscopy time, and follow-up duration, were recorded. Fractures were classified according to the AO/OTA classification system (21). Fracture union was evaluated postoperatively using anteroposterior and side/oblique radiographies of the patients at 2^{nd}, 4^{th}, 6^{th}, and 12^{th} months. The formation of callus tissue in three out of four cortices was considered as a union. Cases with no signs of union at 6 months were recorded as non-union and those with incomplete union were recorded as delayed union. Reduction quality (shortness, angulation, and rotation) was evaluated according to the modified criteria (cortical displacement <4 mm and angulation 10°: Good, acceptable, and poor) of Baumgaertner et al. (22,23). Functional evaluation was done using the lower extremity functional scale (LEFS) (24) and visual analog scale (VAS) (25). To avoid bias, patients were evaluated by a surgeon that is different from the operating surgeon. The presence of infection, shortness, deformation, reoperation, implant failure, and implant extraction observed during the follow-up period was noted.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 25.0 (SPSS Inc., Chicago, Illinois, USA). Data are presented as number, percentage, average, standard deviation, median, and range. Compliance of the data to normal distribution was evaluated by Shapiro-Wilk test. Data were then analyzed by Mann-Whitney U test and Spearman correlation test as appropriate. Statistical significance value set as $p<0.05$.

Surgical Method and Postoperative Protocol

Patients were operated on a fluoroscopy table in a lateral decubitus position. A total of 20 patients received regional anesthesia, whereas 13 patients received general anesthesia. Preoperatively, all the patients received 2 grams of first generation cephalosporin. The fluoroscopy device was placed perpendicular to the operating table, with the C-arm positioned above the patient. Anteroposterior views were taken in controlled traction. Following the confirmation of the region to which a cable was to be applied from the lateral aspect of the fracture line via fluoroscopy, approximately 3-5 cm incision was performed. The tensor fascia lata was dissected in an L-shaped fashion to reach the fracture, with minimum soft tissue damage and blunt dissection. After the fracture reduction was done with reduction forceps, cerclage cable fixation in adequate tension was done with one or more cerclage cables according to the shape and length of the fracture. Afterward, PFNA was inserted under fluoroscopic control and a thick K wire was advanced to the femoral neck over the proximal guide. Anteroposterior position of the K wire was confirmed by fluoroscopy. Lateral fluoroscopic images were obtained in internal and external rotations, with the hip flexed 90° and abducted 45°. Centralization or anteversion-retroversion of the K wire was confirmed using lateral images. Gamma nail of appropriate length was placed on the neck of the femur and compression was performed. All distal locking screws were statically locked. Fracture stabilization was evaluated by continuous fluoroscopy after completion of the fixation. The patients walked with the aid of a walker or crutches on the postoperative first day. Knee and hip range of motion and strengthening exercises were started after the second week. After the observation of radiological union, unassisted weight bearing was allowed.

RESULTS

Of the total patients included in the study, 16 were male and 17 were female. The mean age was 49.84±17 (range: 22-78) years. The fracture was on the right side in 18 (54.5%) patients and on the left side in 15 (45.5%) patients. Etiologically, the cause of fracture was traffic accident in 13 (39.4%) patients and falling from a height in 20 (60.6%) patients. According to the AO/OTA fracture classification, 21 (63.6%) patients had 31A3.1 type fracture and 12 (36.4%) patients had 31A1.3 type fracture. When the fracture patterns were examined, 14 (42.4%) patients had oblique fractures and 19 (57.6%) had spiral fractures. The mean operation time was 90.6±18.36 (range: 50-120) min. The mean fluoroscopy time during the surgery was 127.36±78.55 (range: 34-321) seconds. The mean follow-up duration was 42.15±16.20 (range: 12-80) months.

The mean union time was 20.16±2.8 (range: 16-28) weeks. The mean LEFS score of the patients was 74.08±2.3 (range: 70-80) and LEFS percentage was calculated as 92.75±16.20 (range: 88-100). The mean tip-apex distance was radiologically measured as 17.33±3.24 (range: 12-24) mm. Eleven patients developed shortness of the average 0.97±1.46 (range: 0-4) mm, whereas 22 patients did not develop shortness. Radiologically, 27 patients had no sagittal deformity, whereas 0.42±1.54 (range: -4-+4) sagittal angulation was observed in six patients. Radiologically, there was no coronal deformity in 26 patients, whereas 0.60±1.63 (range: -3-+4) coronal angulation was seen in seven patients. According to the radiological reduction quality evaluation criteria of Baumgaertner et al. (22,23) good results were achieved in 28 (84.8%) patients and acceptable results were obtained in five (15.2%). The mean VAS score was 0.84±1.17 (range: 0-4). Radiological and clinical union was achieved in 32 (97%) patients within 6 months (Figure 1) and union was achieved with some delay in one patient (3%) within 7 months. Serous discharge continuing for 3 weeks following the surgery was observed in one patient, whereas superficial infection, which was healed by antibiotic administration, was observed in two (Table 1). There were no patients with implant failure and implant breakage. There was no reduction loss that required reoperation. There was no statistical correlation between the fracture type and pattern and union time, operation time, and fluoroscopy time ($p>0.05$) (Table 2). There was no statistically significant relationship between the tip-apex distance and shortness, union time, and angulation ($p>0.05$) (Table 3).

DISCUSSION

Subtrochanteric spiral/oblique fractures are difficult to treat and rehabilitate. There is still debate over the optimal treatment method. Open reduction and internal fixation allows better visualization of the fracture and achievement of anatomic reduction; it has also minimized the risk of shortness. Extensive soft tissue injury, periosteal stripping, and evacuation of the fracture hematoma results in damage to the biological environment that is necessary for fracture healing. Anatomic reduction can be achieved with the use of plates as the fixation material. However, it has been reported that plates provide less mechanical performance compared to intramedullary fixation materials (26,27). Intramedullary fixation methods are biomechanically superior in the treatment of subtrochanteric fractures. However, a disadvantage of this method is the indirect reduction of the fracture. Indirect reduction is performed using a closed procedure with Schanz screws, blocking screws, and

Table 1. Demographic, functional, and radiological data of patients

Gender; n (%)	
Male/female	17 (51.5%)/16 (48.5%)
Side	
Right/left	18 (54.5%)/15 (45.5%)
Etiology; n (%)	
Traffic accident	13 (39.4%)
Falling from a height	20 (60.6%)
Age;	
Mean (min-max) SD	49.85±17.08 (min-max: 22-78)
AO/OTA classification; n (%)	
31A1.1	21 (63.6%)
31A1.3	12 (36.4%)
Fracture pattern; n (%)	
Spiral	19 (57.6%)
Oblique	14 (42.4%)
Baumgartner reduction quality; n(%)	
Good	28 (84.8%)
Acceptable	5 (15.2%)
Operation time	
[Minutes; mean (min-max) SD]	90.6±18.36 (min-max: 50-120)
Fluoroscopy time	
[Seconds; mean (min-max) SD]	127.36±78.55 (min-max: 34-321)
VAS score;	
Mean (min-max) SD	0.84±1.17 (min-max: 0-4)
Radiological union time (weeks);	
Mean (min-max) SD	20.16±2.8 (min-max: 16-28)
LEFS;	
Mean (min-max) SD	74.08±2.3 (min-max: 70-80)
LEFS (%);	
Mean (min-max) SD	92.75±16.20 (min-max: 88-100)
Follow-up time	
[Months; mean (min-max) SD]	42.15±16.20 (min-max: 12-80)
Tip-apex distance (mm);	1
Mean (min-max) SD	7.33±3.24 (min-max: 12-24)
Shortness (mm);	
Mean (min-max) SD	0.97±1.46 (min-max: 0-4)
Sagittal angulation (°);	
Mean (min-max) SD	0.42±1.54 (min-max: -4-/+4)
Coronal angulation (°);	
Mean (min-max) SD	0.60±1.63 (min-max: -3/+4)
Complication; n (%)	
No	29 (87.9%)
Serous drainage	1 (3%)
Superficial infection	2 (6.1%)
Delayed union	1 (3%)

AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association, VAS: Visual analog score, LEFS: Lower extremity functional scale, SD: Standard deviation, max: Maximum, min: Minimum

pointed and ball-tipped pushers. Reduction forceps and cerclage cable can be used with a minimally invasive procedure (28).

The effect of deforming muscle forces can cause incorrect positioning of the trochanteric entry and malreduction of the fracture. Malreduction (inability to achieve apposition of the fracture fragments, shortness, or rotation) can cause catastrophic complications, such as malunion, non-union, shortness, and deformation.

The main purpose of treating subtrochanteric spiral/oblique femur fractures is to achieve anatomic and sustainable stable fixation. Rigid fixation must be performed to allow early weight bearing and rehabilitation. It has been reported that intramedullary nail fixation without the use of cerclage cable in unstable comminuted subtrochanteric fractures results in 100% failure due to cyclic weight bearing; it also results in the displacement of the fracture gap with varus deformity and cut-out. Although cerclage cable application is an invasive method, its use is recommended because it provides medial support and prevents fixation failure in complex fractures (11).

The use of cerclage cables has been controversial until recent years because they were thought to disturb the microvascular circulation of the bone, thereby delaying bone union. In experimental and cadaveric studies, it was shown that the vascular support of the periosteum is circular and not longitudinal (14,16). It is supplied by many vascular sources, including recurrent vessels (16). Moreover, it was stated that angiogenesis in the bone proceeds in a centripetal direction and thus cerclage knot around the bone should cause minimal microvascular impairment (29). Minimally invasive percutaneous cerclage application causes minimal damage to the femoral perforating veins. The formation of anastomoses provides sufficient circulation (8). It was shown that non-union can be prevented by minimal soft tissue dissection and periosteal stripping with percutaneous cerclage cable application (14).

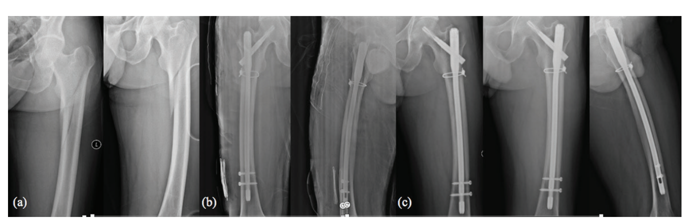

Figure 1. A 39 years old male patient was treated with a mini open cerclage and a long proximal femoral nail for a 31A3.3 type fracture of the left hip due to a fall from a height. Preoperative anteroposterior and optimal lateral oblique direct radiographs (a), postoperative day 1 anteroposterior and lateral femur direct radiographs (b), postoperative 1 year postoperative anteroposterior, oblique, and lateral radiographs (c)

Table 2. Statistical analysis of fracture type and pattern with time of operation, time of fluoroscopy, and time of union

		Operation time	Fluoroscopy time	Union time
AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) fracture type				
31A1.1	Min-max (median)	50-120 (90)	34-321 (140)	16-28 (20)
	Mean ± SD	92.4±20.0	149.1±77.3	20.0±3.2
31A1.3	Min-max (median)	60-110 (90)	44-296 (79)	18-24 (20)
	Mean ± SD	87.5±15.4	89.3±67.9	20.5±2.1
Fracture pattern	**p**	0.437	0.008	0.408
Spiral	Min-max (median)	50-120 (90)	34-321 (85)	16-24 (20)
	Mean ± SD	89.5±18.4	113.2±79.5	20.5±2.4
Oblique	Min-max (median)	60-120 (90)	52-301 (138.5)	16-28 (18)
	Mean ± SD	92.1±18.9	146.6±75.7	19.7±3.3
	p	0.754	0.122	0.203

Mann-Whitney U test and Spearman correlation test, AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association, max: Maximum, min: Minimum, SD: Standard deviation

Table 3. Correlation between type-apex distance and shortness, sagittal angulation, coronal angulation, and union time

	Shortness	Sagittal angulation	Coronal angulation	Union time
Tip-apex distance				
r	0.043	0.213	0.023	-0.117
p	0.811	0.233	0.898	0.724

Mann-Whitney U test and Spearman correlation test

However, cerclage cabling can cause cortical damage and bone resorption with the effect of micromovements (14). Braided cerclage cables decrease the implant-bone contact surface and increase stability (30).

There is a risk of damage to the superficial femoral artery and vein during cerclage cable application (17,31). In *in vitro* CT angiographic evaluation, relatively safe zones were described, particularly for shaft fractures (31,32). The concepts of a safe zone for trochanteric region, number of cerclages that could be applied, and distance between cerclages remain controversial. We applied cerclage cable in all the patients using a minimally invasive method, with minimal soft tissue dissection and periosteal stripping. The cable was inserted after reduction was done with reduction forceps and confirmed by fluoroscopy. No cable-related complications were observed during and after the surgery.

In a study by Codesido et al. (3), patients who had open reduction intramedullary nail and cerclage wire fixation had a mean union time of 4.35±1.75 months, mean incision length of 18.30±4.51, and mean operation time of 100.69±28.12 minutes; complications were observed in one patient (3.3%) and reduction success was evaluated as good in 29 (96.7%), acceptable in one (3.3%), and poor in no patients (0%). In a study by Gong et al. (26), it was reported that the mean union time was 20 (range: 16-24) weeks and that the mean operation time was 105 (range: 85-135) min; there were no major complications, such as non-union, malunion, and implant failure. It was stated that good and perfect results were acquired on functional evaluation and the mean Harris hip score was 90.7 (range: 83-95). The shaft angle of the neck was restored up to 5° and translation was decreased from 2.05 to 0.15 cm. In a study by Hoskins et al. (19), no major complications were observed in 20 patients who received cerclage application, whereas major complications were reported in 9.7% of a total of 135 patients; this rate increased to 11.4% in 20 patients when cerclage was not used. However, in this study, the mean union time was 20.16±2.8 (range: 16-28) weeks, mean LEFS score was 74.08±2.3 (range: 70-80), and LEFS percentage was 92.75±16.20 (range: 88-100). According to the radiological reduction quality evaluation criteria of Baumgaertner et al. (22,23), good results were acquired in 28 (84.8%) patients and acceptable results were obtained in 5 (15.2%) patients. The mean VAS score was 0.84±1.17 (range: 0-4). There were no major complications, apart from the delayed union observed in one patient (3%). There were minor complications in three (9%) patients, of which two had superficial infection, which was treated with antibiotic therapy, and one patient had a serous discharge. There were no patients who developed implant failure and there was no reduction loss that required reoperation.

Study Limitations

There are certain limitations in this study. Some parameters could not be retrospectively evaluated. There was no comparison group. Furthermore, the number of patients was relatively low and the fracture types were classified according to the closest fracture type due to the absence of an optimal fracture classification system. There is need for prospective, randomized, controlled, and multicentric studies with comparisons in homogenous age groups and same fracture patterns with different fixation materials.

CONCLUSION

Spiral/oblique subtrochanteric femur fractures are difficult to treat due to the anatomical position and functional characteristics; therefore, complications are frequently observed. In addition, exposure to fluoroscopy during the surgery is an important disadvantage in the treatment. Treatment with long PFNA and cerclage cable application is a safe method that increases the stability of the fixation, allows early mobilization and weight bearing, and achieves good radiological and functional outcomes.

Ethics

Ethics Committee Approval: Approval for the study was granted by University of Health Sciences Turkey, Erzurum Regional Training and Research Hospital Ethics Committee (approval no: 37732058-514.10).

Informed Consent: The study was conducted at our hospital and informed consent was preoperatively obtained from all the study patients.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.K., M.T., A.A., R.D., Concept: A.K., A.A., M.Ç.E., Design: A.K., A.A., M.T., M.Ç.E., Data Collection or Processing: E.Ö., M.İ., M.S.A., Analysis or Interpretation: E.Ö., M.İ., M.S.A., Literature Search: M.Ç.E., M.T., A.K., S.A., Writing: A.K., M.T.

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