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Long-term radiographic complications following treatment of unstable intertrochanteric femoral fractures with the proximal femoral nail and effects on functional results

Dengesiz intertrokanterik femur kırıklarının proksimal femoral çivi ile tedavisi sonrasında geç dönem radyografik komplikasyonlar ve bunların fonksiyonel sonuçlara etkileri

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Amaç: Dengesiz (instabil) intertrokanterik kalça kırıklarının Proksimal Femoral Çivi (PFN) ile tedavisi sonrasında gelişen radyografik komplikasyonlar ve bu komplikasyonların fonksiyonel sonuçlara etkileri değerlendirildi.

Çalışma planı: Dengesiz intertrokanterik kırık nedeniyle 35 hasta (23 kadın, 12 erkek; ort. yaş 71; dağılım 62-111) PFN ile tedavi edildi. AO sınıflamasına göre 12 kırık tip AII-1, 12 kırık AII-2, 3 kırık AII-3, 3 kırık AIII-1, 5 kırık AIII-3 idi. Hastalar travma tarihinden sonra ortalama 13. günde (dağılım 5-32 gün) ameliyat edildi. Otuz bir hastada kapalı redüksiyon uygulandı. Olgular ortalama 32.4 ay (dağılım 26-52 ay) takip sonunda klinik (Harris kalça skoru) ve radyografik olarak incelendi ve oluşan komplikasyonlar belirlendi.

Sonuçlar: Tüm olgularda iyi ya da kabul edilebilir redüksiyonun sağlandığı görüldü. İmplant ucu-apeks mesafesi ortalama 24.2 mm (dağılım 16-40 mm) ölçüldü. İkisi hariç tüm olgularda tam kaynama elde edildi. Olguların Harris kalça skoru ortalaması 82.1 bulundu. On bir hastada (%31.4) çok iyi, 15 hastada (%42.9) iyi, yedi hastada (%20) orta, iki hastada (%5.7) kötü sonuç alındı. Radyografik komplikasyon olarak, dokuz olguda (%25.7) ikincil varus gelişimi, iki olguda (%5.7) trokanter majör ucunda kalsifikasyon oluşumu görüldü. İkincil varusun proksimal vida sıyrılması (n=2), kırık hattında çökmeye bağlı vidaların geri gelmesi (n=2) ve ters Z etkisine (n=5) bağlı meydana geldiği görüldü. Trokanter majörde kalsifikasyon görülen iki olguda klinik sonuçlar iyi bulundu. İkincil varusu olan dokuz olgunun altısında Harris kalça skoru çok iyi veya iyi, iki olguda orta, bir olguda ise kötü idi. Beş olguda (%14.3) ikinci ameliyat uygulandı.

Çıkarımlar: Osteosentez materyalinin doğru pozisyonda yerleştirilmesi ve proksimal parçanın daha kuvvetli tespitini sağlayan intramedüller çivi kullanımı dengesiz intertrokanterik kalça kırıklarının tedavisinde mekanik komplikasyonları azaltacaktır.

Anahtar sözcükler: Kemik çivisi; kırık tespiti, intramedüller/yöntem; kalça kırığı/cerrahi.

Objectives: We aimed to evaluate radiographic complications occurring after treatment of unstable intertrochanteric hip fractures with the Proximal Femoral Nail (PFN) and their effect on functional results.

Methods: The study included 35 patients (23 women, 12 men; mean age 71 years; range 62 to 111 years) who were treated with the PFN for unstable intertrochanteric hip fractures. According to the AO classification, there were 12 type AII-1, 12 AII-2, 3 AII-3, 3 AIII-1, 5 AIII-3 fractures. The mean time to surgery was 13 days (range 5 to 32 days). Closed reduction was achieved in 31 patients. The patients were evaluated clinically (Harris hip score) and radiographically after a mean follow-up of 32.4 months (range 26 to 52 months) and complications were recorded.

Results: Reduction was assessed as good or acceptable in all the patients. The mean tip-apex distance was measured as 24.2 mm (range 16 to 40 mm). Complete union was achieved in all but two patients. The mean Harris hip score was 82.1. The results were excellent in 11 patients (31.4%), good in 15 patients (42.9%), fair in seven patients (20%), and poor in two patients (5.7%). Radiographic complications mainly included secondary varus displacement in nine patients (25.7%), and calcification at the tip of the greater trochanter in two patients (5.7%). Secondary varus displacement was due to cut-out of the proximal screws (n=2), screw loosening due to collapse of the fracture site (n=2), and reverse Z-effect (n=5). Clinical results were good in two patients with calcification at the tip of the greater trochanter. Of nine patients with secondary varus displacement, the results were excellent or good in six patients, fair in two patients, and poor in one patient. Five patients (14.3%) required a subsequent operation.

Conclusion: The correct position of the osteosynthesis material and use of an intramedullary nail providing a stronger fixation of the proximal part may reduce mechanical complications following the treatment of unstable intertrochanteric hip fractures.

Key words: Bone nails; fracture fixation, intramedullary/methods; hip fractures/surgery.

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Hip fractures frequently occur in the elderly with osteoporosis who have additional systemic problems and functional disabilities. The goal of treatment should be early mobilization and return to the preoperative functional state so that potential complications are avoided.[1,2]

Current treatment approach to intertrochanteric fractures consists of possible anatomical reduction and rigid fixation. Dynamic Hip Screw using often at the treatment of stable fractures, intramedullary nailig (IM) applications have come to the fore at the unstable fractures.

Proximal Femoral Nail (PFN®, Synthes, Switzerland) designed by AO was first used in 1997 in order to overcome the technical problems and complications of first IM nail combinations used in the treatment of unstable intertrochanteric femoral fractures. The nail length 240 mm diameter, distal region 10, 11 and 12 mm options are available. Proximal region 17 mm in diameter. Between distal and proximal parts has an angle of six degrees. Proximal screws are submitted to the part two. Eleven mm neck screw, antirotation screw 6.5 mm in diameter.

An additional anti-rotation (hip) pin to avoid rotation and collapse of the head-neck segment and its special design to decrease stress concentration at the tip distinguish PFN from other IM hip screws.[5,6]

In this study, we aimed to evaluate the postoperative complications of PFN which are specially designed for the treatment of unstable intertrochanteric hip fractures and the impact of these complications on functional outcome.

Patients and method

We performed PFN osteosynthesis in 51 patients who were diagnosed with unstable intertrochanteric fracture between November 2002 – December 2004. Of these, 35 patients who were followed up sufficiently [23 women (65.71%), 12 men (34.29%), mean age 71 (62 – 111) were included. Twenty one patients had right and 14 patients had left hip fracture. The reasons of fractures were simple falls at home in 30 subjects, road traffic accident in three subjects and falling while walking on the street in two subjects. Four of the patients had additional lesions besides hip fracture (fracture of the distal end of the radius, supracondylar femoral fracture in the opposite extremity, humeral diaphyseal fracture, subdural effusion).

Fractures were graded according to AO classification preoperatively (Figure 1). Twelve were (34.29%) type AII-1, 12 (34.29%) type AII-2, three(8.57%) type AII-3 and five (14.29%) type AIII-3.

Patients underwent PFN osteosynthesis at average 13th day (5-32 days) after trauma. All operations were performed under general anesthesia and traction table was used. All except four subjects had closed reduction. In four patients, we performed open reduction because reduction could not be done or was unsuccessful during nail insertion. First generation cephalosporins were administered via intravenous route for prophylaxis at a dosage of two g 30 minutes before the operation and continued one g, four times daily postoperatively until the drain was removed. For deep vein thrombosis (DVT), prophylaxis with low molecular weight heparin was started 12 hours before the operation and continued until discharge. Patients carrying DVT risk were told to continue their medication at home until the end of postoperative 3rd week. According to the stability during operation and control radiographies, 21 patients (60%) were allowed partial weight-bearing with a pair of crutches and 14 (40%) were allowed full weight-bearing. For evaluation of postoperative reduction, we used the criteria defined by Baumgaertner et al.[4] which was modified by Fogagnolo et al (Table 1). TAD value was measured for the neck screws.[7]

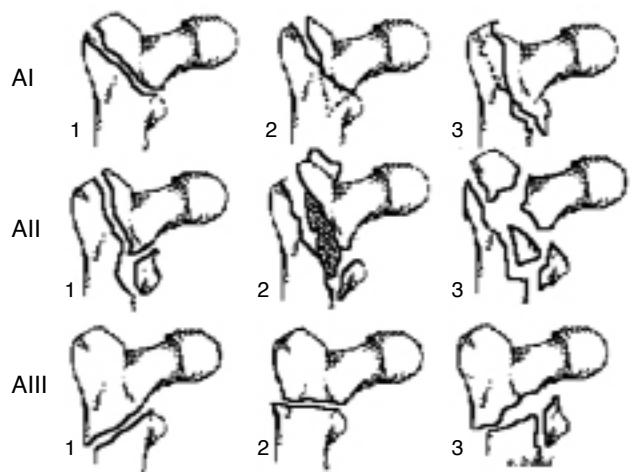

Figure 1. AO classification of intertrochanteric femoral fractures

Table 1. Evaluation of reduction according to Baumgaertner criteria [4] modified by Fogagnolo et al. [3]

Alignment	Antero-posterior view	Normal cervico-diaphyseal angle or slight valgus
	Lateral view	< 20° of angulation
Displacement	More than %80 overlapping in both planes, Less than 5 mm of shortening	
Good	Both criteria met	
Acceptable	Only one criterion met	
Poor	Neither criterion met	

Mean follow-up period was 32.4 months (26-52 months). At the end of the follow-up period, all patients were subjected to clinical and radiological examination and complications were recorded. We evaluated functional outcome using 'Harris Hip Scoring' [8] which encompassed pain, walking capacity and examination findings. Functional consequences of the effects of complications which were put forward.

Results

The first postoperative radiological evaluation showed that good or acceptable reduction was achieved in all subjects. Mean TAD value was measured 24.2 mm (16-40mm). Complete union in all except one subject was confirmed by long-term radiological evaluations. Mean Harris hip score was 82.07. The results were excellent in 11 patients (31.43%), good in 15 patients (42.86%), fair in seven patients (20%) and poor in two patients (5.71%). Seven of nine patients with fair or poor results had type- AII fracture.

Short-term superficial wound infection in one patient healed with antibiotic therapy and dressing. Deep or superficial infection was not observed in long-term. None of the cases of hematoma formation was observed.

Radiological evaluation in the follow-up period showed that two main complications were secondary varus (The reduction of the neck-shaft angle) and calcification at the tip of the greater trochanter. Secondary varus occured as a result of cut-out of the proximal screws, loosening of the screws due to collapse of the fracture site, and reverse Z-effect (Antirotation screw shift laterally) (Table 2). Secondary varus was compared with the opposite hip and classified in three groups as 0 – 5 degrees, 5 – 10 degrees, and ≥ 10 degrees (Table 3).

When the clinical and radiological outcome were evaluated together, clinical outcome was good according to Harris Hip Score System in subjects with calcification in the greater trochanter. Among subjects with secondary varus, the Harris Hip Score results were excellent or good in six, fair in two and poor in one. Among subjects with ≥ 10 degrees secondary varus, clinical outcome was good in two subjects (50%), fair in one subject (25%) and poor in one subject (25%) according to Harris Hip Score System. In two subjects, secondary varus occured due to reverse Z-effect and in two subjects due to screw cut-out of the femoral head (Figure 2a, 2b, 2c). Developed in two cases screw cut-out of the femoral head TAD was measured 16 and 29 mm, cases the reverse Z-effect is 23 and 25 mm as was measured.

Figure 2.(a) Intertrochanteric hip fracture in a 66-year-old woman. **(b)** Postoperative short-term radiography. **(c)** Cut-out at the eighth month. **(d)** Revision with bipolar prothesis.

A secondary operation was performed in subjects who showed reverse Z-effect to remove the anti-rotation screws. Two subjects who had screw cut-out and non-union underwent a revision operation with calcar-replacement partial prosthesis (Figure 2d). In our study, one-year mortality rate was 22.45%.

Discussion

Hip fractures particularly occur in elderly patients due to low-energy injuries. Because these patients usually have additional systemic diseases, long hospital stay may cause complications such as deep vein thrombosis, pulmonary embolism, pneumonia, uremia, urinary tract infection, compression ulcers which have a negative effect on prognosis and increase death rate. Therefore, primary goal of the treatment should be to achieve a stable fixation for early mobilization and to restore to the pre-fracture functional state in the shortest time possible.[1-4, 9]

Because of medial region provide balanced support at the stable intertrochanteric femur fractures, the implants must carry load is reduced. For this type fractures, dynamic hip screws (DHS) are still the golden standard.[4,9] Saudan et al.[10] showed that intramedullary screws have no advantages over dynamic hip screws in stable fractures. In a comparative study between DHS and PFN in pertrochanteric fractures conducted by Pajarinen et al. [1], PFN group showed a significant difference with regard to restoring preoperative walking capacity but reduction loss was observed in similar number of subjects in each group. Crawford et al. [19] reported rehabilitation rate of 94% without a complication for DHS and 89% for intramedullary screw. However, treatment choices for unstable fractures are still under debate.[7] Biomechanical studies have shown that intramedullary (IM) hip screws distributed the load more evenly over the femur calcar with the medialization effect.[5,9,12] IM nails according to extrameduller system have a shorter load arm decreases the tension forces acting on the screw. Thus, implant failure is minimized.[13] Like sliding screws, they provide controlled impaction of the fracture site. Other advantages include shorter operation duration owing to use of closed reduction, less soft tissue dissection, less blood loss and non-drainage of the fracture hematoma.[14, 15] Particularly in reverse oblique fractures (A-III), medial translation of the distal fragment may be avoided with an IM nail using [16].

Sadowski et al.[15] studied patients with AO type III fractures; one subject in PFN group (20 subjects) developed implant failure while seven of 19 patients treated with dynamic condylar screw presented implant failure or non-union. For stable fractures, implant failure due to DHS fixation is reported to be lower than 5% while this rate is up to 20% for unstable fractures. For these fractures, adding a trochanteric stabilizing plate may decrease such high rates of complication risk.[9,14]. Simmermacher et al.[5] reported that complications due to PFN mainly occur in AO type II fractures. Domingo et al.[17] observed AO type II or type III fractures in 10 of 295 subjects who needed secondary operation. In our study, moderate and poor results according to Harris hip scoring system received seven of nine patients were found to be AO type II fractures. Fractures, that called reverse oblique and AO type III group located in , intramedullary nailing osteosynthesis results were found more successful.

Nevertheless, several operative and postoperative complications are reported for PFN.[1, 6, 9, 10, 14, 15, 18-22] Complications such as operative fracture on greater trochanter, improper placement of proximal screws, distal locking difficulties and poor or insufficient reduction are excluded. Long-term radiological complications defined in literature include cut-out, Z-effect, reverse Z-effect, calcification at the tip of the greater trochanter, heterotopic ossification, shortening of the femur or femoral neck, non-union, mal-union, cortical thickening at distal locking site, nail breakage and fracture of the femoral diaphysis distal to the nail.[10, 18-23]

Collapse due to loosening of the screws and secondary varus are the complications reported at different rates for PFN [1, 21]. A study by Herera et al. [21] showed 8% collapse of the fracture site due to migration of the screw. Menezes et al. [18] reported lateral displacement of femoral screw only in one subject among 129 patients followed up for one year. In our study, we observed posterior displacement of the screw in two subjects and both subjects had varus angulations of 5° - 10° (varus angulations of 7° - 9°) . In this cases, TAD was measured 24 and 28 mm. Secondery operation is not considered cases without functional complaints. Insertion of hip screw at wrong position or wrong choice of screw length is held responsible for PFN cut-out. A short hip screw shows ‘blade effect’

with loading and moves in the spongious bone with femoral neck screw and causes screw cut-out resulting in varus formation [6]. Cut-out of the implant was reported in one subject among a series of 46 fractures by Tyllianakis et al. [20], in one out of 191 subjects by Simmermacher et al. [5], in four out of 295 subjects by Domingo et al. [17], in four out of 76 subjects by Alyassari [22], in two out of 55 subjects by Boldin et al. [14], 11 out of 211 subjects by Schipper et al. [6], in one out of 129 subjects by Menezes et al. [18] and in four out of 60 subjects by Banan et al. [13] In our study, we observed cut-out in two subjects (5.71%) and they underwent a revision operation with calcar-replacement partial prosthesis. In this cases, varus angulation 15° and 16°, TAD value 16 and 28 mm were measured. Postoperative reduction is an acceptable level according to the criteria was Fogagnolo. With the aim of preventing the cut-out, Proximal femoral nail with the helical blade (PFN-A ®, Synthes, Switzerland) that provide a stronger involvement of the neck has been developed [24]. One helical knife to be sent from the center of the femoral neck with Baumgaertner et al. [7] by the DHS system for single-screw neck more clearly defined set of values can be TAD is possible.

Z-effect is a specific complication of PFN. It is defined as the migration of hip pin into the joint during postoperative loading period.[14]. In 1999, the movement of the pin into the joint has been avoided by adding a ring on lateral side of the pin. Reverse Z-effect means lateral migration of antirotation (hip) pin [20]. Helwig et al. [25] described Z-effect as tilting of the proximal main segment around the sagittal axis between the screws and relative movement of both screws in the frontal plain. Out of the series of 40 subjects, Papapismos et al. [26] detected Z-effect in four and reverse Z-effect in one, Tylianakis et al [20] detected Z-effect in five subjects and reverse Z-effect in one subject, Boldin et al. [14] detected Z-effect in three subjects and Z-effect in two subjects. In our study, reverse Z-effect was seen in five patients. Two patients (40%) had good, one (20%) had fair and two (40%) had poor functional outcome. In two patients, varus angulation of more than 10° (12°- 14°) occurred. Three patients underwent a secondary operation for removal of the migrating hip screws. Less movement was detected in two patients but a secondary operation was not considered for they had no functional complaints.

Calcification at the tip of the greater trochanter is one of the long-term radiological complications. Calcification at the tip of the greater trochanter was reported by Herrera et al. [21] in 125 subjects and by Domingo et al. [17] in 13 of 295 subjects. Menezes et al. [18] observed heterotropic ossification in a series of 129 subjects. In our study, two subjects showed calcification at the tip of the greater trochanter but without any functional problem.

Following PFN using, particularly if two screws are used for distal locking, cortical reaction may develop in femur causing thigh pain [27]. Domingo et al. [17] reported that they performed material extraction due to thigh pain. In their series, Hardy et al. [27] extracted the material in three of six subjects with cortical hypertrophy. In our series, distal locking was performed using two locking screws but cortical thickening was not observed.

Femoral fracture distal to the PFN is relatively a rare complication. It is usually a common problem with gamma nail [5]. Fracture of the femoral diaphysis distal to the nail was reported by Banan et al. [13] in two out of 46 subjects and by Fogagnolo et al. [3] in one out of 47 subjects. Tyllianakis et al. [20] detected implant breakage at the level of the first distal locking screws in twosubjects. Rappold et al. [28] reported implant breakage at the level of the hole for the femoral neck screw in three subjects. Neither femoral shaft fracture nor implant break was seen in our study.

In literature, frequency of requirement for secondary operation in intertrochanteric fractures treated with PFN varies. Domingo et al. [17] 3.3%, Banan et al. [13] 6.5%, Simmermacher et al.[5] 7%, Al-yassari et al. [22] 7.1%, Saudan et al.[10] 7.6%, Menezes et al.[18] 12%, Papasimos et al.[26] 12.5%, Boldin et al.[14] 18%, Schipper et al.[29] 18.4%, Fogagnolo et al.[3] 20%, Tyllianakis et al [20] 28.8% reported a secondary operation rate. In a series of 121 patients studied by Windolf et al.[30], 78.5% of the patients had no operative or postoperative complications. In our study, five patients (14.28%) required a secondary operation. Two of these patients are applying revision with partial prosthesis because of the cut-out. The other three patients due to the Z-effects have been removed with sliding screws second surgery.

In patients with secondary varus, functional outcome was 66.7% successful. Therefore, patients sho-

uld not be evaluated only clinically or radiologically. In cases where radiological results are poor, functional outcome may be good.

Considering patient's age, general condition, functional level and degree of osteoporosis, intramedullary nail osteosynthesis is the best treatment option with superior biomechanical and anatomical properties for the treatment of unstable intertrochanteric femoral fractures. This type of fracture it is possible to achieve successful results with PFN. In our study, most of the complications were related to the fixation of the proximal segment. From this complication observed in cases with only cut-out were needed revision with partial prosthesis.

Although functional outcome is not always consistent with radiological results, in order to achieve a stable osteosynthesis, used in nail placement according to the technique and if it possible implants that provide a stronger fixation of femoral neck would be more beneficial in unstable intertrochanteric hip fractures.

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