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Fixation of intertrochanteric femur fractures using Proximal Femoral Nail Antirotation (PFNA) in the lateral decubitus position without a traction table

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Objective: The aim of this study was to evaluate whether intertrochanteric femur fractures can be reduced and nailed properly in the lateral decubitus position using Proximal Femoral Nail Antirotation (PFNA) as a fixation device without the use of a traction table.

Methods: The study included 207 patients (81 male and 126 female; mean age: 75 years, range: 22 to 95 years). According to the Evans classification, there were 7 Type 1, 40 Type 2, 33 Type 3, 38 Type 4, 61 Type 5 and 28 reverse oblique fractures. Radiographs were used to measure the tip-apex distance (TAD), the quadrant of the helical blade according to Cleveland and Bosworth, Ikuta's reduction subgroup, collodiaphyseal angle and reduction gaps postoperatively.

Results: Mean follow-up time was 20.4 (range: 6 to 38) months. According to Ikuta's classification, 176 (85%) reduced fractures were of subtype N, 15 (7.2%) subtype P and 16 (7.7%) subtype A. Good or acceptable reduction according to the Herman criteria was obtained in 99% of fractures. Mean TAD was 29.2 millimeters. Mean operation time was 57.2 minutes. Optimal blade position (center-center or inferior-center) was achieved in 53.5% of patients and was in the superior-posterior quadrants in only 2.4% of patients. Cut-out complication occurred in 9 patients (4.3%).

Conclusion: While the nailing of intertrochanteric fractures in a lateral decubitus position does not provide ideal quadrant placement and TAD, results are encouraging probably due to the excellent stability that is provided by PFNA.

Key words: Intertrochanteric fractures; lateral decubitis position; Proximal Femoral Nail Antirotation; traction table.

Hip fractures are one of the most common cause of hospital admission among the elderly.[1] Nearly half of these fractures are extracapsular and are associated with increased mortality.[2] Cephalomedullary nails are the preferred implants in many proximal extracapsular femur fractures.[3,4]

Mechanical complications are most common complications leading to implant failure and requiring revision surgery. Factors leading to mechanical complications can be classified as modifiable and non-modifiable. Non- modifiable factors include bone mineral density and fracture type. Modifiable factors, also known also as 'surgeon dependent factors', are quality of reduction and proper application of selected implants.[5]

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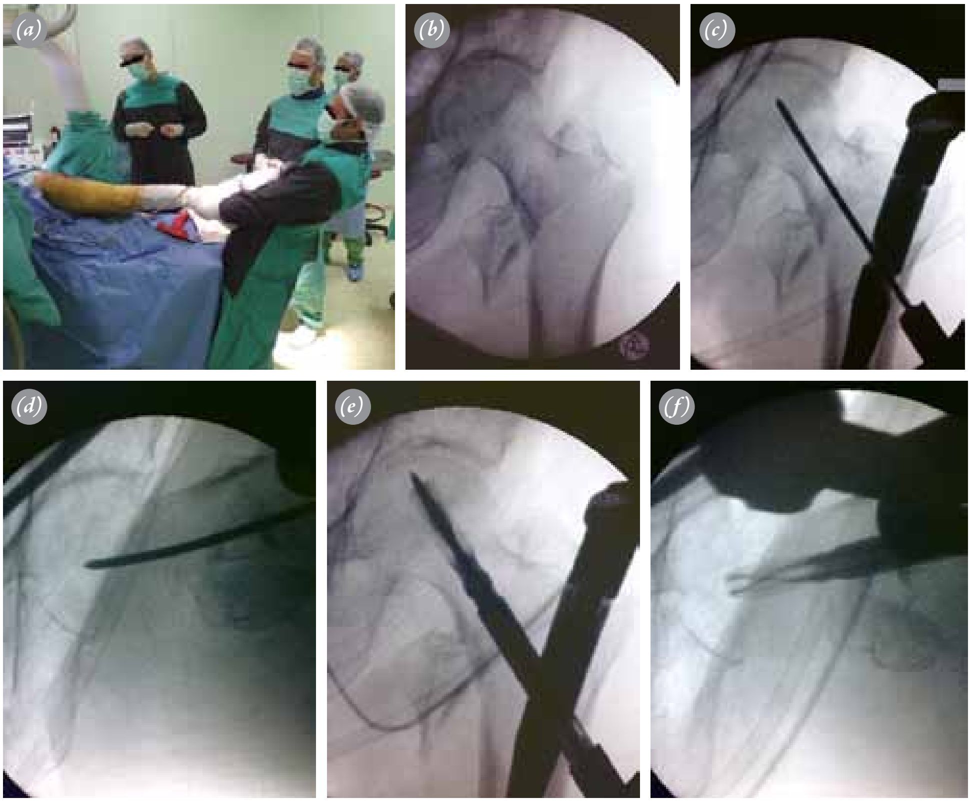

Fig. 1. **(a)** Reduction with manual traction. **(b)** Reduced fracture. **(c)** Use of Kirschner wire as a guide. **(d)** Frog leg view of the wire and reduction. **(e)** Anteroposterior position of the helical blade. **(f)** Position of the helical blade in frog leg view. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Limited data about reduction quality criteria regarding intertrochanteric fractures are available. Using post-reduction lateral radiographs, Ikuta classified reduction into normal, anterior and posterior subtypes according to the position of the head-neck fragment relative to the distal fragment. It has been reported that cut-outs are mostly seen in posterior subtype reduced cases.[6] Another article[7] assessed reduction quality depending on the obtained collodiaphyseal angle (CDA) and fracture gap. Reduction was determined as 'good' if reduction was not in the varus position and the fracture gap was less than 5 mm in both anteroposterior and lateral views. The presence of one of these criteria was determined 'acceptable' and none as 'poor' reduction. Proper reduction and placement of the head-neck fixing device (screw or helical blade) can prevent mechanical complications such as cut-out.

Intertrochanteric fractures are commonly reduced and nailed in the supine position with the help of a traction table. However, not all hospitals, including ours, have a traction or fracture table. Additionally, several complications such as pudendal nerve palsy, erectile dysfunction and perineal sloughing has been reported due to the usage of traction tables.[8,9] Few reports have been published on intertrochanteric fractures treated using Proximal Femoral Nail Antirotation (PFNA) (Synthes GmbH, Oberdorf, Switzerland) in the lateral decubitus position.

The aim of this study was to evaluate whether proximal femoral fractures can be reduced and nailed properly in the lateral decubitus position without a traction table using PFNA as a fixation device

Patients and methods

A retrospective review was performed of 246 consecutive patients with intertrochanteric femur fracture treated with PFNA in the lateral decubitus position without a traction table in a single center between May 2010 and July 2013.

Patients of any age with an intertrochanteric femur fracture treated with PFNA in the lateral decubitus position without a traction table with a minimum of 6 months follow-up were included in the study. Patients with less than 6 months follow-up were excluded.

Three patients died during the early postoperative period and 36 did not come to examinations after discharge. A total of 207 patients (81 male [39%] and 126 female [61%]) were enrolled in this study. Of their fractures, 103 (49.8%) were right-sided and 104 (50.2%) left-sided. Mean age at the time of operation was 75±14.9 (range: 22 to 95) years. According to the Evans classification,[10] there were 7 (3.4%) Type 1, 40 (19.3%) Type 2, 33 (15.9%) Type 3, 38 (18.4%) Type 4, 61 (29.5%) Type 5 and 28 (13.5%) reverse oblique fractures. Spinal anesthesia was used in 173 (83.6%) operations and general anesthesia in 34 (16.4%). Procedures were performed by 13 different surgeons on a conventional operation table. Mean operation time was 57.2±14.7 (range: 30 to 100) minutes.

Patients were positioned and rigidly fixed in the lateral decubitus position on a conventional surgery table. The fixation device was checked to determine fluoroscopic visualization. A total of 3 scrubbed individuals wearing protective lead coats and neck collars under their sterile dressings were present; a primary surgeon, an assistant, and a nurse. Reduction of the fracture was provided by manual longitudinal traction and internal rotation (Fig. 1a). The quality of the reduction was confirmed using an image intensifier positioned in a lateral mode to take images for both anteroposterior and lateral views (Fig. 1b). The lateral view was obtained by flexing the hip to nearly 90° and abducting to 30 to 40°. The PFNA (with a 130° neck-shaft angle) was inserted after a classical 4 cm entry incision 4 to 5 cm proximal to the trochanteric tip. The appropriate diameter was chosen for each patient according to preoperative planning. After inserting the nail, the guide pin was driven into the neck-head. Under manual traction the quality of reduction, position of the guide pin and tip-apex distance (TAD) was evaluated on anteroposterior and lateral projections (Figs. 1 c and d). An optimal guide pin position in center-center or inferior-center was achieved by either turning the nail to the anterior or posterior direction or by burying-retracting the nail. Once the appropriate position was obtained, measurement of the helical blade's length was performed. The near cortex was predrilled and the helical blade inserted by impaction (Figs. 1 e and f). A single static distal locking screw was inserted through the nail's guide.

Based on intraoperative achieved stability and postoperative radiographic findings, patients were either allowed partial weight-bearing using crutches or no weight-bearing in the first 6 weeks. Patients who were not allowed weight-bearing (inappropriate TAD-quadrant or varus reduction) were mobilized with a walker.

Patient files were taken from the hospital's archive to

Table 1. Results of the patients with cut-out complication.

Case no. (years)	Age operation (days)	Time to type	Evans fracture distance (mm)	Tip-apex quadrant	AP quadrant	Lateral subtype	Ikuta's angle	Collodiaphyseal AP/L (mm)	Fracture gap - time (weeks)	Cut-out
10	79	5	5	47	Superior	Anterior	Posterior	120°	0-0	0
69	74	3	5	37	Inferior	Central	Normal	125°	0-0	2
97	76	5	4	50	Central	Posterior	Normal	129°	2-6	2
140	81	3	5	29	Central	Central	Normal	134°	0-0	10
166	64	7	2	45	Central	Posterior	Posterior	118°	4-8	2
169	86	6	4	60	Central	Central	Anterior	130°	4-2	10
173	68	9	3	25	Central	Posterior	Normal	132°	2-10	10
179	76	5	2	55	Superior	Posterior	Posterior	114°	2-0	0
195	70	3	1	28	Superior	Posterior	Normal	133°	2-2	10

Table 2. Comparison of stable and unstable fracture patterns.

	Stable fractures (n=80)	Unstable fractures (n=127)	p
Mean tip-apex distance in mm (range)	25 (20-36.75)	28 (22-36)	0.397
Mean operation duration in min. (range)	45 (40-50)	60 (50-75)	<0.001
Mean collodiaphyseal angle (range)	137° (133°-142°)	135° (130°-139°)	0.019

Table 3. Comparison of patients operated under spinal and general anesthesia.

	Spinal anesthesia (n=173)	General anesthesia (n=34)	p
Mean tip-apex distance in mm (range)	26 (21-35)	31 (24-38.75)	0.079
Mean operation duration in min. (range)	55 (45-65)	57.5 (48.75-80)	0.101
Mean collodiaphyseal angle (range)	135° (131°-140°)	136.5° (128°-139°)	0.848

collect data. Tip-apex distance of the helical blade,[11,12] the quadrant of the helical blade according to Cleveland and Bosworth,[13] Ikuta's reduction subgroup,[6] CDAs and reduction gaps were measured and evaluated on immediate postoperative radiographs using a computer program provided by Probel®. Evaluation, classification and measurements were performed by the chief author. Fractures were compared with previous radiographs for development of secondary varus deformity during follow-up examinations.

Statistical analysis was performed using SPSS for Windows v.17 (SPSS Inc., Chicago, IL, USA). P values of less than 0.05 were considered significant.

Results

Average time to operation was 5.8±3.5 (range: 1 to 29) days and average hospitalization time 12.2±6 (range: 4 to 53) days. Mean operation time was 57.2±14.7 (range: 30 to 100) minutes. Patients were followed up for an average of 20.4±10 (range: 6 to 38) months and 169 patients (81.6%) were followed up for more than 1 year. According to Ikuta's classification, 176 (85%) reduced fractures were subtype N, 15 (7.2%) subtype P and 16 (7.7%) subtype A.

Mean TAD was 29.2±10.9 (range: 4 to 60) mm. Tip-apex distance was 0 to 20 mm in 36 (17.4%) patients, 20 to 30 mm in 94 (45.4%) and over 30 mm in 77 (37.2%). Mean postoperative CDA was 135.3°±7.3 (range: 117° to 154°). The position of the helical blade according to Cleveland and Bosworth quadrants is shown in Figure 2. There were 9 (4.3%) cut-out complications (Table 1). We accepted 130° as a cut-off value for varus alignment and accordingly there were 156 good reductions (75.4%), 49 acceptable reductions (23.7%) (37 varus alignment and 12 with a fracture gap of more than 5 mm) and only 2 (1%) poor reductions according to the Herman criteria.[7] Evans Type 1, 2 and 3 fractures were considered 'stable' and Evans Type 4, 5 and reverse oblique fractures as 'unstable'.

Table 4. Tip-apex distance values of each quadrant.

Quadrant	Mean tip-apex distance in mm (range)
Superior-anterior	38 (17-60)
Superior-central	24.5 (13-34)
Superior-posterior	40.8 (22-64)
Central-anterior	33.9 (16-53)
Central-central	24.3 (4-52)
Central-posterior	31.1 (14-50)
Inferior-anterior	34.8 (28-50)
Inferior-central	32.2 (15-60)
Inferior-posterior	30.6 (13-58)

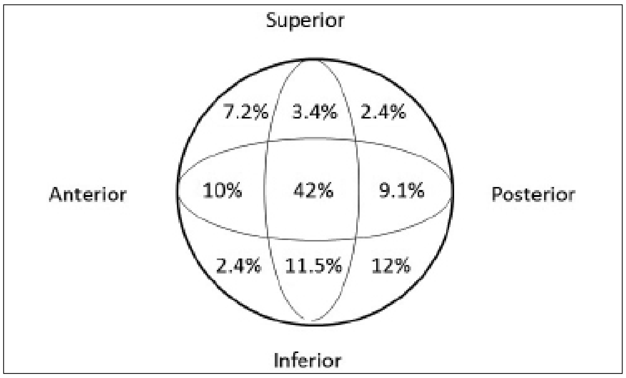

Fig. 2. Position of the helical blade in Cleveland and Bosworth quadrants.

Fig. 3. Radiographs of an Evans Type 5 fracture taken **(a)** preoperatively and **(b)** postoperatively following union.

Fig. 4. Radiographs of an Evans Type 4 fracture taken **(a)** preoperatively and **(b)** postoperatively following union.

Collodiaphyseal angle, TAD and operation times were compared between the stable and unstable groups and between the spinal anesthesia and general anesthesia groups using the Student t-test. Operation times were longer in patients with unstable fractures and the obtained CDAs were higher in patients with stable fractures. These results were statistically significant ($p<0.001$ and $p=0.019$, respectively) (Table 2). There was no statistically significant difference between the spinal anesthesia and general anesthesia groups in terms of CDA, TAD and operation times (Table 3).

Mean TAD values according to quadrants are listed in Table 4. Complications are listed in Table 5. All fractures healed with the exception of the cut-out cases that required revision surgery (hemiarthroplasty). Examples of these cases are shown in Figures 3 and 4.

Discussion

Proximal Femoral Nail Antirotation is a newly designed device which uses a helical blade inserted by impaction to cause trabecular bone compaction which is believed to resist against varus collapse and rotation.[14-16] The implant's technique guide instructs that patients are positioned supine on a traction table.[17] It can be difficult to find the trochanter major and to drill the medullary canal, especially in obese patients.[18] The lateral decubitus positioning was introduced by Kuntscher in 1940 for the intramedullary nailing of femoral shaft fractures and later described by Davis and Frymeyer in 1969 for the treatment of extracapsular proximal femoral fractures.[19] Fracture treatment modalities can be considered sufficient if it allows for acceptable reduction, adequate fixation and provides complication free healing. In our patient group, we obtained 99% good or acceptable reduction according to the Herman criteria and 85% subtype N reduction according to Ikuta. These results are comparable with similar studies which has evaluated the same criteria. Aguado et al. obtained 97% good or acceptable reduction by performing the operation using a traction table although the positioning was not mentioned in their article.[1] In an another recent study, Takigawa et al. reported 83% Ikuta subtype N reductions, 5% subtype A reductions and 12% subtype P re-

Table 5. Complications encountered.

Complication	n	%	Period
Fracture of the greater trochanter	17	8.2	Perioperative
Superficial infection	6	2.9	Early postoperative
Cut-out	9	4.3	In postoperative 10 weeks
Deep venous thrombosis	4	1.9	Early postoperative
Secondary varus*	4	1.9	Late postoperative

*Excluding cut-out cases.

Table 6. Mean operation times of PFNA procedures in recent literature.

	Mean operation time in min. (position)
Xue et al.[25]	50.6 (lateral decubitus)
Xue et al.[25]	65.67 (supine)
Soucanye de Landevoisin et al.[26]	47 (supine)
D'Arrigo et al.[27]	62 (not reported)

ductions following reductions performed on a traction table in the supine position.[6]

For adequate fixation of intertrochanteric fractures, the mainly accepted criteria include the TAD and position of the head-neck fixing device in the Cleveland and Bosworth quadrants. While it is recommended that the TAD should be less than 25 mm for Dynamic Hip Stabilization systems, there is little similar data existing for intramedullary nailing systems.[20] In our patient group, average TAD was 29.2 (range: 4 to 60) mm with 63% of values under 30 mm. This value was slightly higher than the values reported in the literature. Nikoloski et al.[20] reported 53.9% cases under 25 mm, Liu et al.[21] an average TAD of 21.3 mm and Aguado et al.[1] an average TAD of 17.8 mm.

The other necessity for adequate fixation is the insertion of the screw or blade in the correct position in the femoral head-neck. Cleveland and Bosworth[13] divided the femoral head and neck into 9 quadrants. For mechanical strength, the insertion of the fixation device in the central-central[1,21] or the inferior-central[21,22] quadrants is recommended. The superior-posterior quadrant is considered the most unsuitable position.[23] In our postoperative radiographs, we evaluated that optimal blade position was achieved in 53.5% of patients and was localized in the superior-posterior quadrants in only in 2.4% of patients. The minimum TAD value was obtained in the central-central positioned helical blades and the maximum value in the superior-posterior positioned helical blades (24.3 mm to 40.8 mm) in our study. These results also show the importance and correlation of TAD and quadrant position.

Mean operation time was 57.2 minutes. This duration is also comparable with the literature (Table 6). The rate of cut-out reported for intramedullary devices can be as high as 8%. It has been reported that PFNA has the potential to decrease the number of cut-out cases in severely osteoporotic patients.[24] Our cut-out complication rate was 4.3% (9 patients). All of these complications occurred in the first 10 postoperative weeks. Taking a look at these patients' results (Table 1), it can be observed that 5 of the reductions (55.6%) were in the varus position, all of the TAD values were equal to or more than 25 mm and 6 of the helical blades were positioned in the non-recommended quadrant. In 3 patients with an optimal blade position at the center-center or inferior-center, TAD and/or CDA was inappropriately obtained.

There are several limitations to this study, including the lack of a control group of patients treated in the supine position and evaluation of fluoroscopy usage time and blood loss. In addition, procedures were performed by 13 different surgeons which can lead to a variance in the results (reductions, quadrants, TADs, operation times). However, the number of the studied patients and the usage of the same implants, operating room and fluoroscopy can be considered advantages of this study.

In conclusion, although the ideal values of quadrant position and TAD were not provided by the nailing of intertrochanteric fractures in the lateral decubitus position, the results were encouraging probably due to the excellent stability provided by PFNA. Three important criteria must be obtained while nailing intertrochanteric femur fractures in the lateral decubitus position; avoiding varus reduction, obtaining appropriate TAD and inserting the helical blade in the appropriate quadrant. The mechanical strength of the implant should not always be trusted.

Conflics of Interest: No conflicts declared.

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